VAAFM REVIEW AND RECOMMENDATION OF ALTERNATIVES TO THE FEDERAL CAFO MANURE SETBACK REQUIREMENT

Prepared at the request of the Vermont Agency of Natural Resources Department of Environmental Conservation CAFO Program

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Executive Summary

The Federal Concentrated Animal Feeding Operations (CAFO) regulations are a national set of standards administered by the Environmental Protection Agency (EPA) that States can modify to adjust to local conditions and regulatory structures. In Vermont, there are robust agricultural non-point source regulations that have been in place for decades and were significantly strengthened in 2015 following the largest regulatory overhaul in Vermont's agricultural water quality history. A CAFO permit issued by the Department of Environmental Conservation (DEC) to a Vermont farm would be a separate and distinct permit from the current Vermont agricultural non-point source regulatory programs (ANPS) which include the Large Farm Operations (LFO) Individual Permits and the Medium Farm Operations (MFO) General Permit managed by the Vermont Agency of Agriculture, Food & Markets (AAFM).

In the Federal CAFO standards, there is a 100-foot setback for land applied manure, litter and processed wastewater from surface water or conduits to surface water. As an alternative to the setback, CAFOs may utilize alternate practices that demonstrate equivalent or better water quality mitigation results. This report assessed current literature, available modeling tools and existing regulations to examine whether current Vermont regulatory standards are an equivalent alternative practice or whether additional practices are needed to meet the CAFO standard.

The results of AAFM's assessment demonstrate that the required agricultural non-point source regulatory buffers and setbacks meet the equivalency test, and that the required erosion performance framework (which requires farmers to implement additional conservation practices beyond buffers and setbacks) is how Vermont has historically exceeded the CAFO equivalency standard.

The recommendation from these findings is that existing Vermont agricultural non-point source buffer, setback, and erosion standards be incorporated into Vermont's CAFO permitting program. By integrating existing standards into Vermont CAFO requirements, Vermont farms would have a single universal standard required by USDA Natural Resource Conservation Service-Vermont, AAFM, and DEC. EPA also recommends this standard to CAFO permit writers by suggesting that meeting the USDA Comprehensive Nutrient Management Plan—which in Vermont includes our existing buffer and erosion performance requirements—can be sufficient to meet the CAFO permit requirements for land management. Further, EPA performed TMDL modeling in several large watersheds covering most of the agricultural land in production under CAFO-sized operations and identified the existing agricultural non-point source regulatory framework as sufficient to meet Vermont water quality goals for phosphorus.

Introduction

In the Federal CAFO regulations, there are different requirements depending on whether a farm is a Large or Medium CAFO. Large CAFO's are required to implement a 100-foot manure application setback from downgradient waters of the U.S. This 100-foot setback is the effluent limitation for the land application area and is a standard that farms must achieve to obtain permit coverage and protection. EPA recognizes two alternatives to the 100-foot setback including, 1) farms can implement a 35-foot vegetative buffer and manure application setback between the application area and any downgradient surface waters or conduits to surface water, or 2) farms can demonstrate that the 100-foot setback is not necessary because they are implementing alternative conservation practices that achieve equal to or greater pollutant reductions. If an alternative is sought, it is up to farms to request and demonstrate alternative practices that are equivalent to the 100-foot setback and meet equivalent effluent limitations. If approved by the permitting authority, farms must include these additional practices in their nutrient management plans. EPA strongly recommends that farms utilize the NRCS planning process to incorporate erosion and other soil health practices into their operations, and EPA acknowledges in the CAFO Permit Writers' Manual that meeting a USDA Natural Resource Conservation Service (NRCS) comprehensive nutrient management plan (CNMP) is often a way to meet and exceed the effluent limitations alternative, but leaves it to the permitting authority to determine equivalency (EPA, 2012).

AAFM implements parallel permitting programs to the CAFO program under its non-point source jurisdiction for Large (LFO) and Medium (MFO) Farm Operations. As part of implementing these programs, AAFM has been issuing permits that it believes are at least equivalent to the Federal CAFO requirements. The methodology used to consistently meet equivalency incorporates the regulatory programs AAFM administers including the MFO, LFO, and Required Agricultural Practice (RAP) regulations. These regulations require additional practices to manage soil erosion, nutrient applications, nutrient and waste storage, buffers, and more that in combination exceed the Federal CAFO regulatory framework. The below summary explains how these non-point source agricultural programs provide the framework to at least equal the 100-foot CAFO setback requirement. This report also includes modeling and literature review to support AAFM's recommendation for recognizing an equivalent alternative to CAFO's setback requirement.

Review of the Vermont Agricultural Non-Point Source Regulations

Buffers and Erosion Conservation Practices

A Vermont farm with a CAFO permit is in a much different position than it would be if located in a State that has not implemented agricultural non-point source regulations. In Vermont, the non-point source regulations create additional requirements that significantly complement CAFO permits and provide some of the most stringent environmental regulations on farms in the United States. To understand the water quality benefits of these additional State regulations, it is important to understand the general differences between the federal CAFO 100-foot manure setback and the current agricultural regulatory framework in Vermont.

The principal differences are 1) that the CAFO standard permits bare soil on the entire field up to the edge of ditches and surface waters, and 2) CAFO does not include erosion standards (Figure 1.). Conversely, Vermont 1) requires permanent, year-round vegetative buffers along all surface waters and ditches, and 2) includes a strict erosion requirement to protect soils (Figure 2). And, while both CAFO and Vermont ANPS regulations require manure setbacks, the CAFO 100-foot setback allows farms to apply synthetic fertilizers within the 100-foot zone adjacent to a surface water or ditch. CAFO Farms are also able to till the soil right up to the edge of surface water or ditches. Vermont regulations do not allow tillage up to the edge of a surface water or ditch. Moreover, fertilizer applications in the ANPS programs are strictly limited to those that a soil test demonstrates are necessary to establish and maintain the required vegetative buffers. While these are just some of the key physical differences between federal CAFO and Vermont regulatory strategies, these differences can also result in distinct impacts to water quality through sediment, nitrogen, and phosphorus losses which this report assesses.

Figure 1. Example Federal CAFO Requirement

Figure 2. Example ANPS Requirement

The specific permanent vegetative buffer and setback requirement for manure applications in Vermont are established in the RAPs, which require a 25-foot perennial vegetative buffer zone along all surface waters and surface inlets, and a 10-foot vegetative buffer along all ditches. To explain the benefit of this ANPS buffer standard, a field implementing a 100-foot CAFO setback will have greater sediment and nutrient losses than a field with the current ANPS regulatory vegetative buffers. That is because the ANPS vegetative buffers act as filters to catch nutrients and sediment before they reach the water. Demonstration sites in Iowa revealed that 70% of field sediment is removed in the first 10 feet of a vegetated buffer. A summary review of buffer effectiveness in Finland, Norway, Sweden, and Denmark also showed that the upper part of buffer zones are the most effective at reducing total phosphorus mass loads, indicating that even a minimum buffer width is better than no buffer at all (Smith, 1992), (Uusi-Kämppä, 2000). Additionally, it is well established that buffers remove more nitrogen and phosphorus when compared to having no buffers as the federal CAFO setback requirement allows (Mayer, 2007), (Zhang, 2010) (King, 2016) (Valkama, 2019).

