Ohio's Concentrated Animal Feeding Facilities:

A Review of Statewide Manure Management and Phosphorus Applications in the Western Lake Erie Watershed

Ohio Environmental Council

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Acronyms

CAFF	Concentrated Animal Feeding Facility
CAFO	Concentrated Animal Feeding Operation
CLM	Certified Livestock Manager
D&U	Distribution and Utilization
DLEP	Division of Livestock Environmental Permitting
MMP	Manure Management Plan
NPDES	National Pollution Discharge Elimination Permit
OAC	Ohio Administrative Code
ODA	Ohio Department of Agriculture
OEC	Ohio Environmental Council
OEPA	Ohio Environmental Protection Agency
ORC	Ohio Revised Code
PPM	Parts Per Million
STP	Soil Test Phosphorus
WLEW	Western Lake Erie Watershed

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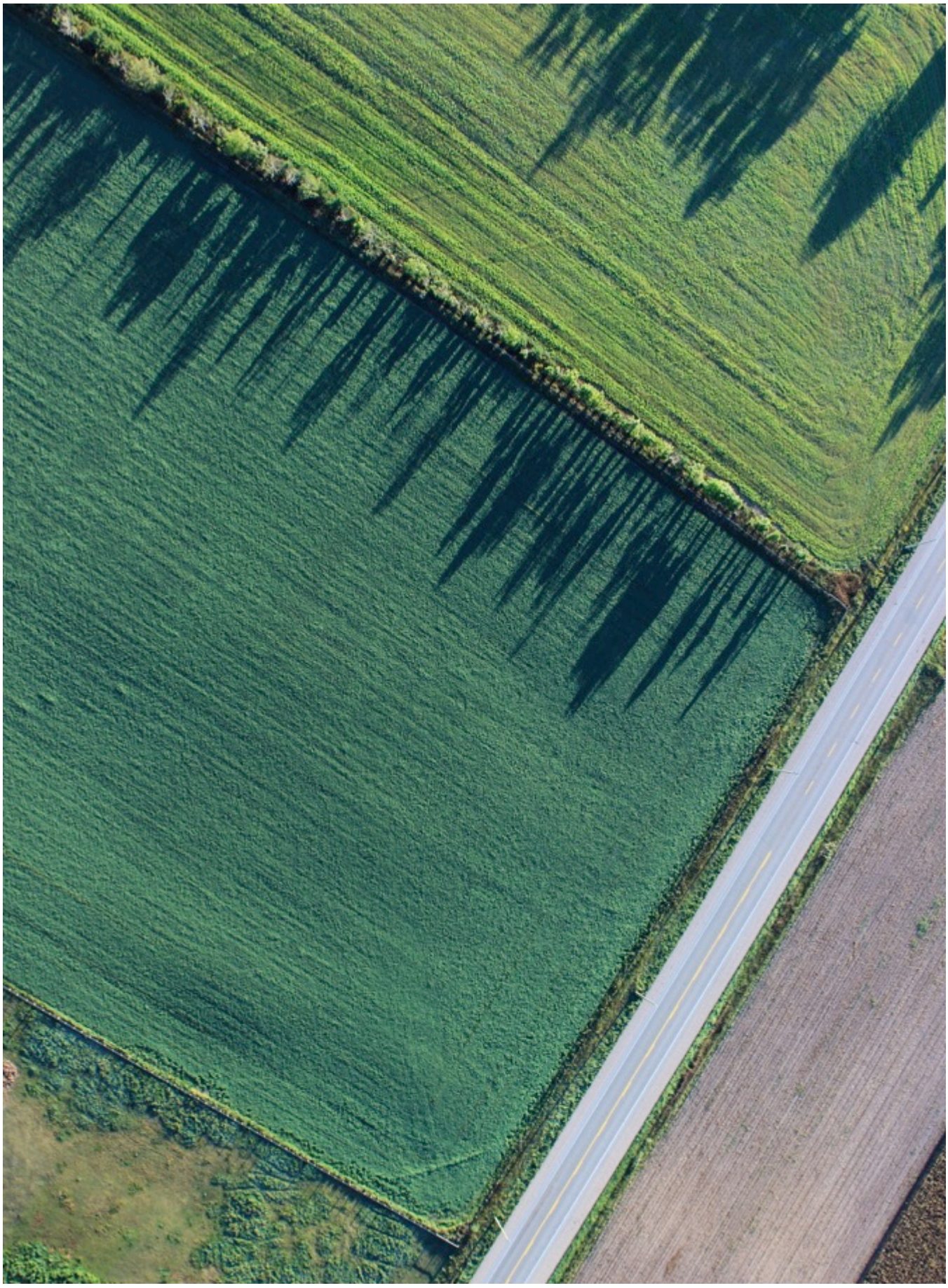


Executive Summary

Toxic algae, or harmful blue-green algae, is a serious problem in Ohio. In 2010, numerous lakes, including Lake Erie, experienced large growths of this algae known for producing dangerous toxins. In 2011, Lake Erie made the front page of National Geographic with, then, the most severe bloom on record as measured by the National Oceanic and Atmospheric Administration. In 2013, Carroll Township, a township of 2,000 people, were told they could not use their tap water for three days because algal toxins contaminated Lake Erie where the city draws its drinking water. In 2014, a modern American city experienced the unthinkable when nearly half a million people in the Toledo area were told they could not use their tap water for approximately three days, again due to toxic algae contaminating a drinking water supply. In 2015, Lake Erie broke the record as the most severe season with harmful algae spanning the distance between Monroe, MI past the shores of Cleveland, Ohio. That same year, toxic algae stretched over 650 miles of the Ohio River.

Agricultural pollution is the main driver of toxic algae found in many of Ohio's rivers, streams, reservoirs and lakes. Manure is a known contributor to this problem, as it contains readily available phosphorus for plant growth. Manure, however, is difficult to track and quantify. Therefore, the Ohio Environmental Council (OEC) reviewed thousands of public records to learn how permitted livestock facilities across Ohio manage their manure specifically in the western Lake Erie watershed (WLEW). This summary report includes the approximate amounts of manure concentrated animal feeding facilities (CAFFs) generate, and the quantities sold or given to farms for application. The report dedicates one section for an evaluation of soil phosphorus levels at the time of manure application for CAFFs in the WLEW in order to assess the potential for possible pollution. It is widely known that in freshwater systems, such as Lake Erie, phosphorus is the limiting nutrient for blue-green algae growths.[1] In other words, the algae will consume all the phosphorus before nitrogen, the other main nutrient.

Box 1. AFO vs. CAFF vs. CAFO

State and federal law differentiates between Animal Feeding Operations (AFOs) and Concentrated Animal Feeding Facilities (CAFFs) based on the specific number of animals it confines. If there are fewer animals than what the law specifies for a CAFF, then it is considered an AFO. This is important because state law only requires Large and Major CAFFs to obtain ODA permits and comply with applicable regulations. Ohio has around 230 permitted CAFFs, but thousands AFOs that do not require any kind of permit or registration with ODA.

CAFOs have the requisite number of animals to be classified as a large CAFF. They can also have fewer animals, but must be designed or found to be discharging pollutants into waters of the state. The law classifies these as medium or small CAFOs, with the latter designated as such by the ODA director. CAFOs that discharge pollutants must have an NPDES permit.

Ohio has thousands of concentrated animal feeding operations (AFOs). The exact number is unknown because the state does not require that AFO owners obtain a permit from the Ohio Department of Agriculture (ODA) unless the operation exceeds a certain number of animals. Those that do are classified as CAFFs, of which Ohio has 231 as of January 2017. Combined, these CAFFs are permitted to raise

[1] Correll, DL. Phosphorus: a rate limiting nutrient in surface waters. Poult Sci. 1999 May;78(5):674-82.

66,989,147 chickens, turkeys, cows, horses, and pigs producing nearly 900,000 solid tons and over 1.5 billion gallons of liquid manure annually according to each CAFF's fact sheet that is issued by the Ohio Department of Agriculture's (ODA) Division of Livestock Environmental Permitting (DLEP). To put this into perspective, this amount of manure would fill the entire Ohio State University football stadium more than two times over (2.3 to be exact). The 64 CAFFs in the western Lake Erie watershed produce 24% (215,098 tons) of all the solid manure and 42% (658,030,505 gal.) of all the liquid manure in the state of Ohio. These amounts are greater than the fecal waste produced daily by the entire metro areas of Los Angeles, Chicago, Dallas and Cincinnati combined.

These numbers are not direct measurements and determining more precise amounts with existing, publicly-available records is extremely challenging. A significant portion of manure applications do not take place under the control of the CAFF, but instead through the distribution and utilization method of manure management (D&U) established in regulations. These rules allow a certified livestock manager or certified fertilizer applicator to apply manure to cropland - nearer to the CAFF for liquid manure (5 miles averaged), or farther away for solid manure (3 - 400 miles with many reporting a 50 mile average).

Annual estimates show 87% of the solid manure and 36% of the liquid manure was applied through D&U for all of Ohio's CAFFs. In the WLEW, the numbers increase to 91% of solid manure and 53% of liquid manure. This has important implications for understanding overall phosphate inputs from both manure and commercial fertilizer in watersheds throughout the state.

Determining if there is adequate cropland available for appropriate manure applications is also challenging and requires detailed analysis of each CAFF's manure management plan (MMP). However, available cropland frequently changes when a CAFF leases additional acres or transfers manure through the D&U. In some cases, fields will no longer be available for application if the Bray-Kurtz P1 soil test phosphorus results exceed 150 parts per million (ppm).[2] Regulations allow manure applications even when tests show levels exceed what is necessary for optimal crop production, which is 40 ppm for corn and soybeans. This is the upper limit for the amount of phosphorus three land-grant universities recommended be maintained in the soil to produce maximum yields of corn and soybeans, this is also called the critical level, beyond which phosphorus begin to build up in the soil. This report uses agronomic rate to refer to keeping soil phosphorus levels at or below this critical level. When the soil test phosphorus level is above 40 ppm, manure applications are typically unnecessary to grow corn and soybeans, and could be considered an excess application in most instances. To fully assess the extent of this practice, one

[2] Bray-Kurtz P1 refers to a testing method and specific extraction solution used to measure soil phosphorus levels and used to establish critical soil phosphorus levels in the Tri-State Fertilizer Recommendations. References to soil test phosphorus results are those obtained through the Bray-Kurtz P1 testing method.

must look at each CAFF's inspection reports to find soil phosphorus levels at the time of manure application. However, many of these reports lack specific enough details when soil phosphorus levels fall below 150 ppm to track excess applications. The reason is 150 ppm is the amount where regulations discourage further application, and fields below this level are not consistently listed in CAFF inspection reports.

Several inspection reports do list soil phosphorus levels at the time of application, allowing for more detailed analysis for the CAFFs in the WLEW. These reports showed, of the 43 facilities where information was available, 38 (88%) applied manure when soil test phosphorus levels were above 40 ppm. Unfortunately, inspection reports lack adequate detail to effectively track manure applications completed through D&U. If these manure applications follow this trend, it represents a significant risk of excess application since, in the WLEW, 53% of liquid manure applications and 91% of solid are done through D&U. Even more concerning are the number of unpermitted AFOs in the watershed that may be following this same trend.