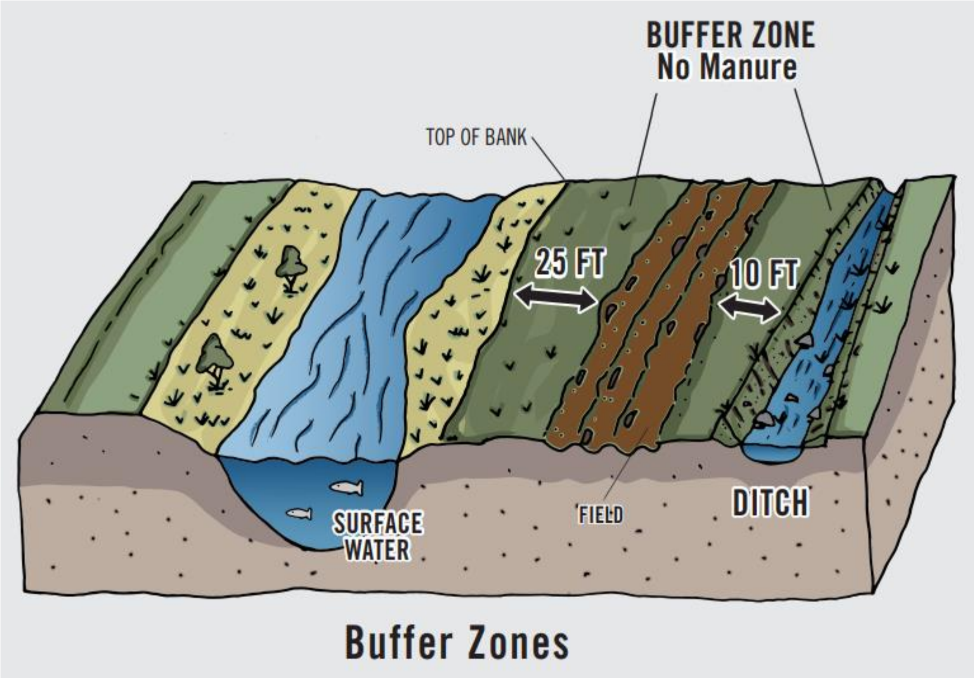

Figure 3 Illustration of RAP minimum buffer widths

In addition to Vermont's minimum buffer requirements, Vermont farms must also implement additional practices to meet our erosion standards. There are no explicit erosion requirements listed in the Federal CAFO standard, while Vermont farms are required to meet the tolerable soil loss or "T" when their fields are managed under the ANPS program. To meet the "T" standard, farms often find that leaving bare soil or continuously replanting the same annual crop without conservation practices over a rotation may not be a suitable compliance outcome, so farms choose from a variety of practices including cover cropping, manure incorporation, additional setbacks or buffers, split applications of nutrients, shorter rotations of crop types, strip cropping, no-till planting, and others to meet the erosion standard. The erosion performance standard allows farms flexibility to meet Vermont's substantial water quality requirements and to implement site-specific conservation practices on each field as appropriate.

The buffer standards alone, and a few selected practices farms commonly use to meet the erosion performance standard, consistently provide greater nutrient and sediment reductions than the 100-foot CAFO setback. The modeling detailed later in this report demonstrates that the current ANPS regulatory buffer standard is independently equivalent to the CAFO standard, and that Vermont's erosion standard requires Vermont farms to implement additional conservation practices beyond the baseline buffer requirements. All conservation practices implemented for erosion management are researched by USDA-Agricultural Research Service (USDA-ARS) often at the farm scale, and many practices are also researched at the watershed scale (USDA-NRCS). These common conservation practices also have USDA-approved practice standards to support their efficiencies in achieving nutrient reductions.

Additional Required Practices of the Vermont Ag Non-Point Source Regulations

In addition to the erosion performance standard and vegetative buffers and manure application setback requirements referenced above, there are several other required practices under Vermont's agricultural non-point source framework that further expand protections that exceed federal CAFO standards. These practices are difficult to model as the related tools have not been specifically developed, but common sense and the fact that these additional practices exceed CAFO requirements further support a conclusion that Vermont's ANPS regulatory framework surpasses the CAFO setback requirement. Below is a summary of these additional practices that the RAPs require and that apply to all Vermont farms that meet the definition of any size CAFO.

Nutrient Restrictions

In the CAFO regulations the 100-foot setback only applies to manure, litter, and process wastewater. In Vermont regulations the setbacks cover manure, composts, or other wastes, and can include fertilizers. While the use of fertilizer for the establishment and maintenance of a required vegetative buffer zone is allowed in the RAPs, it must be consistent with nutrient management plan requirements, soil analysis, and agronomic recommendations for the buffer zone. Because the CAFO requirements for setbacks do not include fertilizer, the State's requirements are more restrictive when nutrients (in the form of fertilizers) are used in the setback area.

100-foot Setback on Sloped Fields

The RAPs include a significant additional requirement whenever a farm field's slope exceeds 10%. Specifically, a 100-foot setback that also includes a 100-foot vegetative buffer is required on those Vermont fields. Since steeper fields are more susceptible to runoff, this is a substantially greater standard than CAFO. CAFO does not require any form of vegetative buffer associated with the required 100-foot setback. In the RAPs at Section 6.05(f), the rule specifically states: "manure or other agricultural wastes shall not be applied to annual cropland, vegetable cropland, or small grain cropland where the average field slope exceeds 10%, unless a permanently vegetated buffer zone of 100 feet adjacent to downslope surface water has been established. Manure shall not be applied within the buffer zone."

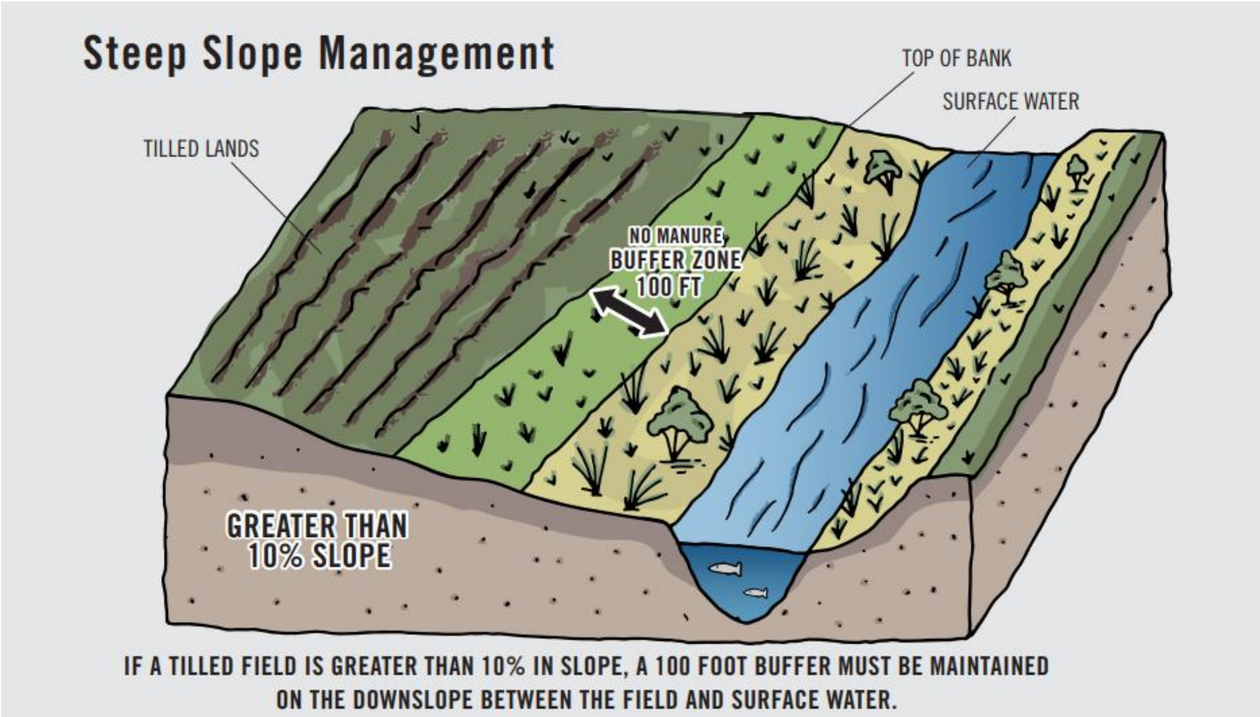

Figure 4 Illustration of RAP Steep Slope Management

Tillage Within Buffers

The CAFO requirement for a 100-foot setback allows for tillage right up to waters of the U.S. and conduits to surface waters. This can significantly increase the erosion potential and risk of runoff and pollutants entering the water due to the proximity of the tillage. Vermont requirements do not allow for tillage in specified buffer zones, with the rare exception of the establishment and maintenance of the buffer zone.

Farm Roads Within Buffers

The CAFO requirement for a 100-foot setback allows for farm roads to be established within the setback. The roads can create opportunities for flow paths to develop that direct runoff to enter surface water. The increased volume and concentration of runoff that may be associated with a farm road often results in increased erosivity of the soils, thereby increasing the pollutant loading into surface water. In Vermont, a buffer cannot include a farm road for these specific reasons.

Excavated Spoils Within Buffers

The CAFO requirement for a 100-foot setback allows for excavated spoils to be left within the setback following drainage ditch cleaning. The excavated spoils, if left on site, can create opportunities for sediment and nutrients to enter surface water due to the proximity of the exposed, loose soils adjacent to the ditch. In Vermont, a buffer cannot be used as storage of excavated spoils for these specific reasons.

Gully Soil Erosion

In addition to meeting tolerable soil loss standards, or “T”, the RAPs also require management of field borne gully erosion. This ensures that field management activities do not allow for such excessive erosion because a field’s “T” value may otherwise allow for isolated gully erosion to occur since it is designed to calculate sheet and rill erosion.

Soil Nutrient Risk Limitations

Both CAFO and Vermont ANPS regulations require a field-specific assessment of the potential for nitrogen and phosphorus transport from the field to surface water. For the phosphorus field-specific assessment, both standards require the inclusion of a field-specific soil test for the transport assessment. However, the CAFO requirements do not have a standalone soil phosphorus test-based requirement independent of a transport model. In Vermont, the soils test result alone can limit land application regardless of the Vermont Phosphorus-Index tool. In the RAPs, a soil test result of 20 ppm phosphorus or higher triggers the requirement for a drawdown strategy to be implemented. A drawdown strategy can include various management strategies to eliminate or reduce manure applications, however the 20 ppm trigger specifically limits nutrient applications to less than recommended phosphorus rates on fields with pattern tile drainage. CAFO has no restrictions that integrate soil risk independent of transport risk or tile drainage risk into the requirements.

Winter Manure Spreading

The national CAFO requirements do not include effluent limitations that restrict land application of manure during the winter. EPA provides opportunity through the regulatory oversight on “timing” of manure application for States to create additional restrictions on CAFOs, but it is up to each State to decide this issue. Vermont has several requirements to limit land application during these higher risk conditions, including a prohibition on land application to frozen or snow-covered ground. Vermont also has a ban on manure application from December 15 through April 1 each year, regardless of whether the ground is frozen or snow covered. Many states throughout the U.S. do not have similar restrictions under non-point source regulations or under CAFO permits.

Field Condition Limitations

The CAFO requirements do not include specific restrictions to land application when the ground is flooded, ponded, or when other off-site movement is likely. Again, CAFO provides the opportunity for States to make their own determination that “timing” and “method” of application should be restricted under a State specific CAFO permit to minimize nitrogen and phosphorus movement to surface waters, but there is no related requirement to specifically restrict manure applications. In CAFO, if a precipitation event is the cause of such runoff, it is considered an exempt agricultural stormwater discharge if the farm is following the approved nutrient management plan. Under Vermont requirements, the farm is liable for runoff when the conditions at time of spreading were likely to cause runoff regardless of whether the application followed the nutrient management planned allocations.

Field Stacking Standards & Floodable Soils

The CAFO requirements for buffers do not consider whether field stacked wastes, composting animal mortalities, or on-farm composting of imported food processing residuals are nearby. In Vermont, the regulations ensure that, in addition to buffers, all stacked manure and agricultural wastes are located at least 200 feet from surface water and 100 feet from conveyances to surface water. Additionally, in the CAFO requirements there is no restriction on utilizing floodable soils for field stacking. In situations where a field floods, a buffer or land application setback will likely have no effect on mitigating off site nutrient losses. In Vermont under the ANPS regulations, a farm cannot stack in a floodway or area subject to annual flooding.

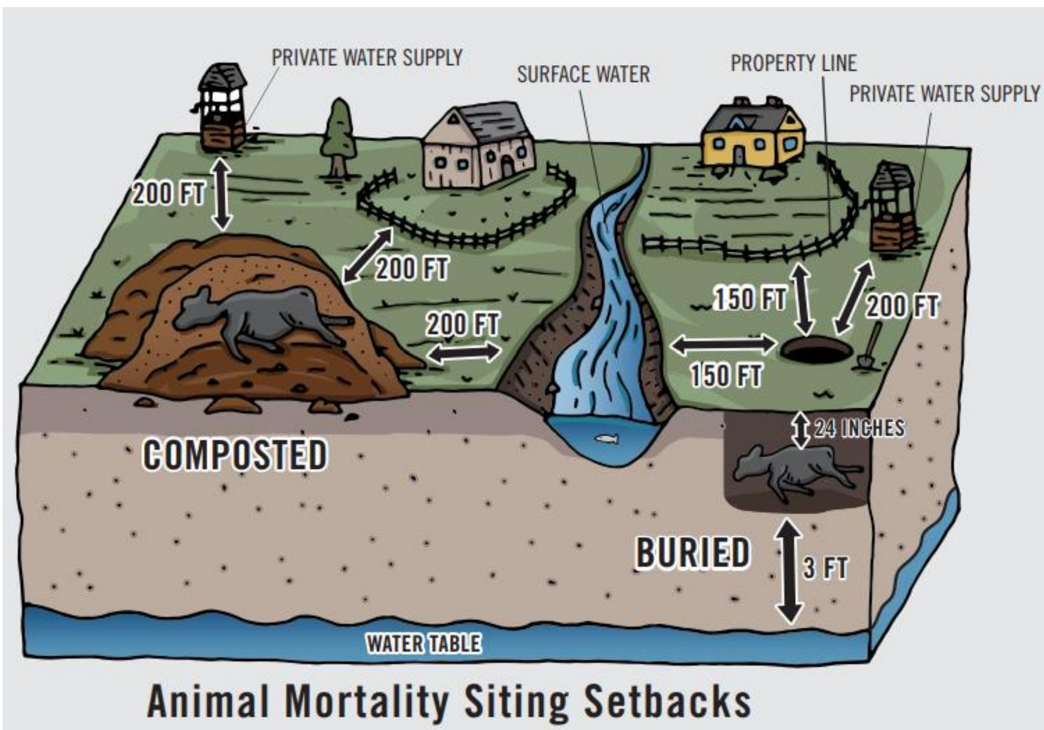

Figure 5 Illustration of RAP stacking standards

Education & Regulation

CAFO is focused on ensuring farms can demonstrate they are meeting standards in the field. There is no requirement to ensure farms have, and continue to have, education surrounding best practices and regulations. Additionally, CAFO cannot regulate contractors such as custom manure applicators or technical service providers as they are independent businesses from the CAFO. In Vermont, all farms and custom applicators are regulated and required to obtain education credits to ensure they remain knowledgeable about current regulations and best practices. Currently all custom applicators are required to be certified to operate in Vermont. Starting in 2022, all technical service providers will be regulated in Vermont as well, which includes both a continuing education component and an aptitude testing component.