Box 2. Top Recommendations

Establish Regulatory Safeguards

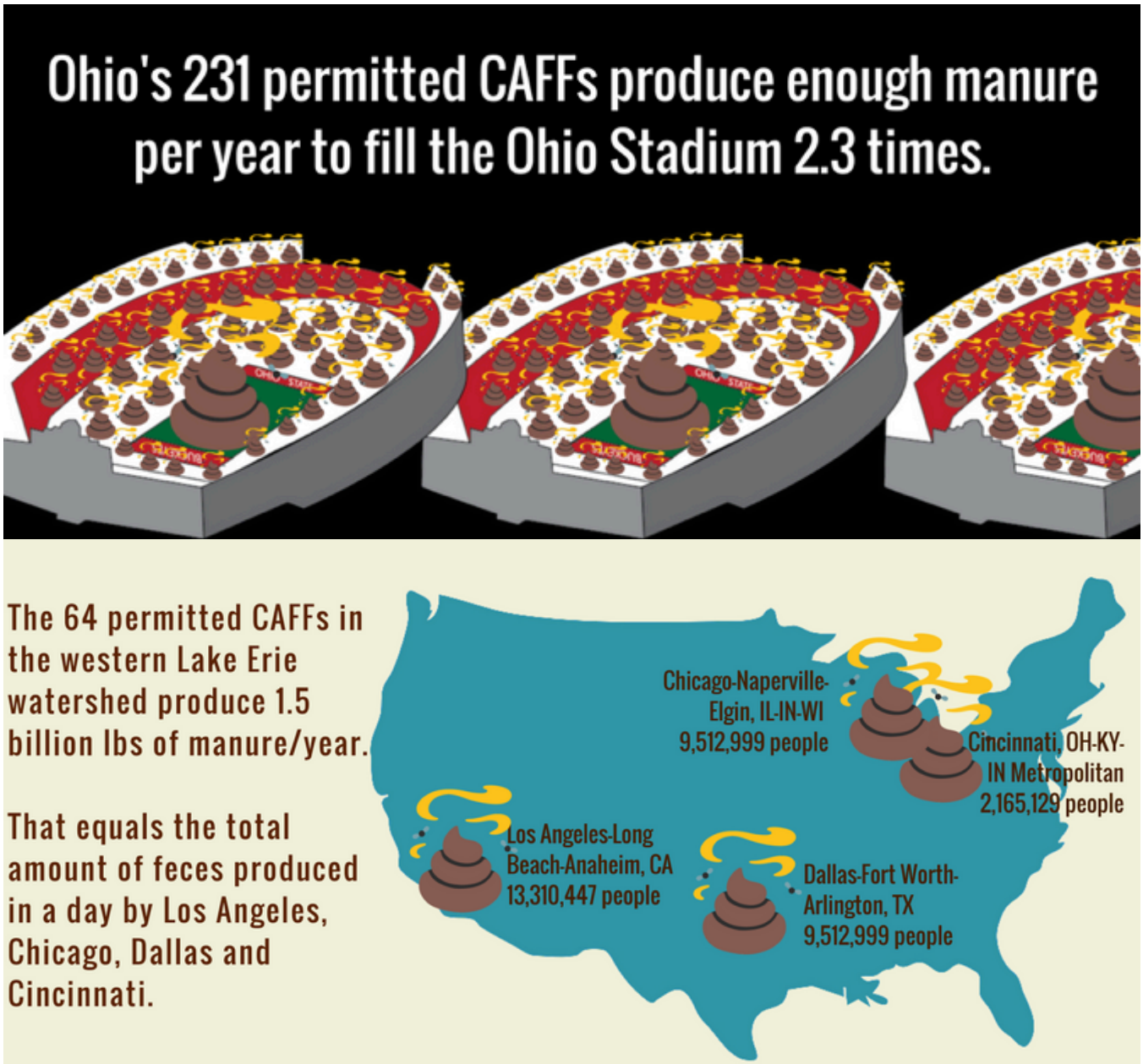
- Require all AFOs to register with ODA, and direct those that would meet the medium sized CAFOs definition to follow a pollution prevention plan.
- Revise Distribution & Utilization regulations to require soil tests and field maps before manure application.

Improve Reporting

- Require annual reports to include more detailed Distribution & Utilization information.
- Ensure inspection reports include soil phosphorus levels for all fields that receive manure applications and list phosphate application rates.

The OEC provides several recommendations to begin addressing these systemic problems and to transition to a system that effectively reduces the risks of pollution, (see Box 2). These recommendations include establishing clearer and more consistent reporting protocols, and bringing more accountability for manure managed through D&U. To address more systemic problems, the ODA needs to begin transitioning manure management towards ensuring applications adhere to appropriate agronomic rates (the amount of nutrients crops need for optimal growth). This will take time since the rules establish an industry standard where each CAFF's storage capacity and operational design rests on the allowance to apply manure with soil test phosphorus levels reaching 150 ppm. Therefore, if regulatory reforms are to be accepted and successful, they must allow for a reasonable transition period for existing CAFFs. The first step is to establish a cap on manure applications when soil test phosphorus levels are at 100 ppm, unless there is an emergency situation. Current rules direct that when soil levels reach this amount, then phosphate applications must match the agronomic rate for a single growing season. Therefore, this seems like a reasonable level for an immediate cap on applications as the state works with producers to ratchet down rates to the proper amounts. For new or expanding CAFFs, the rules should direct applications match the agronomic rate. Finally, and perhaps most important, Ohio needs to establish a system to manage the thousands of AFOs that do not have any type of state permit. At the very least, lawmakers should require each one to register with the ODA's Division of Soil and Water Conservation and direct all operations of a certain size to develop and follow publicly available operation and management plans.[3]

[3] That size should be equal to the number of animals listed as a medium CAFO in ORC 903.1(Q)



Introduction

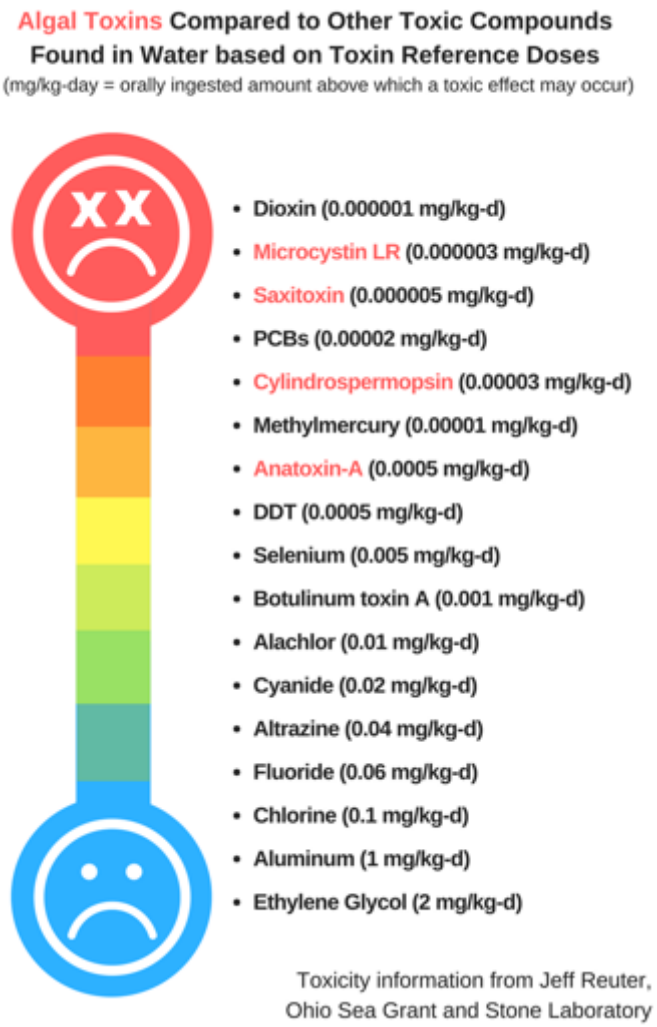
Industrial livestock production is major industry in Ohio that receives well-earned scrutiny due to concerns from potential threats it poses to Ohio's water, air, and overall quality of people's lives. Manure from livestock that is not properly managed can contribute to bacterial contamination that impairs the water quality of many Ohio rivers and lakes, creating unsafe conditions along numerous beaches in the state.[4] It is also a known contributor to the phosphorus pollution that spurs the growth of toxic algae in Grand Lake St. Marys and western Lake Erie.[5]

[4] See the OEPA 2016 Final Integrated Report, Section F.

[5] See the multi-modeling project led by the University of Michigan Graham Sustainability Institute showing phosphorus inputs into the Maumee River from different sources, including manure. See also, OEPA Beaver Creek and Grand Lake St. Marys Watershed TMDL Report

Across the State, millions of chickens, turkeys, cows, horses, and pigs are confined in buildings called animal feeding facilities or operations (AFOs).[6] Ohio has thousands of them, but the exact number is unknown because the ODA only tracks the largest facilities based on the number of animals they house. These are called Concentrated Animal Feeding Facilities (CAFFs) and they must obtain a permit from ODA's Division of Livestock Environmental Permitting (DLEP) to install and operate a CAFF, which among other requirements, includes developing and following a manure management plan (MMP). The permitted facilities, of which Ohio has 231 as of January 2017, must file annual reports and the ODA performs regular inspections to ensure regulations are appropriately followed. The remaining thousands of smaller AFOs lack this oversight.

Complicating the distinction between CAFFs and AFOs, is the term concentrated animal feeding operation (CAFO). While many people have heard this term, its exact meaning can be confusing. If an AFO confines the requisite number of animals set by the U.S. Environmental Protection Agency (EPA), it is classified as a large CAFO. If it contains fewer animals and discharges pollutants into state waters, then it can be classified as a medium or small CAFO.[7] Ohio uses the same definitions established by the U.S. EPA. These CAFOs must obtain a special permit to discharge pollutants, called a National Pollution Discharge Elimination System (NPDES) permit. Pollutants are more than just manure and include any agricultural waste such as contaminated stormwater. The Ohio EPA currently issues these permits and has extensive rules governing their requirements.



While CAFFs and CAFOs must adhere to complex requirements, AFOs follow a much simpler set of rules that focus on abating pollution from manure, and are not enforceable until after a waterway becomes contaminated.[8] In fact, there is little accountability until a local resident calls or writes to complain, and an official investigation confirms an instance of water pollution. The lack of comprehensive laws and regulations targeting AFOs provides no way to track how these operations manage their manure or to know where it gets applied. This gap in adequate oversight means it is impossible to fully account for the potential impacts of

[6] Ohio uses the U.S. EPA animal feeding operation definition found at O.R.C. 903.1(B).
[7] See U.S. EPA regulatory definitions.
[8] See OAC 901:13-1 Abatement Chapter

Ohio's livestock industry. However, we can evaluate the data from Ohio's permitted livestock facilities, the CAFFs, to explore how they manage their waste, and by extension obtain a better understanding of how the rest of Ohio's unpermitted AFO's may handle their manure.

One reason for such an evaluation is the recent focus on how much manure these livestock facilities generate, their potential contribution to western Lake Erie's phosphorus pollution, and the resulting growth of toxic algae. The concern that manure contributes to toxic algae has spurred debates about its actual role in causing phosphorus pollution. This is based on the quantity of manure produced compared to the amount of cropland available for appropriate manure application. Documented instances of manure discharges, which is the planned or unplanned releases of manure from these facilities directly into surrounding watersheds, are additional causes of concern.[9]

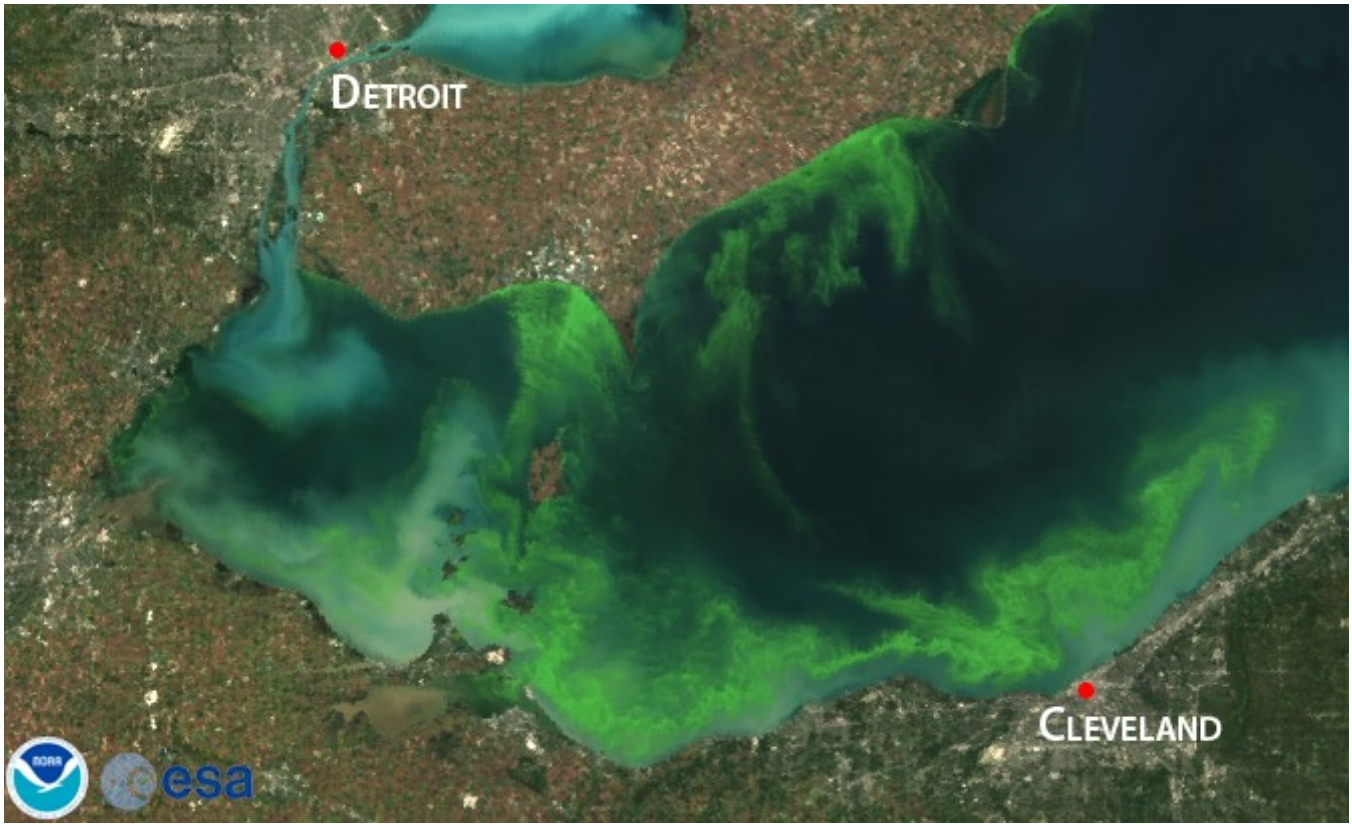
Pollution can occur from manure directly flowing into Ohio's streams and rivers from crop field surface runoff or through the subsurface drainage systems (i.e. tile drains) used to prevent flooding that quickly funnels surface water and liquid manure into ditches. Another concern is excessive manure applications can create high levels of soil phosphorus, especially within the top few inches of soil, which becomes a source of dissolved, or soluble, phosphorus that flows out of tile drains, typically during or after heavy rain events.[10]