Nutrient Loss Assessment

While literature reviews demonstrate that implementing 10-foot buffers and manure setbacks on ditches and 25-foot buffers and manure setbacks on surface waters can have positive impacts on capturing sediments and nutrients before they reach surface water, it is important to understand how these management practices compare to the 100-foot CAFO setback requirement when applied in Vermont. To demonstrate the impacts on phosphorus losses between the CAFO and ANPS requirements, the Revised Universal Soil Loss Equation Version 2.0 (RUSLE2) and the Vermont Phosphorus Index (VT P-Index) were used to perform scenario analyses. These tools utilize local soil types, climate, and field management practices to model erosion and phosphorus losses. Scenarios in these tools were created to mimic the CAFO conditions which include land application of manure with a 100-foot setback, fertilizer applications within the 100 feet adjacent to surface waters or ditches, and tillage right up to surface waters or ditches. The tools were then utilized to simulate the 10-foot and 25-foot ANPS setbacks and buffers, and additional conservation practices including manure incorporation, manure injection, cover cropping, no-till planting, and no-till planting with cover cropping. These additional conservation practices are often utilized to meet erosion standards under the ANPS framework. To understand the impacts on nitrogen, literature review data was assessed and shared to demonstrate the relative effects of setbacks, buffers, and additional conservation practices on nutrient reductions.

Modeling Assumptions

Pursuant to DEC's request, assessments using the VT P-Index were evaluated under a "worst case" scenario to meet its described National Pollutant Discharge Elimination System (NPDES) permit standard. To achieve worst case scenario, selections were made within the tools and the justifications for those selections are itemized below to document how decisions and assumptions were made.

First, the primary crop type of this assessment was silage corn fertilized with dairy manure for all options, except when evaluating fertilizer use within the 100-foot setback to test the fertilizer CAFO scenarios. Cow dairies are the most common type of farm that would receive a CAFO permit in Vermont, and their land application of manure and fertilizers to annual cropland represents the highest risk sources of sediments and nutrients from their land application areas.

Next, a user can choose where in Vermont the assessed land is located, and "NW (Addison, Chittenden, Franklin, Grand Isle)" was chosen because it includes the major dairy farming regions of the State. The Agricultural Census of 2017 recorded 841 milking farms with 128,742 cows in Vermont, and Addison and Franklin counties had 30% of the State's dairy farms and 50% of its milking cows, making it home to more potential Medium and Large CAFO farms than any other Vermont region (NASS-USDA, 2017).

After inputting the high-level dairy operation variables, additional high-risk variables were entered to create a universal baseline including choosing the highest elevation possible (>1,000 feet), a soil test threshold in the excessive range (21ppm), a very rare and high manure application rate in pounds of P_20_5 (100 lbs.), and the lowest categories (0-20%) of vegetative cover. These inputs were used on all four of Vermont's different hydrologic soil types.

To test whether it is appropriate to use the general hydrologic soil groups as opposed to specific soils, the P-Index was run using a Vergennes soil, because NRCS determined it has the highest erosivity factor in Vermont. That output was compared to running the P-Index using the generic Other (HydroGrp D, Clay) option, which is the general category that includes the Vergennes class of soil. The output results for the specific soil and generic soil group did not differ in either the P-Index value or interpretation category. Therefore, the worst-case scenario held constant when applying the general categories to the four hydrologic groups A, B, C and D.

In the Revised Universal Soil Loss Equation version 2 (RUSLE2), generic soil categories are not options and a specific soil must be selected. Typical agricultural soils representing the different hydrologic group categories were selected for each soil. Specifically, Adams, Hadley, Limerick, and Vergennes soils were utilized in RUSLE2 for A, B, C, and D hydrologic groups respectively. Our soil selection process is further described below.

Since Vermont covers several geographic regions, the soils vary by region, except for a Limerick soil which is present throughout Vermont, which is why it was selected as the "C" soil. Additionally, the K factor on a Limerick soil (0.49 Kw) is the same as the higher K values selected for other soils. The K factor indicates the soil's susceptibility to sheet and rill erosion and ranges from 0.02 to 0.69 with the higher values being more susceptible to erosion losses. Soils are grouped by NRCS where the characteristics are similar.

For the A soils, Adams and Windsor are present in most (but not all) regions of the State and are also in the same group based on their characteristics. When reviewing the erosion factors for both soils, the Adams soil (0.17 kw) and the Windsor soil (0.17 Kw) have the same K factor. Upon reviewing the regions where the soils are located, the Adams soil is not commonly present in the northeast portion of Vermont, which is heavily forested. The Windsor soil is not present in the southwest portions of Vermont, which still retain a rich agricultural landscape. Therefore, the selection was made to use the Adams as the "A" soil to be most representative of agricultural soils.

For the "B" soil, Hadley is often grouped with Winooski soil, and when comparing lands along the larger rivers where it is commonly found, Hadley appears to cover larger areas of the agricultural fields while Winooski soils are more random and smaller in map units. Also, the K factor for Hadley (0.49 Kw) is equivalent to the Winooski (0.49 Kw). Therefore, as the Hadley soil covers larger areas of agricultural fields it was utilized.

Vergennes soil was used to represent a "D" soil as this is a common agricultural soil in the Lake Champlain basin and has shown it can stay in suspension for long periods and is well known for its erosivity (0.52 Kw) as being the most erodible soil in Vermont.

In the P-Index, there are two options, "clay" or "non-clay," for each generic soil category. Lookup tables in the P-Index also provide the determination of "clay" or "non-clay" for each soil type. For each soil type utilized in

RUSLE2, the P-Index's corresponding "clay" or "non-clay" category was used to select the appropriate generic category. Correspondingly, all A, B, and C soils are demarcated as "non-clay" and the D soil is "clay".

The scenarios for this modeling exercise were run with surface applications of fertilizer or manure in the spring and fall. It is important to note that one major limitation in this assessment is the inability for the P-Index to fully test the CAFO 100-foot manure setback option. In other states that have implemented the CAFO setback option, farms can choose the 100-foot setback of manure, however they can also apply synthetic fertilizer in the 100-foot manure setback area adjacent to surface water at full crop utilization rates. The P-Index alone cannot model a scenario where synthetic fertilizer is applied within 100 feet of a surface water while manure is simultaneously applied 100 feet from the edge of the surface water, essentially 'behind' the synthetically fertilized area. Therefore, the analysis compared the CAFO manure setback and ANPS manure setbacks and buffers to each other, and then a separate scenario tested the CAFO fertilizer to ANPS manure setbacks and buffers. There is no scenario where the typical application (fertilizer within the first 100' and manure in the area beyond 100' of the surface water) of the CAFO 100-foot setback is utilized because the P-Index tool is not developed to model nutrient applications in this way.

To properly distinguish the differences that the vegetative buffer in the ANPS regulations have on overall field erosion losses compared to the CAFO setback standard, RUSLE2 was used. The erosion differences of the various buffer widths were quantified in RUSLE2 and then within the P-Index the setback distances of manure and fertilizer applications were assessed. Another way to explain why this methodology for quantifying different erosion rates was necessary is because this assessment must compare the overall impact of all the buffer options within the same field boundary or common land unit (Figure 3). If the erosion rates were held constant between the various buffer scenarios (0, 10 and 25 feet) it would not differentiate the impact of the buffers on erosion and sediment-bound phosphorus leaving the field. However, since we are comparing a change within the same field boundary, it is important for this scenario testing to include the buffers' impact on erosion reduction as erosion rates differ significantly when a field is plowed to the edge of surface water compared to when a vegetative buffer separates annual cropland from surface waters.

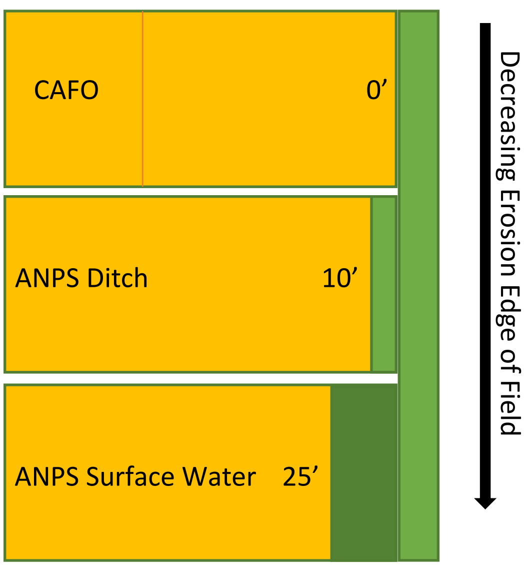

Figure 6. Vegetative Buffer Widths Compared

When running the tools for regulatory purposes to meet the ANPS requirements, the buffer is not an optional variable and the tools are run to ensure the field management, regardless of the buffer, can meet the erosion performance management standards inside the field, not within the common land unit boundary. Therefore, guidance for using the P-Index does not normally suggest utilizing RUSLE2 to calculate a different erosion rate when vegetative buffers are implemented. Since CAFO does not require a vegetative buffer, the guidance for the P-Index would not adequately quantify the comparison of the CAFO and ANPS requirements. Therefore, RUSLE2 was utilized to compare the erosion rates with and without vegetative buffers to adequately represent the ANPS and CAFO requirements.

To test the regulatory buffers, ideally erosion rates for 0, 10, and 25-foot buffers would be calculated. However, the easiest way to do this in RUSLE2 utilizing guidance from USDA NRCS is to generate scenarios for 0, 10, 20 and 30-foot buffers (Widman, 2007) (USDA-ARS, 2013). By using 20-foot buffers, while it is less than the 25-foot regulatory standard, it is also a more conservative distance as it tests a narrower buffer width. Since RUSLE2 was used to determine the varying erosion rates of the different buffer scenarios, the buffer widths for ANPS scenarios were not duplicated within the P-Index tool. Instead, the manure setback option for 100-foot, 10-foot, and 25-foot setbacks were used to simulate manure setbacks. Therefore, RUSLE2 was used to evaluate the benefit of the vegetative buffer zone and the P-Index was utilized to calculate the impacts of manure and fertilizer application setbacks from the surface water.

Additional Conservation Practices

The baseline scenarios described above were all run with and without the presence of pattern tile drainage in the modeled field. These baselines with and without pattern tile drainage were then run to simulate the 10-foot and 25-foot regulatory buffers in Vermont, both with no additional conservation practices. To compare additional conservation practices, the baseline scenarios with 10-foot and 25-foot regulatory buffers and setbacks with and without tile were run individually with cover crops, injection of manure or incorporation of manure, no-till, and no-till with cover crops. The focus of this analysis was to test practices that are commonly utilized to meet the erosion performance standard of “T” as required by the ANPS and the RAPs.

RUSLE2 could have been utilized to gather additional erosion rates for practices such as cover cropping, however, to limit the number of fluctuating variables, the same erosion rate was used from RUSLE2 when implementing 10 or 20-foot buffers and the P-Index was used to simulate the conservation practice applied for the scenario. When evaluating cover crops, the P-Index variables that were changed were the inputs: application of manure to vegetated ground in the spring, the crop type selected includes silage corn plus a successful cover crop, and the surface cover was increased to greater than 20%. This is a conservative approach, as planners following the USDA nutrient management standard normally calculate erosion in RUSLE2 with cover crop, which results in a lower erosion rate, and choose these variables in the P-Index. For incorporation and injection of manure, the same RUSLE2 values from the 10 or 20-foot buffers were again used, and the P-Index was used to simulate the applied practices. The selected timing of manure injection is “immediate” as that is the most common method of injection. For incorporation, the maximum time period representing the greatest risk was selected within the tool, which is 8-21 days.

The P-Index cannot accurately estimate the impacts of no-till without applying the erosion rate calculated from RUSLE2 for no-till management. Therefore, RUSLE2 was utilized to generate a no-till value under the same 10- and 20-foot buffer scenarios. When cover crops are added to no-till, the P-Index was once again utilized to demonstrate the additional impacts to no-till of adding cover crops rather than including cover crops to the no-till in RUSLE2. This is once again a conservative approach as technical service providers following the USDA nutrient management standards will implement cover crops and no-till in the RUSLE2 calculations, which reduces erosion rates, and these options are also selected within the P-Index. Had AAFM performed the same selections as a technical service provider in the P-Index, the risk categories would be reduced even further below the CAFO requirements. However, since these practices already exceed the CAFO requirement, AAFM elected not to create additional scenarios.

Results for Phosphorus

The categorical risk results from the phosphorus index scenarios on various soil types demonstrate that Vermont’s buffer and setback requirements are equivalent to the 100-foot CAFO setback (APPENDIX B and C). Then, additional conservation practices individually applied -- such as manure incorporation, cover cropping and no-till -- can be selected as part of meeting the “T” performance requirement of the ANPS and RAPs. They add additional protections beyond the baseline regulatory vegetative buffer zone and manure application setbacks.

While the results of the risk categories in the P-Index are equivalent for CAFO’s 100-foot manure spreading setback and ANPS’s 25-foot and 10-foot vegetative buffer zones and manure spreading setback (e.g., high risk and high risk), the P-Index also reports numeric values. These numeric values are a quantification of directional risk which is not correlated with offsite nutrient transport loads. In comparing the numeric values, there are only a few instances where the ANPS scenario value is not lower than the 100-foot CAFO setback value. It is important to reiterate that the model was not able to simulate the actual CAFO implementation effect of fertilizer within the first 100 feet from surface water or a ditch when manure is applied behind the setback in the remainder of the field. Therefore, these are conservative values as the methods could only test either manure or fertilizer application, not both used in conjunction.

The instances where ANPS values were less than CAFO exclusively occur when the 100-foot manure CAFO setback is compared to the 10-foot buffer width and manure setback in the ANPS requirements (APPENDIX B). However, if you compare the CAFO fertilizer scenario to manure applications under ANPS requirements, the ANPS program consistently outperforms CAFO requirements for all buffer widths (APPENDIX C). Additionally, where the manure values demonstrate a lower value for the CAFO option, the ANPS and CAFO values are within a few points of each other (±4%) and well within the deviation between the values (±12%) in the same comparison group, seemingly well within the variability of the tools utilized. Further, if tile drainage is added as a conservation practice, then all but one of the numeric values for the 10-foot buffer scenarios provide a more protective phosphorus transport benefit compared to the CAFO setback. The only 10-foot buffer scenario that is greater than the CAFO setback is only one point different (0% deviation) and thereby is justifiably equivalent, especially when considering the modeling limitations.