Harmful blue-green algae are actually growths of specific types of cyanobacteria that release dangerous toxins when they break open after dying. The City of Toledo issued a "do not drink" advisory for area residents' tap water in August 2014 because the microcystin toxin was found in the city's treated drinking water. *Microcystis* produced the toxin, which is just one of many different cyanobacteria species. Toxic algae has become a common, unscientific term for growths of cyanobacteria or blue-green algae. These bacteria feed on phosphorus and nitrogen to thrive, which is present in livestock manure. Since phosphorus is a highly reactive element, it combines with oxygen in soil forming particulate phosphorus or in water as dissolved phosphorus. Total phosphorus is both the particulate and dissolved forms. Nitrogen is also an important nutrient and research is underway to better understand its role in producing cyanobacterial toxins.[11] Research shows there has been an increase over the recent decade of dissolved phosphorus flowing into Lake Erie as compared to total phosphorus.[12] Increased tile drainage and greater soil phosphorus availability is a likely contributor to increased dissolved phosphorus loads flowing into western Lake Erie.[13] For this reason, excess manure applications that create high levels of soil phosphorus are a legitimate concern.

Previous studies and models that include manure as a source of Lake Erie's phosphorus pollution lack the necessary data for a full analysis. For example, knowing the amount of manure produced

[9] See Less=More Coalition's "Follow the Manure" report that quantified manure production in the western Lake Erie watershed, tracked Clean Water Act violations and federal subsidies each CAFF received.
[10] Bahman Eghball *, G. D. Binford and David D. Baltensperger. Phosphorus Movement and Adsorption in a Soil Receiving Long-Term Manure and Fertilizer Application. JEQ Vol. 25 No. 6, p. 1339-1343 Received: Dec 4, 1995. Nicolas Stämpfli* and Chandra A. Madramootoo. Dissolved Phosphorus Losses in Tile Drainage under Subirrigation. Water Qual. Res. J. Canada, 2006 • Volume 41, No. 1, 63–71.
[11] See Beversdorf LJ, Miller TR, McMahon KD (2013) The Role of Nitrogen Fixation in Cyanobacterial Bloom Toxicity in a Temperate, Eutrophic Lake. PLoS ONE 8(2): e56103. https://doi.org/10.1371/journal.pone.0056103
[12] See Environ. Sci. Technol. 2015, 49, 3392−3400

does not necessarily mean we can know how much phosphorus pollution is occurring. One would need to know the amount of available cropland, existing soil phosphorus levels, the cropping schedules, methods of manure application, and several other variables. Models can predict how much manure contributes to phosphorus pollution, but absent this information and more, they must use assumptions to fill in data gaps. Ultimately, there is a need to more closely examine the potential for phosphorus pollution from livestock operations, and to also explore manure management practices as a whole to identify opportunities to reduce pollution risks.



Project Description

The Ohio Environmental Council's project evaluated how CAFFs across Ohio manage manure and the phosphorus each generates annually with a special emphasis on phosphorus applications in the WLEW. The project sought to answer the following questions:

- How many CAFFs currently operate in Ohio, specifically in the western Lake Erie watershed, and how many animals are they permitted to house?
- How much manure and phosphorus do these CAFFs produce?
- How much manure and phosphorus do CAFFs manage through distribution and utilization in the state, and specifically in the western Lake Erie watershed?
- How much cropland is available for these facilities to apply their manure?
- How many facilities in the western Lake Erie watershed apply manure when soil test phosphorus levels are above 40 ppm?

To answer these questions, the OEC evaluated and entered data from thousands of pages taken from each CAFF's annual reports, inspection reports, fact sheets and, when available, MMPs.[14] After consulting with experts familiar with ODA permitted facilities, it was decided there was no single approach that could accurately determine the amount of manure and phosphorus CAFFs generate due to concerns about the accuracy and inherent variability of information, especially since much of the available information are estimations rather than precise measures. Therefore, this report compares manure amounts listed in each CAFF's fact sheet (or MMP in some instances) with the 2015 Annual Reports to determine differences between what the CAFF lists in its permit compared to its actual production. The project also calculated amounts of manure and phosphate generated based on the number of animals by using a conversion table provided in the ODA rules, referred to in this report as the Ohio Administrative Code (OAC) Appendix.[15] Manure calculations account for only produced volumes and do not include all the waste that CAFFs generate, as specified in the definition of manure from Ohio law provided below. In other words, the fact sheets and annual reports oftentimes, but not consistently, report solid and liquid manure (measured in tons or gallons respectively), which includes much more waste than animals produce such as contaminated storm water or bedding material. The OAC Appendix provides a conversion tool for manure and phosphorus produced, with the option of three different measures for the former (pounds, cubic feet and gallons). To maintain consistency, this report only uses gallons for the manure calculations even though some manure is produced and stored as a solid. Appendix A contains a full methodology description.

Definitions and Background Policies

In order to understand many of the findings in this report, it is important to explain specific definitions and some of the basic legal underpinnings of Ohio's livestock industry. State law differentiates between CAFFs, CAFOs and AFOs in specific ways. First, the definitions establish what constitutes an animal feeding facility based, in part, on the length of time livestock may be confined and fed. These facilities are the same as AFOs.[16] Concentrated animal feeding facilities are those that confine a specific number of animals depending on type. For example, a large CAFF would contain 700 or more mature dairy cows or 2,500 swine weighing 55 or more pounds. A major CAFF would confine ten times that number.[17] All large CAFFs are also considered large CAFOs, and the law establishes medium and small categories as well. Medium CAFOs are animal feeding operations that confine the requisite number of animals defined in the Revised Code, and also discharge pollutants into state waters. A small CAFO has fewer animals than a large or medium operation and also discharges pollutants, but it must receive its designation from the ODA director.[18]

These distinctions are important because current state law only requires concentrated animal

[14] Much of the information in this report comes from each CAFF's fact sheet, which provides a summary of the actual permit, which includes the MMP. However, fact sheets lack phosphorus data, so a public records request for this information was sent in July 2016. The ODA response was to send each CAFF's full permit and at the time of writing, the OEC received ODA's final response, but was not able to fully review the information in a timely manner to include in this report.

[15] See Appendix in OAC 901:10-2-10 that provides a conversion chart to help new facilities estimate adequate manure storage capacity for planning purposes

[16] See ORC 903.1(B) and (C).

[17] See ORC 903.1(E), (M) and (N).

[18] See ORC 903.1(Q) and (EE).

feeding ***facilities*** to obtain permits from ODA's Division of Livestock Environmental Permitting which reviews and approves each one to ensure they meet all the requirements in the applicable state regulations.[19] The term of these state permits last five years before they must be renewed, which requires an updated MMP. The thousands of animal feeding ***operations*** in Ohio do not require any ODA permit and instead fall under the agency's Agriculture Pollution Abatement Program administered by the Division of Soil and Water Conservation.[20]

As explained, small and medium CAFOs by definition discharge pollutants into waters of the state, and CAFFs may as well. Any facility or operation that does so must obtain a NPDES Permit from the Ohio Environmental Protection Agency (OEPA). These federal permits are necessary if the facility or operation is, "designed, constructed, operated, or maintained such that a discharge will occur."[21] For example, some egg producing poultry CAFFs have enhanced treatment systems designed to discharge contaminated stormwater. A NPDES permit may be necessary for both CAFFs and CAFOs that have confirmed instances of manure discharge due to a lack of effective "site specific nutrient management practices that ensure appropriate agricultural utilization of the nutrients in the manure, litter, or process wastewater,..."[22] However, of all 231 CAFFs in Ohio, only 28 facilities and just two CAFOs have have NPDES permits. ***It is important to note of all 28 NPDES permits, 7 are expired and 11 more will expire later this year.*** This report does not include the two CAFOs with an expired NPDES permit since they are not under the authority of ODA's Division of Livestock Environmental Permitting.

Since much of this report focuses on the amount of manure that CAFFs must manage, it is important to note how the law defines this term.

> Manure means any of the following wastes used in or resulting from the production of agricultural animals or direct agricultural products such as milk or eggs: animal excreta, discarded products, bedding, process wastewater, process generated waste water, waste feed, silage drainage, and compost products resulting from mortality composting or the composting of animal excreta.[24]

Given the broad definition, this report includes stormwater, process wastewater, mortality compost and other CAFF wastes when using the term "manure", unless otherwise noted. Each CAFF must provide for adequate manure storage to prevent discharges. These include storage ponds, treatment lagoons, or fabricated structures. Facilities store manure until a time is available for the owner or operator to appropriately apply it to land either owned or leased from farmers. CAFF owners or operators can also sell or transfer manure instead of applying to land they control.

Numerous rules govern the use of manure, including specifying the timing and amounts of

[19] See OAC Chapter 901:10-2 Permits; Management Plans
[20] See ORC Chapter 939 and OAC Chapter 901: 13-1
[21] See US EPA 2010 Implementation Guidance on CAFO Regulations – CAFOs That Discharge or Are Proposing to Discharge, EPA-833-R-10-006
[22] See 40 CFR 122.23(e). Agricultural storm water discharges are not subject to NPDES requirements and this section explains if site specific nutrient management practices ensure appropriate utilization of manure or other wastes, then any pollution resulting from application is an agricultural storm water discharge.
[23] See Ohio EPA CAFO NPDES website under "Permits in Ohio."
[24] See ORC 903.1(O).

phosphate applications.[25] These rules are much too complicated for a full discussion here, but one outcome is a system that works to reduce the risk of phosphorus pollution. The rules direct that before any land application of manure, a risk assessment must occur either through the Phosphorus Risk Index or the Phosphorus Soil Risk Assessment. Each seeks to prevent additional manure applications when the Bray-Kurtz P1 soil test phosphorus results show levels at 150 ppm or more.[26] The Phosphorus Soil Risk Assessment also recommends limiting applications on fields with soil test levels between 100-150 ppm to what the planted crop is expected to utilize in a growing season.[27] The recommendations are meant to minimize the risk of phosphorus pollution, but do not explicitly prohibit manure application. For example, the Phosphorus Risk Index incorporates multiple factors to assign a score measuring the overall potential of a field to lose phosphorus.[28] Factors specific to manure include soil test results, manure nutrient content, application rate and method. The tool also incorporates erosion and runoff potential by using variables such as soil types, field slope, and connections to waterways. Fields with high soil phosphorus test results could still have low scores due to these other factors. Many believe manure applications are not appropriate when soil phosphorus levels exceed what is necessary for optimal crop growth (i.e. the agronomic rate of application) regardless of the Phosphorus Risk Index score. The reason is that crops cannot utilize the excess nutrients in a typical growing season, which can result in a buildup of soil phosphorus levels and increase the risk of phosphorus pollution in our rivers, streams, and lakes.