Given this data and information, it is logical to assume that ANPS requirements would always exceed the true implementation of the CAFO standard when incorporating fertilizer into the 100-foot manure setback. This is because the CAFO fertilizer applications always result in increased nutrient losses when compared to the ANPS scenarios. The manure results for CAFO and ANPS are also categorically the same and very close in numeric value, suggesting the programs are equivalent. Therefore, with the manure application results being comparable, any addition of fertilizer within the 100-foot setback would easily make the ANPS requirements better than CAFO when it comes to reducing pollution losses. Farms will seek to keep land productive, and it should be expected that farms will utilize the opportunity under the CAFO regulations to use fertilizer where they cannot apply manure.

To further support this conclusion, the results of the additional conservation practice scenarios described above demonstrate that injection and incorporation with 10- and 25-foot buffer and setback options consistently exceed the 100-foot setback option for tile and non-tile drained fields. Cover cropping, no-till, and no-till with cover crops all also exceeded the CAFO standard in all soils with and without tile drainage. Vermont farms often implement these practices to meet ANPS erosion standards and farms also implement site and field-specific RAPs that cannot be modeled, so it is an easily justifiable and reasonable conclusion that the ANPS program consistently exceeds Medium and Large CAFOs requirements.

Results for Nitrogen

While the Phosphorus-Index tool can only simulate phosphorus losses, nitrogen is also a nutrient of concern when it comes to water quality. In reviewing literature, it has long been established that buffers are beneficial for nitrogen reductions and a meta-analysis study revealed that across decades of research it was not apparent that the width of an existing buffer impacted nitrogen losses. In this meta-analysis the presence of buffers, regardless of width, was shown to reduce total nitrogen by 57% as compared to no buffers at all (Valkama, 2019). Therefore, it is reasonable to expect that the 10-foot and 25-foot vegetated buffer zones in the ANPS requirements are better at protecting water quality against nitrogen impacts as compared to the unbuffered CAFO standard.

The additional conservation practices of manure incorporation and/or injection, no-till, and cover crops are all additionally beneficial for reducing not only nitrate losses, but also ammonia volatilization. Incorporating manure, whether by disking in a surface application or using injection, can reduce the total nitrogen up to 98% and the total phosphorus up to 87% (Jokela, 2016). Additionally, under no-till cropping, ammonia emissions were documented to be reduced by 91-99% when manure was injected (Dell, 2012). Studies have shown that the change in erosion management practices from conventional to no-till does not have an increased impact on nitrate losses (Zhu, 2003). Further, when cover crops are integrated into the no-till system, there do not appear to be negative impacts on nitrogen losses either (Waring, 2020). One study that assessed over 106 other studies from around the world identified that cover crops reduce nitrogen leaching and increase soil organic carbon without subsequently increasing nitrous oxide emissions (Abdalla, 2019). Therefore, cover crops planted in a conventional tillage system or in a no-till system are shown to be beneficial for water quality and greenhouse gas emissions by reducing nitrogen losses as compared to not implementing these practices at all.

Results for Biological Oxygen Demand

There is a paucity of literature on biological oxygen demand (BOD) losses from land application of dairy manure. Research on BOD often focuses on pre-land application technologies or constructed systems to reduce BOD. A literature review suggests that agricultural management practices that include land application of manure increases BOD in the soil, however it does not build up over time (Long L. , 1979). This makes sense as manure is made of organic matter which requires oxygen to decompose, however soils are naturally aerated and over time can process decomposition and continually aerate, thereby limiting the buildup of BOD.

Another study suggests that when manure is applied and incorporated it does not result in significant BOD runoff differences as compared to soils without manure application (Long L. L., 1975). This is likely due to the incorporation protecting the manure from runoff. Incorporating manure is a common practice to meet the erosion standards in the ANPS requirements, however there are some practices that limit incorporation such as hay, cover crops, or no-till systems. These systems all have increased vegetative growth, which, there is a body of BOD research on constructed wetlands and other natural treatment areas, that find that vegetation in the treatment system provides greater removal efficiencies (>75%) for BOD than unvegetated treatment areas (Karathanasis, 2003). Other research on agricultural wastes have assessed the ability of vegetative filter strips to treat silage runoff as it is known to be high in BOD. In one study, the use of a filter strip showed a 77% reduction in BOD from runoff of high flow silage leachate (Holly, 2016). All this research suggests that adding a vegetative buffer and using practices such as manure incorporation will benefit BOD losses. The CAFO requirements do not require buffers or incorporation, while the ANPS does require buffers and incorporation in floodplains, and most farms utilize incorporation to meet the erosion performance standards and reduce nitrogen losses from land applied manure.

Ditches versus Surface Water

This assessment compared the existing 100-foot CAFO setback to Vermont's 10-foot buffer and setback requirement for cropland ditches. However, CAFO requirements never specifically state that the 100-foot setback requirement applies to ditches, instead it applies to "conduits to surface water", which is not further defined in the CAFO statute, rules, procedure, or guidance. States such as Pennsylvania do not universally include ditches in the CAFO buffer or setback standards, however they do not allow direct application within ditches (PA-DEP, 2018). Some states such as Ohio have included additional practices such as incorporation and injection that nullify a buffer requirement on ditches, while Maryland permits manure injection with only a 10-foot setback and no buffer on ditches (OH-NRCS, 2012) (MDA, 2016).

New York provides an alternative buffer requirement to CAFO's 100-foot setback of a 15-foot setback plus incorporation of manure, but does not explicitly include ditches. New York appears to evaluate keeping manure runoff from entering ditches as a performance standard rather than a specific setback (NYDEC, 2017) (CCWQMA, 2017). The definition of 'surface waters of the State' in New York specifically states that: "ditches are not surface waters of the State unless they are mapped Waters of the State or continuously flowing," which is how this undefined setback is determined (NYDEC, 2017). Maryland regulations exclude field ditches from the definition of surface water for the purpose of nutrient application setbacks (MDA, 2016). The CAFO standards of these heavily agricultural states demonstrate the lack of directive in the CAFO requirements surrounding ditch buffers or setbacks. The CAFO Permit Writer's Guidance Manual states "CAFO's *should* also not apply manure in the following areas or under the following conditions: within concentrated water flow areas (vegetated or non-vegetated) such as ditches, waterways, gullies, swales and intermittent streams (emphasis added)" (EPA, 2012). This guidance suggests [should] instead of requires [shall] that manure not be applied directly into a ditch. The CAFO Permit Writer's Guidance Manual does not suggest that a ditch is necessarily a conduit to surface water or that the 100-foot manure spreading setback requirement applies to all ditches irrespective of whether they are a conduit to surface water.

Based on Vermont field experience and research, it is clear there can be significant differences between a ditch and a protected surface water. Research on ditches mostly demonstrates that the potential connectivity of ditches to surface water within the overall system varies significantly and that the presence of additional vegetation in ditches acts as a filter that provides pollution abatement (Moloney, 2020) (Cui, 2020) (Kroger, 2007). The nutrient reductions from adjacent buffers coupled with the benefits from ditch vegetation are reasons why a narrower vegetated buffer is acceptable for ditches than surface waters.

Vermont structured its non-point source regulations to include a universal 10-foot buffer and setback standard for ditches, but the regulations also provide flexibility to heighten requirements when a ditch may act more like a surface water or when the minimum buffer standard is insufficient to treat runoff. In instances when a 10-foot buffer is inadequate, the Agency of Agriculture has the authority to require larger buffers. This protects water quality with an equitable regulatory standard that is not over-inclusive and does not unnecessarily exclude land from production simply because it is adjacent to a ditch that is not a conduit to surface water.

One last important point about ditches is that Vermont's agricultural fields are very small compared to other states. An analysis of Vermont cropland fields shows an average cropland field is 9.77 acres (Appendix D). These fields are often adjacent to either a roadside ditch or a diversion ditch, which begins to create significant land losses when buffer widths are increased. An assessment of the impact of increasing buffers on Medium Farm Operations in Vermont suggests that an additional 5,389 acres could be lost to production if a 35-foot vegetated buffer was required for all surface waters and ditches (Appendix E).

Given that Large Farm operations operate roughly the same amount of land as MFOs based on 2021 Annual Compliance Reports, an estimated additional 5,000 plus acres of land on Large Farm Operations is likely to also be lost to production if the CAFO 35-foot buffer is applied (Appendix E). The potential additional buffer requirement could result in a 10,000 acre loss in agricultural production of annual crops. If assessed at a general real estate value of $4,000 per acre, the financial impact could be equated to removing $40,000,000 worth of land from agricultural production. Considering the potential financial impact, we believe it important to ensure that any additional water quality protections are demonstrably necessary.

Recommendation

This report demonstrates that existing ANPS 10-foot buffers and setbacks on ditches and 25-foot buffers and setbacks on surface waters are equivalent and often exceed the CAFO 100-foot setback. In addition, this report shows ANPS standards further exceed the CAFO requirement when farms implement the conservation practices often necessary to meet the erosion performance standard of "T" in the ANPS regulatory programs. Moreover, there are numerous additional field management requirements in the RAPs that exceed federal CAFO requirements that were not modeled that provide additional water quality benefits. By aligning Vermont CAFO standards with ANPS regulations, Vermont farms can continue to have a single field management standard that is required by USDA Natural Resource Conservation Service, AAFM, and DEC. The EPA also recommends this standard in its CAFO permit writers manual when it suggests that meeting the USDA Comprehensive Nutrient Management Plan (which in Vermont includes these existing ANPS buffer and erosion performance requirements) can be sufficient to meet CAFO permit requirements for land management (EPA, 2012). Further, EPA performed TMDL modeling in several large watersheds covering most of the agricultural land in production under CAFO-sized operations, and identified AAFM's existing ANPS framework as sufficient to meet Vermont's water quality goals for phosphorus in the Lake Champlain Basin and Memphremagog watersheds.

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Appendix A. RUSLE2 Erosion Plan Calculation Records

USDA NRCS Natural Resources Conservation Service

Vermont USDA-NRCS

RUSLE2 Erosion Plan Calculation Record

Inputs:

Farm Information:

Owner name	Location	Tract #
	USA\Vermont\Addison County	

Field name	Soil	Slope T Value	Slope length, ft	Slope steepness, %
A_Adams	soils\SSURGO\Addison County, Vermont\AdB Adams loamy sand, 0 to 8 percent slopes\Adams Loamy sand 85%	5.0	100	4.0
B_Hadley	soils\SSURGO\Addison County, Vermont\Hf Hadley very fine sandy loam\Hadley Very fine sandy loam 85%	5.0	100	4.0
C_Limerick	soils\SSURGO\Addison County, Vermont\Le Limerick silt loam\Limerick Silt loam 85%	5.0	100	4.0
D_Vergennes	soils\SSURGO\Addison County, Vermont\VgB Vergennes clay, 2 to 6 percent slopes\Vergennes Clay 88%	2.0	100	4.0

Results:

Field name	Management	Support practices	Cons. plan. soil loss, t/ac/yr
A_Adams	Corn,silage; No till, manure	Width as pct of slope length\1- Cool season grass filter strip 10 percent of slope length	0.7
A_Adams	Corn,silage; No till, manure	Actual width\20-ft Cool season grass filter strip	0.5
A_Adams	Corn,silage; No till, manure	Actual width\30-ft Cool season grass filter strip	0.3
A_Adams	Corn,silage; SP, manure	-- none --	2.0
A_Adams	Corn,silage; SP, manure	Width as pct of slope length\1- Cool season grass filter strip 10 percent of slope length	1.5
A_Adams	Corn,silage; SP, manure	Actual width\20-ft Cool season grass filter strip	1.1
A_Adams	Corn,silage; SP, manure	Actual width\30-ft Cool season grass filter strip	0.8
A_Adams	Corn,silage; SP	-- none --	2.2
B_Hadley	Corn,silage; No till, manure	Width as pct of slope length\1- Cool season grass filter strip 10 percent of slope length	1.6
B_Hadley	Corn,silage; No till, manure	Actual width\20-ft Cool season grass filter strip	1.2
B_Hadley	Corn,silage; No till, manure	Actual width\30-ft Cool season grass filter strip	0.9
B_Hadley	Corn,silage; SP, manure	-- none --	4.9
B_Hadley	Corn,silage; SP, manure	Width as pct of slope length\1- Cool season grass filter strip 10 percent of slope length	3.7
B_Hadley	Corn,silage; SP, manure	Actual width\20-ft Cool season grass filter strip	2.6
B_Hadley	Corn,silage; SP, manure	Actual width\30-ft Cool season grass filter strip	1.8
B_Hadley	Corn,silage; SP	-- none --	4.8
C_Limerick	Corn,silage; No till, manure	Width as pct of slope length\1- Cool season grass filter strip 10 percent of slope length	1.6
C_Limerick	Corn,silage; No till, manure	Actual width\20-ft Cool season grass filter strip	1.2
C_Limerick	Corn,silage; No till, manure	Actual width\30-ft Cool season grass filter strip	0.8
C_Limerick	Corn,silage; SP, manure	-- none --	5.0
C_Limerick	Corn,silage; SP, manure	Width as pct of slope length\1- Cool season grass filter strip 10 percent of slope length	3.7
C_Limerick	Corn,silage; SP, manure	Actual width\20-ft Cool season grass filter strip	2.6
C_Limerick	Corn,silage; SP, manure	Actual width\30-ft Cool season grass filter strip	1.8
C_Limerick	Corn,silage; SP	-- none --	5.9
D_Vergennes	Corn,silage; No till, manure	Width as pct of slope length\1- Cool season grass filter strip 10 percent of slope length	2.3
D_Vergennes	Corn,silage; No till, manure	Actual width\20-ft Cool season grass filter strip	1.7
D_Vergennes	Corn,silage; No till, manure	Actual width\30-ft Cool season grass filter strip	1.3
D_Vergennes	Corn,silage; SP, manure	-- none --	6.0
D_Vergennes	Corn,silage; SP, manure	Width as pct of slope length\1- Cool season grass filter strip 10 percent of slope length	4.6
D_Vergennes	Corn,silage; SP, manure	Actual width\20-ft Cool season grass filter strip	3.5
D_Vergennes	Corn,silage; SP, manure	Actual width\30-ft Cool season grass filter strip	2.6
D_Vergennes	Corn,silage; SP	-- none --	5.2

Appendix B. Comparison of P-Index Results, 100-ft. CAFO Manure Setback, No Fertilizer