The Tri-State Fertilizer Recommendations for Corn, Soybeans, Wheat and Alfalfa details fertilizer application rates for key nutrients such as phosphorus.[29] Looking at recommendations for corn and soybeans, the dominant crops grown in Ohio, Bray-Kurtz P1 soil test phosphorus levels above 40 ppm are not necessary to achieve optimal yields. In other words, a crop will not grow any better with additional phosphorus input exceeding 40 ppm. Even wheat and alfalfa do not need levels above 50 ppm. Additionally, these recommendations established in 1995 are being revised, and many expect lower numbers in future updates. In fact, CAFF inspection reports obtained during this project included notations such as the following statement:

> Target soil test levels should be maintained as close to agronomic sufficiency levels as possible, which is 15-30 ppm or 30-60 lbs./acre for corn and soybeans and 25-40 ppm or 50-80 lbs./acre for wheat and alfalfa. This allows for multiple year nutrient application and the buildup/drawdown of nutrients without causing deficiencies or increasing environmental risks.[30]

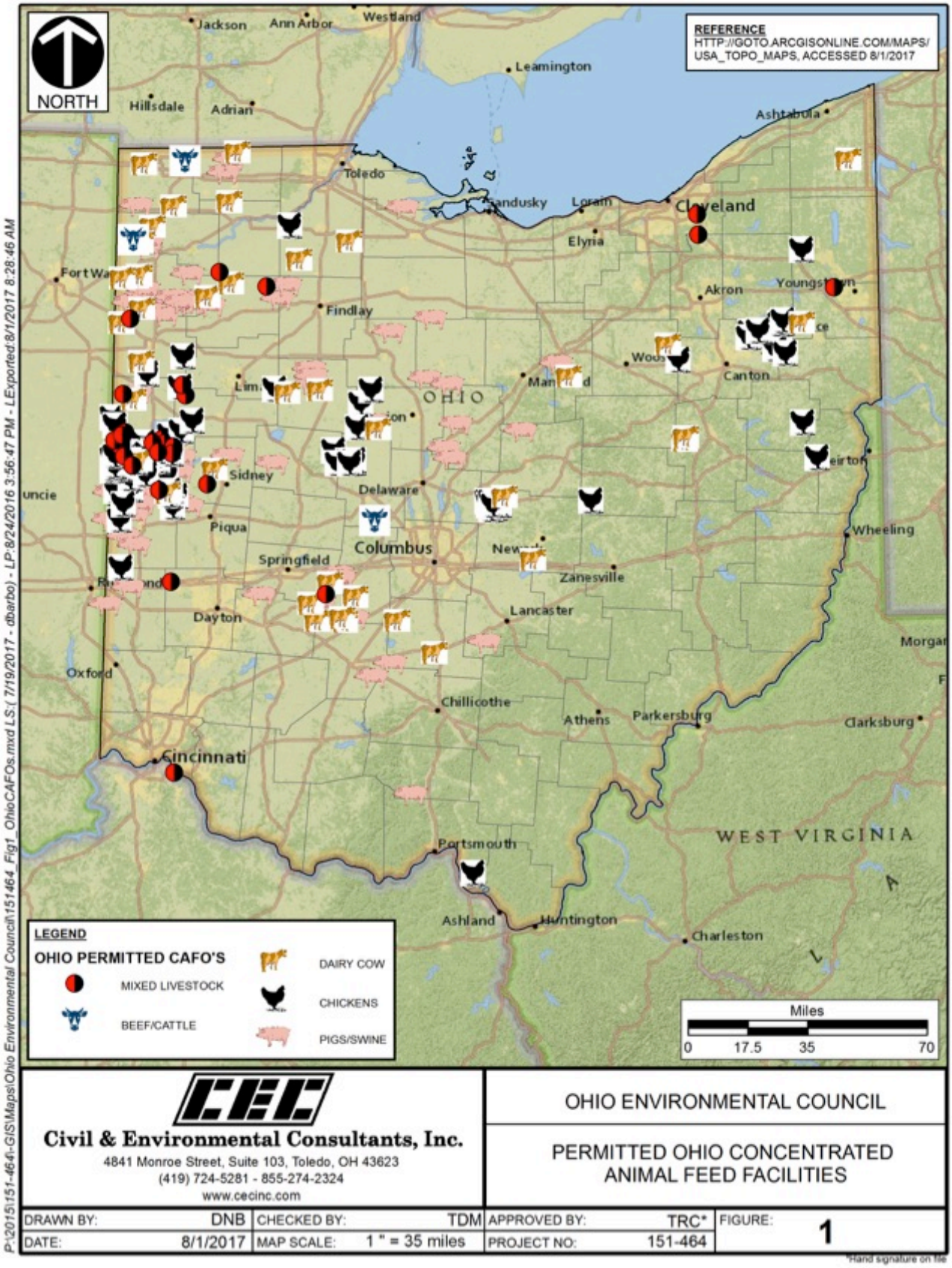
To be clear, the livestock rules and guidelines are meant to ensure a thriving livestock industry that does not create excessive environmental hazards, but they still allow phosphate applications above what is agronomically necessary.

[25] See OAC. 901: 10-2-14 (E),(G) and Appendix A (7)
[26] See number 7 in Appendix A to rule 901:10-2-14: How to Use the Appendices to this Rule, which refers to the use of the Phosphorus Risk Index found in Appendix E Table 1 to Rule 901:10-2-14: Phosphorus Index (P Index) Risk Assessment Procedure.
[27] See Appendix E Table 2 of Rule 901:10-2-14: Phosphorus Soil Test Risk Assessment Procedure
[28] Appendix E Table 1 to Rule 901:10-2-14: Phosphorus Index (P Index) Risk Assessment Procedure
[29] See Bulletin E2567
[30] See Catalpadale/Bristol Dairies April, 2016 Inspection Report reminder actions by inspector Samuel Mullins.

Farmers have long used manure as a replacement or as a supplement to commercial inorganic fertilizers. Many CAFF owners, if they have cropland at all, do not own enough acres to appropriately apply all their manure even though the regulations allow applications that exceed the agronomic rate. As a consequence, many CAFF owners or operators sell or transfer the excess manure to other farmers through a legal mechanism called the distribution and utilization method of manure management (D&U). When the manure leaves the control of the CAFF, the owner or operator is no longer legally liable for its use. In fact, Ohio has an entire industry where livestock manure brokers, applicators, and certified livestock managers help arrange the sale, transportation, and application of a CAFF's excess manure. The economics of transportation typically limits how far liquid manure can travel before it becomes cost prohibitive, but solid manure is easier and cheaper to move, and has a much larger transportation radius.[31]

The law requires anyone who applies manure from a CAFF to have either certification as a fertilizer applicator or a livestock manager (CLM). The former must complete a two hour training course if they have pesticide applicator certification or a three hour course if they do not.[32] Certified Livestock Managers must complete a two-day training session, which is required for anyone who handles more than 4,500 dry tons of manure or 25 million gallons of liquid manure in a year. The goal is that these certifications will help prevent or reduce pollution risks. However, there is little public reporting of manure applications completed through D&U by CLMs, though ODA does review their operation records during inspections. Presumably they also follow guidelines that allow for applications that exceed the agronomic rate. Some CAFF records include estimates of the amount of manure and nutrients managed through D&U, but there is no reporting requirement for the location of these manure applications or corresponding soil phosphorus test results. While some of this information may be in operation records kept on site at the CAFF or by the certified livestock manager, these records are not available in publicly available inspection or annual reports. As such there is no way to track manure applications completed through D&U. This is an important data gap because many efforts to determine the extent that manure may increase the risk of phosphorus pollution cannot account for manure being moved into or outside watersheds, or even between Ohio's neighboring states - Michigan and Indiana. To put this in perspective, between 2010-2015, permitted facilities in the Grand Lake St. Marys watershed exported over nine million pounds of phosphate, with no public reporting of where or how the manure was utilized.[33]

[31] See this article for a discussion on manure transportation costs.
[32] See https://nutrienteducation.osu.edu/FertilizerCertification
[33] Based on a spreadsheet provided via email from ODA's DLEP Chief Kevin Elder, dated March 4, 2016



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OHIO ENVIRONMENTAL COUNCIL

PERMITTED OHIO CONCENTRATED ANIMAL FEED FACILITIES

DRAWN BY:	DNB	CHECKED BY:	TDM	APPROVED BY:	TRC*	FIGURE:	1
DATE:	8/1/2017	MAP SCALE:	1 " = 35 miles	PROJECT NO:	151-464		

*Hand signature on file

Project Results and Discussion - Ohio

The charts and graphs below show information for all 231 CAFFs in Ohio and Appendix B includes detailed spreadsheets with individual data for each CAFF with an ODA permit.

Table 1. Total Number of Permitted Livestock in Ohio as of January 2017 Based on Fact Sheets

Livestock Type	Number of Livestock
Beef Cattle	16,220
Dairy Cow	113,630
Poultry	66,404,189
Swine	450,897
Horse	4,211
Total Livestock	66,989,147

Table 2. Total Number of Permitted Livestock Facilities in Ohio as of January 2017

Livestock Type	Number of Facilities
Beef Cattle	3
Dairy Cow	41
Poultry	92
Swine	68
Horse	4
Multiple	23
Total	231

Of Ohio's 231 permitted CAFFs, 23 raise two types of animals. Separating the amounts of manure from the different livestock is difficult because the fact sheets only report the total amount of manure all the animals generate. The fact sheets do not separate amounts between the two types of livestock. Therefore, this report uses a "multiple" livestock type for these CAFFs.

Ohio CAFF Manure Production

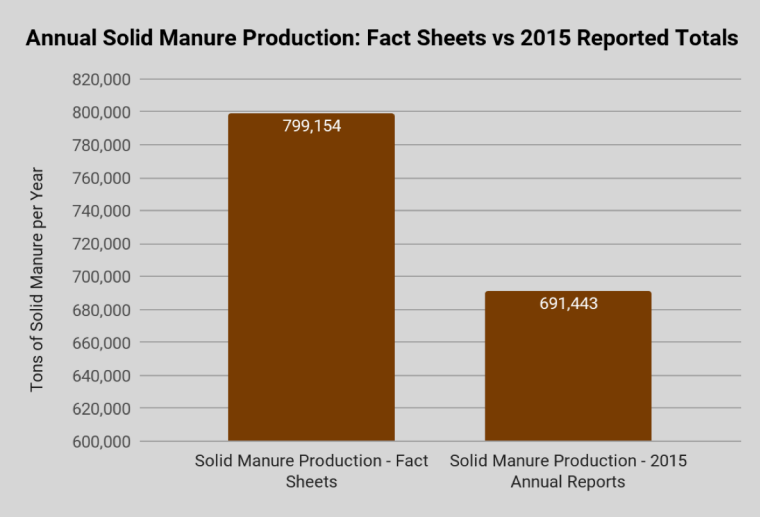
Table 3. Annual Manure Production Estimated in ODA DLEP Fact Sheets, Reported in 2015 Annual Reports and Calculated using the OAC Appendix

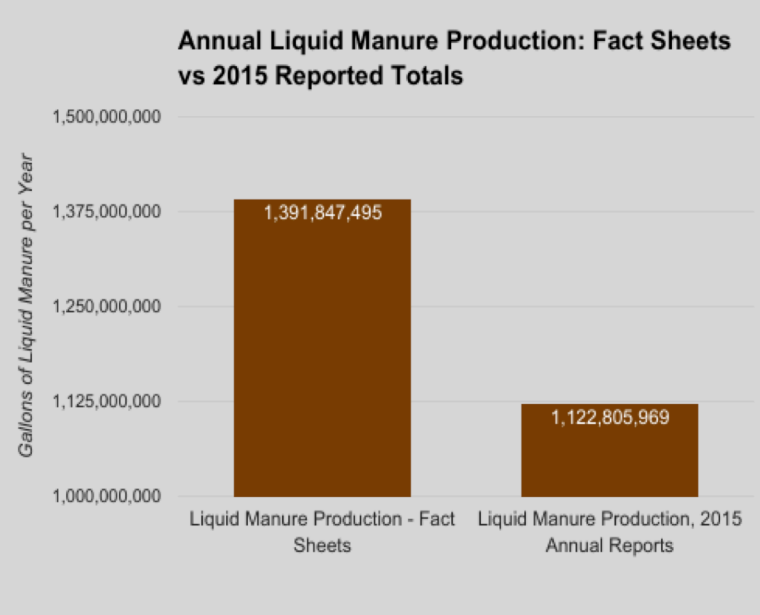
Livestock Type	Solid Manure Produced - Fact Sheets (tons)	Liquid Manure Produced - Fact Sheets (gal.)	Solid Manure Produced - 2015 Reported (tons)	Liquid Manure Produced - 2015 Reported (gal.)	Manure Produced - Calculated (gal.)
Beef Cattle	38,740	14,500,000	8,280	6,549,000	19,878,163
Dairy Cow	125,428	1,091,872,996	118,508	838,702,611	613,364,599
Poultry	639,623	183,621,299	496,417	80,158,033	358,644,401
Swine	1,885	252,188,581	15,962	172,786,861	121,462,835
Horse	52,685	0	9,006	0	10,298,001
Multiple	40,950	37,600,197	43,270	24,609,464	78,185,378
Total	899,310	1,579,783,073	691,443	1,122,805,969	1,201,833,376

To put these vast numbers into something a bit more relatable, the total manure summed from the fact sheets would fill the entire Ohio State University football stadium more than two times over (2.3 to be exact).[34]

Chart 1 compares manure production specified in the fact sheets with the 2015 Annual Reports. The latter does not include data from 37 facilities where the information was not available due to missing reports, illegible numbers, reports that were not yet required to be filed, were empty, not constructed or in operation, or facilities that received a permit after 2015. To be clear, the chart only compares information from fact sheets of the 194 permitted facilities where annual reports were also available in an attempt to compare actual manure production with what all the CAFFs could potentially generate at maximum stocking levels.

Chart 1. Comparison of Annual Solid & Liquid Manure





[34] Fact sheets include the amount of manure each CAFF is designed to produce and listed in its permit.

All the 2015 reported manure amounts are less than the totals from each CAFF's fact sheet, but this is especially the case for liquid manure. Solid manure reported in 2015 is 13.5 % less and liquid manure reported in 2015 is 19.3 % less than their respective permitted amounts. This is not surprising given that the fact sheets summarize each CAFF's MMP, which typically assumes the CAFF to be at maximum stocking level and production. Therefore, the annual reports may better reflect the actual manure production in a given year, but their information is variable due to changes in stocking levels and year-to-year changes in operations. For example, some CAFFs were empty in 2015, and others changed ownership or title. This highlights the year-to-year variability in manure production and likely application, further demonstrating the need for better reporting mechanisms. Annual reports also lack basic information, such as the official name of the CAFF. Some reports were handwritten and illegible, raising questions if all manure amounts were properly recorded. Therefore even a multi-year average of annual reports may not provide a more accurate measure of a CAFF's manure production than a single year or amounts determined through other methods.

Manure Utilization and Available Cropland

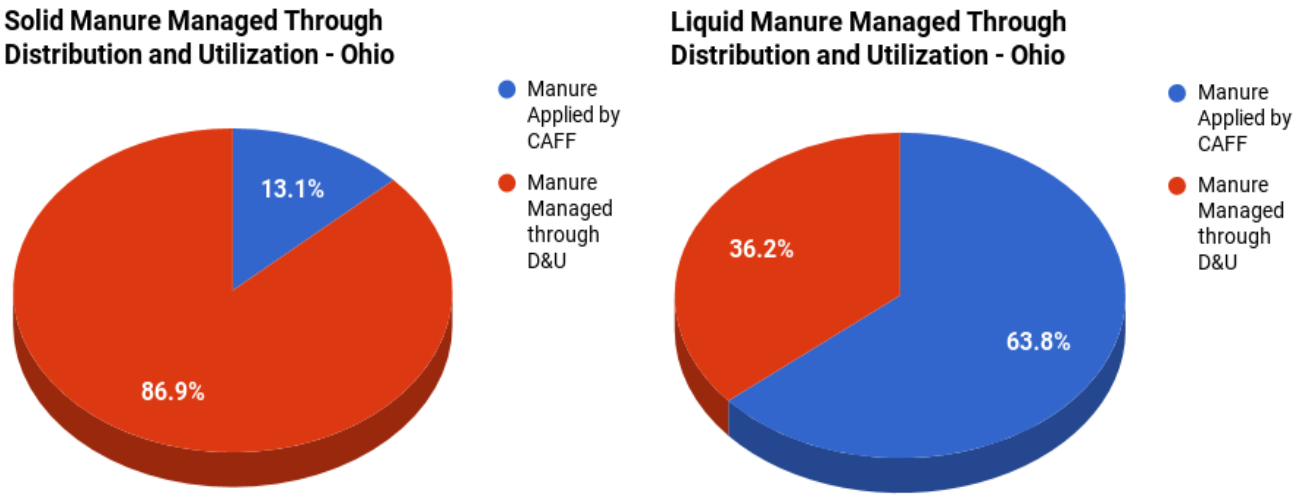
Often CAFFs produce more manure than can be applied at agronomic rates on the acres owned or leased from nearby farmers, even with rules that allow phosphorus application to soils already oversaturated with phosphorus - levels up to 150 ppm. Because so many CAFFs produce more manure than they themselves can utilize, many owners or operators elect to use D&U to transfer their excess waste. Unfortunately, not all fact sheets specify the amount of manure managed through D&U or applied by the CAFF. Some fact sheets only provide a general reference, while others entirely omit this information. Also, cases exist where the CAFF owner or operator adopted D&U after receiving an ODA permit, so the information would not be in the fact sheet or even in the CAFF's MMP. It is important to remember the MMPs are five-year plans and changes in operations, such as increase in D&U, do not necessarily require permit modifications. All this is to say that the numbers, again, are not precise so the amounts applied by the CAFF owners or operators and the amounts distributed do not always equal the total amounts found in Table 4. The amounts of manure managed through D&U can change from year-to-year and these numbers show some interesting trends. Specifically, the vast majority of poultry manure and nearly half of the dairy manure is managed through D&U, but most swine CAFF owners or operators apply their manure to acres they control. Each CAFF's annual report includes a section for reporting the distance the manure may travel if managed via D&U, however this information was often left blank. Looking at a five year average (2011-2015) from all the annual reports showed solid manure travel distances to be so variable that any reliable trend was indiscernible. Average distances ranged from 3 - 400 miles with many CAFFs reporting a 50 mile average. Liquid manure has a

much shorter travel distance than solid manure, typically between 4.5 - 5 miles. This begs the question regarding the amount of available cropland for manure applications. Does enough exist within this range? Here one must look to the inspection reports that include a section for manure managed through D&U. These reports must verify that applications are performed by a certified livestock manager or a certified fertilizer applicator. Some inspection reports list the amounts of manure applied and even the label of receiving fields, but not the precise location or if other CAFFs utilize the same fields. Few reports included any soil phosphorus information. Therefore, even inspection reports lack enough information to determine if manure applications exceeded even the 150 ppm threshold established in state rules.

Table 4. Manure Utilization: Annual Amounts Applied by CAFF vs. Distributed

Livestock Type	Applied by CAFF - Solid (tons)	Distributed - Solid (tons)	Applied by CAFF - Liquid (gal.)	Distributed - Liquid (gal.)
Beef Cattle	25,223	13,517	14,500,000	0
Dairy Cow	73,784	44,759	533,426,329	496,146,667
Poultry	2,650	636,972	179,111,966	4,509,333
Swine	1,313	417	205,805,675	39,206,906
Horse	0	52,685	0	0
Multiple	13,684	27,245	30,004,593	6,767,604
Total	116,655	775,596	962,848,563	546,630,510

Chart 2. Proportions of Solid and Liquid Manure Managed Through Distribution and Utilization



Fact sheets often list the general amount of cropland available for manure application, either owned by the CAFF or leased from nearby farmers. Unfortunately, determining the precise acreage is difficult due to variability in how often a CAFF leases additional land or find other acres

for application. Soils tests may also reach or exceed 150 ppm, necessitating that a CAFF find alternative acres. Because of this variability and uncertainty, the total cropland listed in the fact sheets and actual acres in the MMP represents an estimate at the time the ODA DLEP issues a permit. Therefore, this report uses information provided in each CAFF's most recent inspection report except when unavailable. In those instances, the analysis uses acres from the fact sheets. Due to data ambiguities and incomplete records, it was not possible to separate acres into those owned, leased, or when applications occurred through D&U.

Table 5. Total Reported Cropland Available for Manure Application

Livestock Type	Total Available Cropland Acres
Beef Cattle	3,194
Dairy Cow	188,247
Poultry	10,046
Swine	53,664
Horse	0
Multiple	25,435
Total	280,586

Since most CAFFs rely on the D&U method of manure management, it is not possible to conclude if there is enough cropland available for proper utilization except on a case-by-case basis for the cropland under the control of the CAFF owner or operator. Ultimately, determining trends for the possible over-application of manure requires more information about phosphorus production, application rates, soil test results and other factors.

Phosphate Production and Applications

Phosphorus is an element that soil tests measure, but it must be bound to oxygen in order for crops to utilize it as a nutrient. In this form it is called phosphate, and specifically, P_2O_5. To determine the amounts of phosphate CAFFs produce annually, two methods are available: 1) use the OAC Appendix to calculate the pounds of P_2O_5 each animal produces per day and multiply that by 365 days[35] (Table 6 shows these calculated amounts); and, 2) total the P_2O_5 each CAFF applies to cropland it controls with how much sold or transferred. With some exceptions, each MMP includes these numbers. Unfortunately, during the time of this report's writing, the OEC had not received ODA's final response to its July 2016 records request, so a full review of each MMP to determine the amount of phosphate each CAFF produced was not possible. Therefore, this report only includes the total phosphate estimates in the manure management plans for those CAFFs in the WLEW. See Table 12. A full comparison of the calculated amounts and the totals from the MMPs is in the corresponding section below. However, this comparison shows significant discrepancies between the two methods where, except for poultry, all the phosphorus amounts in

[35] This is the Appendix to rules 901:10-2-04 and 901:10-2-10

[36] The OAC Appendix explains, "The actual characteristics of manure for individual situations can vary ±30% or more from table values due to genetics, dietary options and variations in feed nutrient concentration, animal performance, and individual farm management."

the MMPs were well below the calculated values. This suggests either the OAC Appendix is grossly inaccurate or the manure management plan estimates have significant flaws in their estimates. An example from the MSB Dairy CAFF suggests it could be either or both. Here the annual production listed in the manure management plan is 66,002 pounds of phosphate for 2,960 cows, but the OAC Appendix calculates the amount would be 501,846 pounds, a 435,844 pound difference. While the OAC Appendix provides the caveat that as-excreted amounts do not include any treatment, an 87 percent overestimation is far beyond the stated 30 percent variation.[36] As such, a case-by-case comparison would be necessary to determine the frequency of such discrepancies, but certainly the manure management plans cannot be considered 100 percent reliable.

Table 6. Ohio CAFF Annual Calculated Phosphate Production

Livestock Type	Phosphate (P_2O_5) As-Excreted (lbs)
Beef Cattle	360,386
Dairy Cow	16,173,661
Poultry	17,138,019
Swine	4,189,550
Horse	230,552
Multiple	2,334,544
Total	40,426,714

Project Results – Western Lake Erie Watershed

Given the recent concerns and questions about the role manure plays in causing Lake Erie's toxic algae, this project focused more closely on the 65 facilities throughout Ohio's portion of the western Lake Erie watershed (WLEW). This report includes the Sandusky watershed in this area.