Categorical Risk
Low
Medium
High
Very High

100 FOOT CAFO MANURE SETBACK, NO FERTLIZER

Comparison of P-Index Results to 100 foot Setback-SPRING

	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile
	No practices	No practices	No practices	CC	CC	Injection	Injection	Incorporation	Incorporation	No-Till	No-Till	No-Till w/ CC	No-Till w/ CC
Soil Group	100' Setback w/ Manure	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer
A	85	84	73	67	57	40	32	75	65	67	61	50	44
B	183	173	146	147	121	97	75	156	131	130	118	103	91
C	238	234	205	194	166	121	99	209	182	191	176	149	136
D	268	273	248	226	202	137	120	245	221	236	219	188	173

	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile
	No practices	No practices	No practices	CC	CC	Injection	Injection	Incorporation	Incorporation	No-Till	No-Till	No-Till w/ CC	No-Till w/ CC
Soil Group	100' Setback w/ Manure	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer
A	104	101	89	81	69	47	38	91	79	80	73	60	53
B	176	155	126	137	107	99	73	142	114	104	91	84	72
C	225	208	177	177	146	116	90	188	159	157	143	124	110
D	283	278	251	230	203	144	124	250	225	234	216	184	168

Comparison of P-Index Results to 100 foot Setback-Fall

	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile
	No practices	No practices	No practices	CC	CC	Injection	Injection	Incorporation	Incorporation	No-Till	No-Till	No-Till w/ CC	No-Till w/ CC
Soil Group	100' Setback w/ Manure	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer
A	93	94	83	88	76	40	32	83	73	77	70	70	63
B	196	190	162	182	153	97	75	169	143	147	134	137	123
C	257	259	228	244	213	121	99	228	200	216	200	200	183
D	292	304	276	287	260	137	120	267	242	267	248	250	230

	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile
	No practices	No practices	No practices	CC	CC	Injection	Injection	Incorporation	Incorporation	No-Till	No-Till	No-Till w/ CC	No-Till w/ CC
Soil Group	100' Setback w/ Manure	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer
A	114	113	100	106	93	47	38	100	88	93	85	85	77
B	186	168	137	162	131	99	73	151	123	116	103	108	95
C	242	229	196	218	185	116	90	203	173	177	162	165	150
D	308	309	280	291	261	144	124	273	246	265	245	245	225

Appendix C. Comparison of P-Index Results, Fertilizer in CAFO Setback, No Manure

Categorical Risk	
●	Low
●	Medium
●	High
●	Very High

FERTILIZER IN CAFO SETBACK, NO MANURE

Comparison of P-Index Results to 100 foot Setback-SPRING

	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile
	No practices	No practices	No practices	CC	CC	Injection	Injection	Incorporation	Incorporation	No-Till	No-Till	No-Till w/ CC	No-Till w/ CC
Soil Group	Fertilizer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer
A	90	84	73	67	57	40	32	75	65	67	61	50	44
B	193	173	146	147	121	97	75	156	131	130	118	103	91
C	285	234	205	194	166	121	99	209	182	191	176	149	136
D	298	273	248	226	202	137	120	245	221	236	219	188	173

	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile
	No practices	No practices	No practices	CC	CC	Injection	Injection	Incorporation	Incorporation	No-Till	No-Till	No-Till w/ CC	No-Till w/ CC
Soil Group	Fertilizer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer
A	108	101	89	81	69	47	38	91	79	80	73	60	53
B	172	155	126	137	107	99	73	142	114	104	91	84	72
C	259	208	177	177	146	116	90	188	159	157	143	124	110
D	300	278	251	230	203	144	124	250	225	234	216	184	168

Comparison of P-Index Results to 100 foot Setback-FALL

	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile	No Tile
	No practices	No practices	No practices	CC	CC	Injection	Injection	Incorporation	Incorporation	No-Till	No-Till	No-Till w/ CC	No-Till w/ CC
Soil Group	Fertilizer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer
A	97	94	83	88	76	40	32	83	73	77	70	70	63
B	207	190	162	182	153	97	75	169	143	147	134	137	123
C	307	259	228	244	213	121	99	228	200	216	200	200	183
D	325	304	276	287	260	137	120	267	242	267	248	250	230

	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile	Yes Tile
	No practices	No practices	No practices	CC	CC	Injection	Injection	Incorporation	Incorporation	No-Till	No-Till	No-Till w/ CC	No-Till w/ CC
Soil Group	Fertilizer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer	10' Setback & Buffer	25' Setback & Buffer
A	116	113	100	106	93	47	38	100	88	93	85	85	77
B	180	168	137	162	131	99	73	151	123	116	103	108	95
C	276	229	196	218	185	116	90	203	173	177	162	165	150
D	327	309	280	291	261	144	124	273	246	265	245	245	225

Appendix D. Vermont Agricultural Cropland Analysis

	# of Cropland Fields	Cropland Acres in County	Average size of field
Addison	10,140	119,537.16	11.79
Bennington	1,536	11,784.03	7.67
Caledonia	3,079	29,470.29	9.57
Chittenden	3,314	32,158.44	9.70
Essex	622	6,865.70	11.04
Franklin	7,039	74,281.72	10.55
Grand Isle	1,210	14,084.79	11.64
Lamoille	1,633	16,587.50	10.16
Orange	3,487	28,297.19	8.12
Orleans	5,905	55,264.50	9.36
Rutland	4,601	38,362.65	8.34
Washington	1,456	12,346.61	8.48
Windham	1,719	12,416.33	7.22
Windsor	2,626	21,105.01	8.04
Statewide	48,367	472,561.92	9.77

Appendix E. Number of MFOs and LFOs in Vermont

MFOs	Total Corn (acres)	Total Hay (acres)	Total Pasture (acres)	Total Other (acres)	Total Acreage	Number of Currently Operating MFOs*
Total	24,108.5	45,996.8	3,827	848	74,780.3	107
Average	225.31	429.88	35.77	7.93	700.06	

LFOs	Total Corn (acres)	Total Hay (acres)	Total Pasture (acres)	Total Other (acres)	Total Acreage	Number of Currently Operating LFOs**
Total	34,646.8	45,105.1	Unknown	Unknown	79,751.9	36
Average	962.41	1,252.92	Unknown	Unknown	2,215.33	

Appendix F. Analysis of Cropland Impact of Buffer Widths

Field	Buffer Type	Buffer Length	Current Buffer Width	Proposed Buffer Width	Change	Change if Double (both sides)
Dimensions (ft)	Ditch	1500	10	35	25	50
	SW	800	25	35	10	20
Area (sqft)	Ditch		15000	52500	37500	75000
	SW		20000	28000	8000	16000
Area (ac)	Ditch		0.344	1.205	0.861	1.722
	SW		0.459	0.643	0.184	0.367
	Field		20	20	20	20
Percent of Field			1.72%	6.03%	4.30%	8.61%
			2.30%	3.21%	0.92%	1.84%
	Total		4.02%	9.24%	5.22%	10.45%
Farm	Number of Fields	**Frequency**	50	50	50	50
Fields	Ditch	50%	25	25	25	25
	SW	30%	15	15	15	15
Acres	Ditch		8.6	30.1	21.5	43.0
	SW		6.9	9.6	2.8	5.5
	Farm		1000	1000	1000	1000
	Total		15.5	39.8	24.3	48.6
	Percent of Farm		1.5%	4.0%	2.4%	4.9%
All MFOs	Number of Farms	111	1,720	4,415	2,695	5,389