Table 7. Western Lake Erie Watershed (Ohio) - Total Number of Livestock Housed in CAFFs as of January, 2017

Livestock Type	Number of Livestock
Beef Cattle	7,500
Dairy Cow	44,734
Poultry	13,268,366
Swine	171,301
Horse	0
Total Livestock	13,491,901

Table 8. Western Lake Erie Watershed (Ohio) - Number of CAFFs as of January, 2017

Livestock Type	Number of Facilities
Beef Cattle	2
Dairy Cow	20
Poultry	10
Swine	28
Horse	0
Multiple	4
Total	64

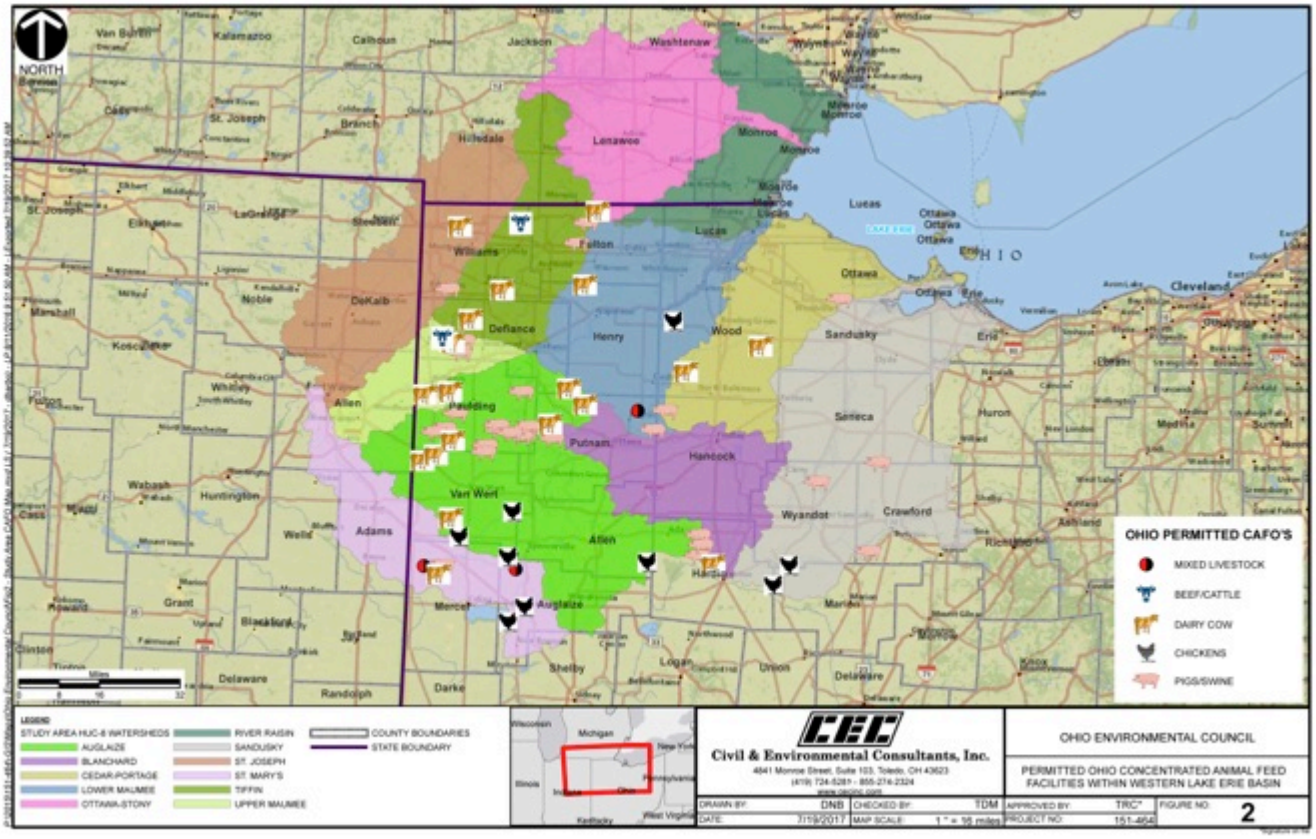


Table 9. Western Lake Erie Watershed (Ohio) Facilities - Annual Manure Production Estimated in Fact Sheets, Reported in 2015 and Calculated with the OAC Appendix

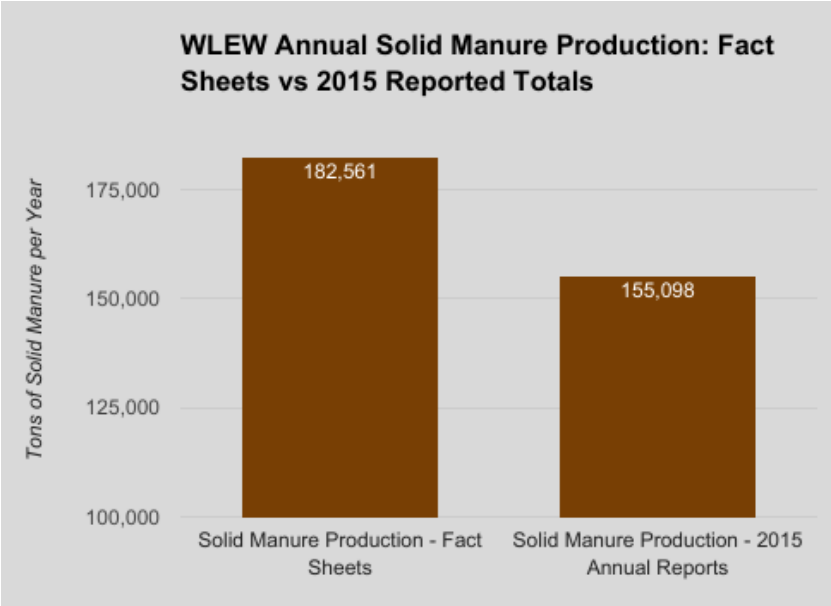
Livestock Type	Solid Manure Produced - Fact Sheets (tons)	Liquid Manure Produced - Fact Sheets (gal.)	Solid Manure Produced - 2015 Reported (tons)	Liquid Manure Produced - 2015 Reported (gal.)	Manure Produced - Calculated (gal.)
Beef Cattle	13,517	8,500,000	434	6,549,000	15,609,298
Dairy Cow	56,424	515,970,000	65,236	416,001,727	283,538,511
Poultry	140,753	14,650,000	81,078	13,952,015	75,324,766
Swine	856	108,262,159	70	75,934,127	47,276,450
Multiple	3,548	10,648,346	434	7,572,889	10,594,220
Total	215,098	658,030,505	155,098	520,009,758	432,343,244

To put these vast numbers into something a bit more relatable, the total manure summed from the fact sheets exceeds the daily amount fecal waste produced by of all the people in the entire metro areas of Los Angeles, Chicago, Dallas and Cincinnati combined.

As a reminder, the calculated manure amounts do not include all the waste these CAFFs produce such as contaminated stormwater, process wastewater, mortality compost, bedding, etc. The fact sheet is an estimate for the manure produced based on the maximum number of livestock the

CAFF is permitted to manage, often based on actual operating records for those currently in existence. The 2015 Annual Reports show the total manure produced that year, which often is less than the fact sheet numbers because the CAFF was not fully stocked to maximum capacity. It is important to note, not all fact sheets include a full inventory of all the waste products, and the annual reports were often incomplete, so it is unclear if those facilities reported all their waste as well. In short, the reported and calculated manure production values show partial figures and estimates and cannot be considered accurate measures.

Chart 3. Comparison of Annual Solid & Liquid Manure Production for Western Lake Erie Watershed (Ohio) Facilities



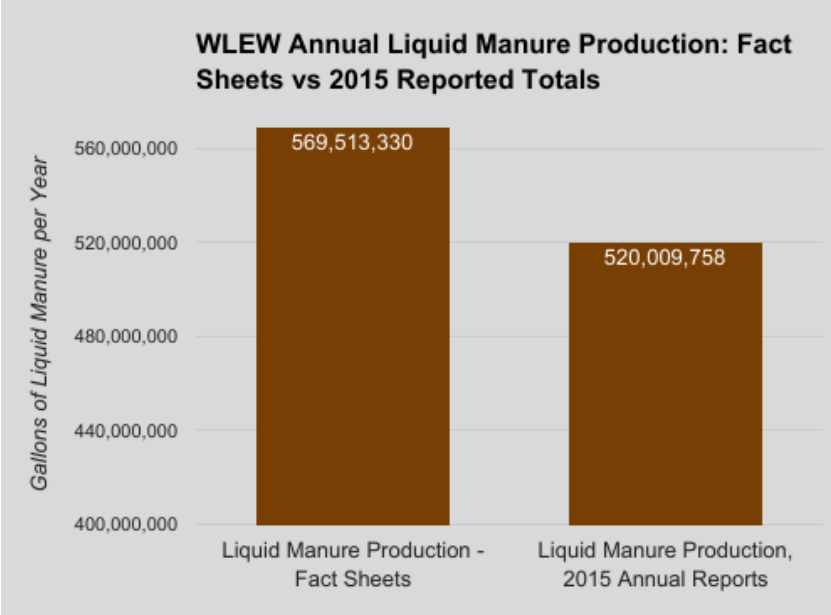


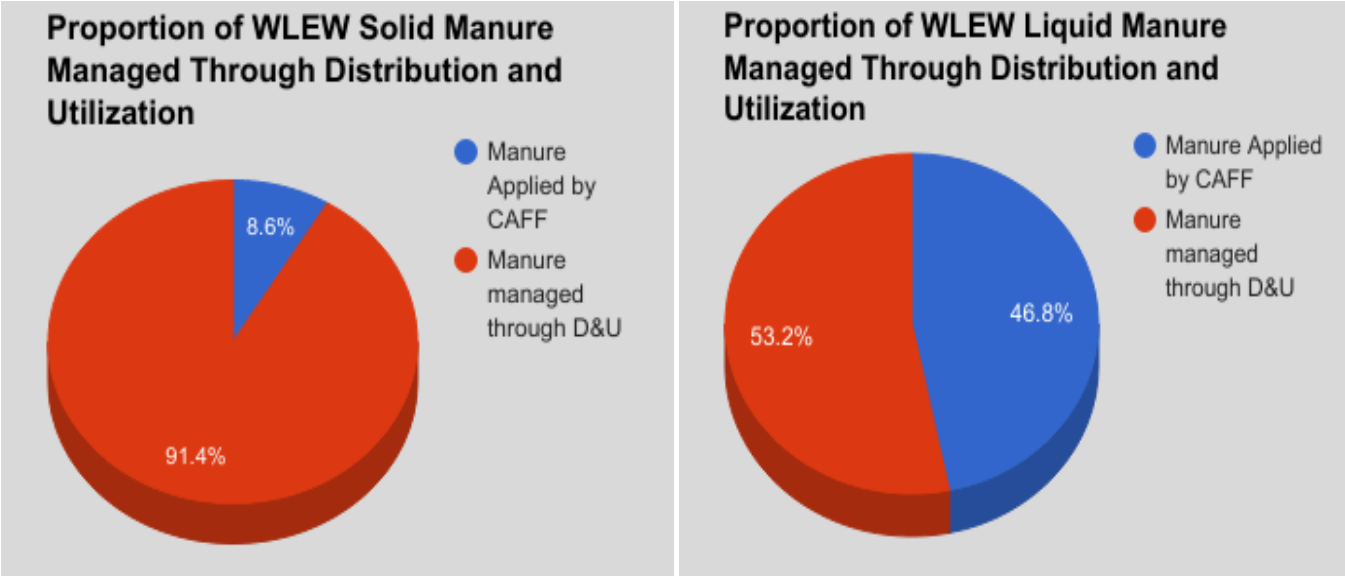
Chart 3 shows amounts of solid manure listed in the fact sheets are 15% higher compared with the 2015 Annual Reports, which is slightly higher for all CAFFs statewide where amounts reported in the fact sheets were 13.5% higher. However, for liquid manure the difference was much smaller

at 8.9% for CAFFs in the WLEW compared with the statewide difference of 19.3%. Given the greater number of dairy and swine operations that primarily use liquid manure management systems, this suggests the annual reports are closer to amounts listed in the fact sheets when compared to the state as a whole.

Table 10. Manure Utilization in the Western Lake Erie Watershed (Ohio): Annual Amounts Applied by CAFF vs. Distributed

Livestock Type	Applied by CAFF - Solid (tons)	Distributed - Solid (tons)	Applied by CAFF - Liquid (gal.)	Distributed - Liquid (gal.)
Beef Cattle	0	13,517	8,500,000	0
Dairy Cow	15,483	37,891	163,163,333	292,906,667
Poultry	1,735	139,018	14,650,000	0
Swine	312	389	90,924,659	10,161,500
Multiple	631	2,917	6,651,942	3,996,404
Total	18,162	193,732	283,889,934	307,064,571

Chart 4. Proportions of Solid and Liquid Manure Managed Through Distribution and Utilization in the Western Lake Erie Watershed (Ohio)



Facilities in the Ohio WLEW rely more on D&U compared to CAFFs statewide, significantly so for liquid manure. Considering the average travel distance is only 5 miles for liquid, much of it likely stays in the local watershed. Interestingly, all of Ohio's dairy facilities manage liquid manure through D&U at a 45% rate, which is lower compared to just those in the WLEW at 52%.

Available Cropland – Western Lake Erie Watershed (Ohio)

With such a reliance on D&U in the WLEW for both liquid and solid manure applications, knowing the available cropland is crucial for determining the potential for excess application. As was the case for all facilities, very few reported "other" acres as D&U, yet when evaluating each CAFF's MMP, 42 out 65 included estimated pounds of phosphate for distribution.[37] While D&U acres may be unreported, especially for solid manure from poultry facilities, it is still useful to look at average manure application rate with the available cropland.

Table 11. Western Lake Erie Watershed (Ohio) CAFFs - Total Cropland Available for Manure Application & Averaged Application Rates Based on Fact Sheet Totals [38]

CAFF Type	Total available acres	Total Solid Manure (tons)	Solid application (ton/acre)	Total Liquid Manure (gal.)	Liquid application gal/acre
Beef Cattle	2,668	13,517	5	8,500,000	3,186
Dairy Cow	61,312	55,515	0.9	500,070,000	8,156
Poultry	2,036	140,753	69.1	14,650,000	6,804
Swine	22,020	856	0.04	108,262,159	4,917
Multiple	3,930	3,548	0.9	10,648,346	2,710
Total	93,692	215,098	2.4	642,130,505	6,973

These numbers illustrate how much manure ***could*** be applied to acres available to each type of CAFF, but without knowing the phosphorus content in the manure and the soil phosphorus levels, it is unclear if these are excess applications. Furthermore, it was not possible to discern the amount of total acres that received manure applications through D&U, so the average application rates are likely inaccurate. A more informative approach would be to evaluate the actual phosphorus applications while comparing them to the soil phosphorus levels.

Western Lake Erie Watershed (Ohio) Phosphorus Generation and Applications

Each CAFF's MMP details most aspects of each CAFF's operations including manure nutrient content, and the pounds of phosphorus applied by the CAFF's owner or operator and the amount managed through D&U. Added together these amounts provide an estimate of the CAFF's overall phosphorus production. See Table 12 comparing calculated pounds of phosphorus produced by each CAFF with the amounts listed in each MMP.

[37] Three of the MMPs did not have nutrient budget sheets in their plans so the phosphorus applied and distributed is not included for these CAFFs.
[38] ODA notes the per acre application rate for poultry is not likely. Given the reliance on D&U for poultry manure applications, the OEC agrees.

Table 12. Western Lake Erie Watershed (Ohio) CAFFs - Phosphate (P_2O_5) Calculated with the OAC Appendix vs Pounds listed in Manure Management Plans

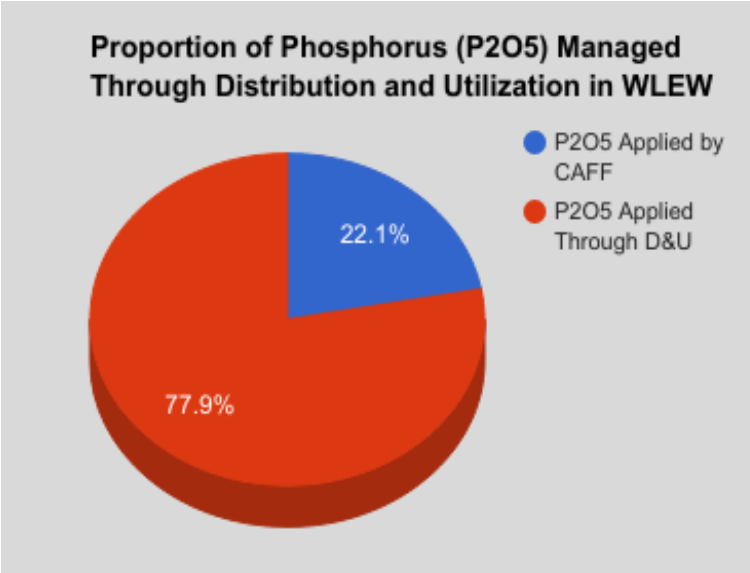
CAFF Type	P_2O_5 calculated (lbs)	P_2O_5 applied by CAFF - MMP (lbs/yr)	P_2O_5 managed through D&U - MMP (lbs/yr)	Total P_2O_5 applied - MMP (lbs/yr)	Difference between P_2O_5 amounts in MMPs and calculated (%)
Beef Cattle	289,956	41,606	95,427	137,033	52.7%
Dairy Cow	7,535,788	1,631,906	1,800,520	3,432,426	54.4%
Poultry	3,544,695	85,439	7,140,095	7,225,534	103.8%
Swine	1,652,972	817,601	261,934	1,079,535	34.7%
Multiple	384,133	120,989	224,665	345,654	10.0%
Total	13,407,544	2,697,541	9,522,641	12,220,182	8.9%

Table 12 helps illustrate how close the calculated phosphate amounts are in comparison to the applied amounts listed in each MMP. Comparing the second column with the fifth, there is an 8.9 percent difference overall, suggesting the calculated values may be fairly close to what is shown in the MMPs. However, that is only because pounds calculated for poultry was vastly under MMPs estimates. Only the multiple facilities were within the OAC Appendix's 30% margin of error, with a 10% difference.[39] Upon closer inspection the differences are much greater for dairy cows and beef cattle with a 52.7% and 54.5% difference respectively. This suggests either the MMPs contain inaccurate estimates or the OAC Appendix may be an extremely poor phosphorus generation. The large discrepancy in poultry manure could be due to the fact that moisture values drop significantly from the as-excreted amount to the time of application, starting at 78 percent moisture and dropping to 30 percent, sometimes 15 percent by the time of application. While the OAC Appendix certainly needs reevaluation to improve its accuracy, estimates in the MMP also need verification.

[39] The appendix to OAC 901:10-2-10 explains, "The actual characteristics of manure for individual situations can vary ±30% or more from table values due to genetics, dietary options and variations in feed nutrient concentration, animal performance, and individual farm management."

Table 12 also shows nearly 78% of the phosphorus estimated in the MMPs is managed through D&U. Correlating this amount with liquid manure managed through D&U, it is likely 53% of this phosphate gets applied within five miles of each CAFF. This may lead to over applications of manure to cropland in these areas, especially if they also receive manure from nearby AFOs that do not have a permit.

Chart 5. Proportion of Phosphate Managed Through Distribution and Utilization in Western Lake Erie Watershed (Ohio)



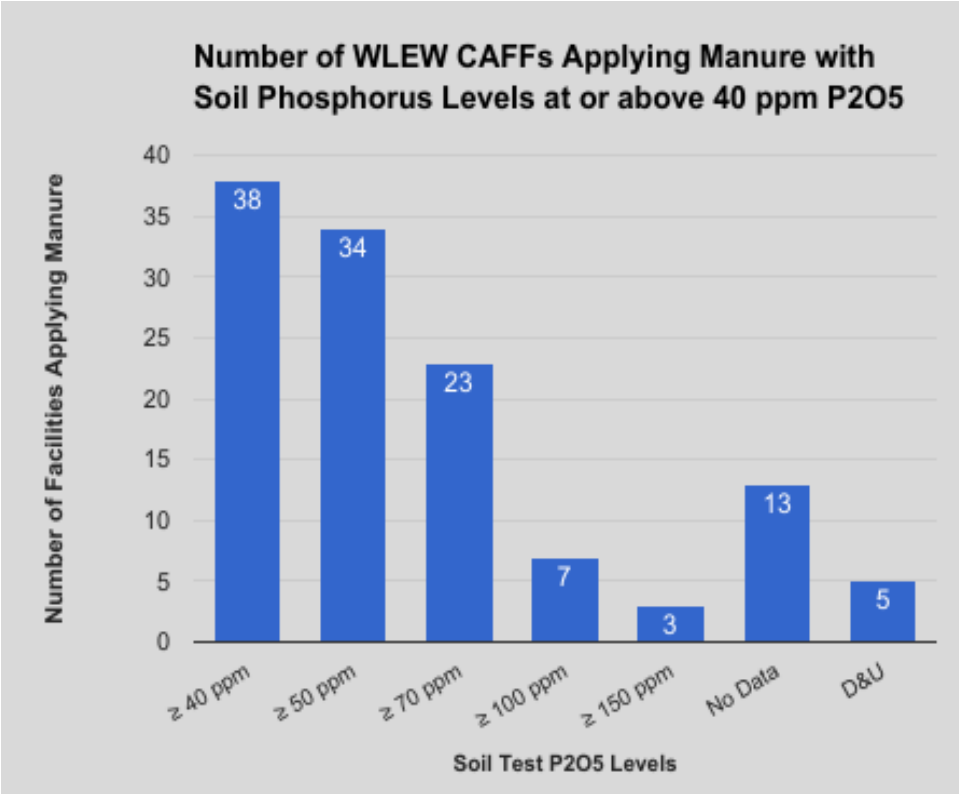
WLEW CAFF Phosphate Applications

Given the wide discrepancies between the calculated amounts and those estimated in the MMPs, it is even more important to evaluate actual phosphate applications. Ultimately, the best assessment of phosphate applications is to evaluate the data from each CAFF's inspection report. Many show the most recent soil test phosphorus results, dates of application and, in some cases, the actual pounds of phosphorus applied. A careful analysis of all these records provides some insights into the amounts of phosphate CAFFs produce as well as actual applications. However, only some inspection reports provided this information in formats that allowed for confident analysis, many more reports lacked adequate detail or clarity.[40] Therefore, this level of analysis is reserved for just those facilities in the WLEW. Chart 6 below shows the number of CAFFs that applied manure with soil phosphorus levels between 40 ppm to 150 ppm or higher.
It is important to note, even when the inspection reports include the pounds of phosphate applied to specific fields, these amounts were based on manure nutrient content analysis completed by each CAFF. Depending on sampling methods, these nutrient values have varying degrees of accuracy.[41]

[40] Some inspection reports provide tables listing soil phosphorus levels at the time of application and pounds of phosphorus applied. However, many inspection reports omit this information and others use different formats requiring much further analysis to determine soil phosphorus levels and application rates that is beyond the scope of this report.
[41] Dou Z1, Galligan DT, Allshouse RD, Toth JD, Ramberg CF Jr, Ferguson JD.Manure sampling for nutrient analysis: variability and sampling efficacy. J Environ Qual. 2001 Jul-Aug;30(4):1432-7.

Additionally, CAFFs apply manure to multiple fields under their control that have varying soil phosphorus levels. Regulations only require soil tests every three years, and then with just one sample for every 25 acres. Inspection reports show individual fields with a range of phosphorus levels so manure applications can occur on one field with 41 ppm and a different field with 79 ppm. Therefore, Chart 6 may show the same CAFF applying manure with soil test phosphorus (STP) at both 50 ppm and 70 ppm. In other words, CAFFs in Chart 6 can be counted multiple times depending on the soil phosphorus levels. For example, a CAFF could have one field measuring 43 ppm, another with 57 ppm and still another at 88 ppm. In this scenario, the same CAFF would be counted three times in different columns.

Chart 6. Western Lake Erie Watershed (Ohio) CAFFs Applying Manure with Soil Phosphorus Levels at or above 40 ppm



Of the 64 CAFFs in the WLEW, data were only available for 46 facilities for a variety of reasons.[42] Three of these CAFFs did not specify their application rates, so the inspection reports only show 43 CAFFs since these have verified manure applications along with specified soil test phosphorus levels. ***Looking at Chart 6, it is clear most CAFFs apply manure to at least one or more of their fields when soil test phosphorus results show sufficient levels for optimal crop yields.***[43] The critical maintenance soil phosphorus level for optimal corn or soybean production is 40 ppm, and 38 facilities applied manure with levels at or above this amount. At 50 ppm, which is the critical

[42] Either the CAFF was recently permitted so no reports were available at the time of this project's review, or the soil phosphorus levels were not specified in the report. Five CAFFs manage all their manure through D&U so there is no soil test data provided.
[43] Based on the Tri-State Fertilizer Recommendations, inspection reports did not specify the phosphate application rates for three CAFFs, so it is unclear if those fields received manure applications.

level for wheat and alfalfa, 34 facilities applied manure. Even when soil phosphorus levels were at 70 ppm, 23 facilities applied manure. Not until levels were at 100 ppm did the number of facilities applying manure drop to single digits. It is important to note, three CAFFs not shown in the graph omitted phosphate application rates in their inspection reports, so it was unclear if there was an actual manure application. Each had soil levels above 40 ppm of which one was above 150 ppm. Certainly, CAFF owners or operators applied manure to fields with soil test phosphorus levels less than 40 ppm, but the inspection reports showed only five CAFFs had soil test phosphorus results below 40 ppm for all fields receiving manure applications.

Table 13. Percent of WLEW CAFFs Applying Manure with Soil Test Phosphorus (STP) at or above 40 ppm [44]

Soil Test P_2O_5 Results (ppm)	Percent of Facilities Applying Manure
STP ≥ 40	88%
STP ≥ 50	77%
STP ≥ 70	53%
STP ≥ 100	16%
STP ≥ 150	7%

Table 14 shows 88% of CAFFs in the WLEW apply manure when soil test phosphorus levels are 40 ppm or more, and 53% apply manure when levels are at 70 ppm or more. This demonstrates CAFFs routinely apply manure when there is no agronomic need for phosphate applications, though there may be a need to reduce the amount of manure in the CAFF's storage system. When looking at the amounts of phosphate applied to specific fields, the data are so variable that identifying specific trends is not possible. For example, on the lower end reports show phosphate application rates of just 5 - 10 pounds per acre or less but, on the higher end those rates jump to 200 - 325 pounds per acre.[45] If manure applications completed under D&U follow this trend, it represents a significant risk of excess application since 52% of liquid manure applications and 91% of solid manure applications are done through D&U. Even more concerning are the number of unpermitted AFOs in the watershed that may be following this same trend.

[44] Many CAFFs have multiple fields with soil phosphorus levels at or above 40 ppm P_2O_5, which is why the total percent exceeds one hundred. These percents are for those facilities reporting applications.
[45] It is important to note the OAC places does not recommend phosphate application between 250 - 500 lbs/acre and have specific conditions that must be met in such instances. See OAC 901.10-2-14(E)(3)

Main Findings

Evaluating manure and phosphorus production, as well as utilization, was a massive undertaking, complicated by delays in obtaining public records, the lack of consistent reporting formats, incomplete records and the obscurity regarding manure managed through the distribution and utilization method of manure management. Even with these challenges, an in-depth review of the records provides some insights into Ohio's livestock industry.

Overall, Ohio's 231 concentrated animal feeding facilities produce vast quantities of manure and phosphate, but determining exact numbers with existing records is nearly impossible. Quantities provided in the manure management plans use estimates from previous records and are only updated when the CAFF renews its permit every five years. The OAC Appendix provided in state regulations significantly underestimates the amount of phosphate production for poultry facilities and exceeds the 30% range of variability for other types of livestock compared to amounts in the MMPs. Since these conversions only account for manure each animal produces, they cannot account for all the waste these facilities manage as defined in the regulations. However, the MMP estimates could be flawed as well. Ultimately, the best method for tracking manure and phosphorus production may be through annual reports, but they would require validation and need to include significantly more information.

Many CAFFs in the state rely heavily on the D&U method of manure management, which is not necessarily a problem if applications adhere to agronomic rates, and there is better oversight of the practice. As it stands, once the manure leaves the control of the CAFF owner or operator, its use and any resulting pollution that may occur is not considered their responsibility. Some manure applicators, especially certified livestock managers, keep operation records, but the specific details are not part of a CAFF's reporting requirements. While inspection reports must verify when a certified livestock manager or certified fertilizer applicator takes the manure, these reports lack the necessary information to appropriately track D&U manure applications, such as the field location, soil phosphorus levels, application rates, and the number of total applications if other facilities or AFOs apply manure to those same fields. Improving the transparency of D&U applications and ensuring they adhere to agronomic rates could improve its acceptance, and possibly increase the use of manure as a nutrient source thereby helping reduce the need for costly commercial fertilizer.

Based on the inspection reports from CAFFs in the WLEW, one can conclude a majority of manure applications occur on fields with soil phosphorus levels above what is necessary for optimal crop production, and range between 40 ppm to 70 ppm. If CLMs and certified applicators follow this trend, manure applications completed through D&U may occur on fields with no agronomic need. If this trend extends to all AFOs in the watershed or throughout the state, that would result in potentially thousands of facilities and operations routinely applying excess manure.

To be clear, this is a result of current state regulatory requirements, or the lack thereof, for AFOs, and not because of any ill intent by individual CAFF owners or operators. Unless there is a direct manure discharge, no one is considered in violation of the rules and ultimately that is the crux of the problem. Manure applications need to match the soil phosphorus levels with the agronomic needs of the next planted crop or crop rotation.

Final Recommendations

To begin addressing these systemic problems and transition to a system that effectively reduces water pollution risks, the OEC offers the following two categories of recommendations:

Establish Common Sense Regulatory Safeguards

- Require all AFOs, regardless of size, to register with the ODA's Division of Soil and Water Conservation, and require a certain subset to develop and follow operation and management plans. We recommend this subset be any AFO that confines the same number of animals as a medium CAFO.
- Begin transitioning manure applications toward meeting agronomic rates through the following actions:
    - Immediately revise state regulations to cap phosphate applications when soil test phosphorus results are at 100 ppm for all existing CAFFs unless an emergency situation arises. The revised rules should establish a reasonable time period for when all manure applications must transition to agronomic rates.
    - For new or expanding CAFFs, revise state regulations to direct all manure applications adhere to agronomic rates.
- Revise D&U state regulations to require current soil tests, and field maps before any manure application, and they adhere to agronomic rates.

Improve Reporting and Establish Standardized Reporting Protocols

- Make all public records available on ODA's website, ensure they are kept up to date, and that the database is user-friendly.
- Ensure all public records include the CAFF 's basic information as well as dates of filing or issuance. For example, all fact sheets should have a date on them.
- Provide an online submission tool for all operation records and required reports, and make them publicly available.
- Require annual reports to include the location of fields receiving manure through D&U, if not their precise location, then at least the subwatershed (HUC 12) name. Require they also include the amount of phosphate applied to fields under control of the CAFF owner or operator and transferred through D&U. Ensure all parts of the report are fully completed, and do not accept handwritten submissions.
- Establish consistent inspection reporting formats to ensure that each CAFF includes all soil test phosphorus results for fields that receive manure applications and list phosphate application rates. Require these reports to include the same information for fields receiving manure applications through D&U. Additionally, require inspection reports to indicate if these fields receive manure from other animal facilities or AFOs. As part of each ODA inspection, verify that the previous year's annual reports are correct.
- Replace the OAC Appendix provided in the departmental regulations with the Natural Resource Conservation Service's handbook or another conversion tool that provides a more accurate and comprehensive method to estimate annual manure and nutrient production.

Appendix A. Project Methods and Discussion

In March 2016, the OEC submitted a records request to ODA to obtain each CAFF's fact sheet, last two inspection reports, and annual reports from 2011 - 2015. In July an additional records request was sent for phosphorus information contained in each CAFF's manure management plan. The ODA responded by sending each CAFF's full permit, which includes the MMP along with other sections, and in most cases totals hundreds of pages. At the time of writing, the OEC had just received the final response to the public records request. Therefore specific phosphorus information in the MMP is only available for CAFFs in the WLEW. Additionally, since the OEC's initial records request sent in March 2016, several new CAFFs obtained permits during the review process. This report includes those with approved permits as of January 2017. However, these newer CAFFs, and those permitted in 2015, do not have corresponding inspection or annual reports as those were not yet due at the time of the records request. The following section provides a short description of each type of public record used during the review.

Sources of Information

Fact Sheets - A one-or two-page summary of information proposed for each CAFF's permit to operate (PTO) or permit to install (PTI) including the location, and maximum number and type of animals, the approximate amount of manure generated by all animals, and the overall storage capacity, among other information. These were used as the primary source of basic CAFF information, though manure quantities and maximum stocking levels were replaced by more accurate information from inspection reports or MMPs if available or necessary due to unclear language or omission.

Annual Report - State regulations require each CAFF to submit a report to ODA each year containing the number and type of animals, an estimation of total manure generated in the last 12 months, the total amount of manure managed through D&U and other information.[33] Many reports were not fully complete, and some were handwritten making some of them illegible. Therefore, data summaries from these reports may be inaccurate.

Manure Management Plan (MMP) - Numerous state regulations dictate the contents of these plans and address all aspects of operation including annual manure production, storage, monitoring, nutrient analysis and application, and many other components.[34]

Inspection Report - State rules require each CAFF to keep operating records detailing numerous aspects of each CAFF's operations that includes soil test results and land application information.[35] The CAFF must have regular inspections with reports that summarize details from operation records, including the amount of manure applied to fields under the control of the CAFF owner or operator .In some instances these reports include the amounts phosphorus applied, but not consistently. An inspector also visually checks the CAFF for potential violations.

[33] See 901:10-2-20 Annual report.
[34] See Chapter 901:10-2 Permits; Management Plans and see here for a current MMP template.
[35] See 901:10-2-16

Conversion Tables - The Ohio Administrative Code (OAC) contains numerous rules for the installation and operation of CAFFs. This includes information requirements for MMPs such as the amount of manure each CAFF must store. To assist in estimating requisite manure storage capacity during the planning phase, the OAC rules provide a conversion table as an appendix (OAC Appendix) to calculate the volume of manure produced by each animal type at different respective weights along with their associated nutrient contents.[36] Although the table notes it has a 30 percent margin of error, this provides a means to estimate the potential manure generation for each CAFF. It is important to note that the OAC Appendix lists several subcategories for each type of livestock (cattle, poultry, swine, horse). For example, dairy cattle have three classifications: calf, heifer and mature. Each type of livestock had to be separated into their respective subcategories and specific weight classes in order to use the OAC Appendix. In order to determine the appropriate weight class this project consulted the Natural Resource Conservation Service's Agricultural Waste Management Field Handbook and the Ohio State University Extension's Ohio Livestock Manure Management Guide, Bulletin 604.

Data Collected

The following is a list of data collected and analyzed as part of the review process.

- Basic CAFF information - Current CAFF name, and when applicable, the previous name, street address, city, zip code, HUC 8 watershed, and GPS coordinates.[37]
- Livestock number and category - Types of livestock include dairy cow, beef cattle, swine greater or less than 55 lbs, poultry, and horses. Depending on the detail of information provided, each category was separated into subcategories necessary to perform the calculations, such as layer or broiler for poultry, and farrowing or finishing for swine.
- Manure produced - Solid and liquid manure listed in each CAFF's fact sheets or MMP, 2015 Annual Reports, and calculated amounts using the OAC Appendix.
- Phosphate generated - Calculated using the OAC Appendix and for CAFFs in the western Lake Erie watershed, pounds listed in each MMP classified as either distributed or applied to acres under its control.
- Manure applications - Fact sheets list the amounts applied by the CAFF owner, operator or certified livestock manager, and amounts also managed through D&U.
- Soil phosphorus levels & application rates - Inspection reports include soil characterizations that specify soil phosphorus test results completed every three years, though not all reports consistently include these levels if they are below 150 ppm. Some reports also list the pounds of phosphate applied and the dates of application to individual fields, again inconsistently. When possible, this report includes information for CAFFs in the WLEW recording soil phosphorus levels and application rates.
- Transportation distances - Annual reports provide a section for CAFFs to record distances manure traveled, though not consistently. Distances were recorded from each annual report from 2011 - 2015 and averaged for each CAFF to determine a likely travel distance for manure the CAFF managed through D&U.

[36] See appendix to 901:10-2-10

[37] Obtaining an accurate list of all the CAFFs currently in operation was a deceptively difficult task. Some changed ownership or the name of their business multiple times, and yet others closed altogether…

- Available Cropland - Fact sheets and MMPs list acres available for manure application, but the inspection reports appear to have the most recent data since available cropland is so variable and can change from year to year. This report uses inspection reports when available and fact sheets for facilities that did not have inspection reports at the time of this review. It is important to note this information is inconsistent for acres available through D&U application.

Determining Basic Livestock CAFF Information

Initially each CAFF's basic information was collected from its fact sheet and their GPS coordinates recorded from a separate records request. Several CAFF names did not match those listed on the annual reports or inspection reports, and through subsequent records requests it was discovered some CAFFs had changed their name, been sold to new owners, or simply closed. In order to keep the list updated, names were collected from the public notices and fact sheets available on the ODA DLEP website, but several links were inaccurate or did not work. In some instances the website did not even list the CAFF. To verify the list of CAFFs currently operating as of January 2017, a comparison was performed between a list received from a public records request with names collected from fact sheets. Incongruities were corrected through a conversation with the DLEP Chief Kevin Elder. Additionally, GPS coordinates for several CAFF locations were not the same as those provided in previous records and required verification. This was done by using Google satellite imagery software or the CAFF's installation permit. Determining the actual number of livestock each CAFF could house was another challenge. The fact sheets provided this information, but they represent the total capacity, which can change during the five-year span before permit renewal. Therefore, the maximum design capacity listed in each CAFF's most recent inspection report was used when the number differed from what was reported in the fact sheet.

Determining Manure and Phosphate Generated

A number of options were available to determine the quantities of manure CAFFs generate each year. The CAFF's fact sheet or MMP lists the total amount of manure produced. Fact sheets may differ from what ultimately is in the final MMP, but they offer a quick summary of each CAFF's manure production including process wastewater, contaminated stormwater, mortality compost, etc. In some instances, the MMP provided more precise figures for manure production, however, if the CAFF was in the process of renewing its permit, the fact sheets contain more recent information. Additionally, several permits had just been received at the time of this report's writing and had not been adequately reviewed so the fact sheets were most often utilized in this report. Amounts were summed to determine the approximate total manure production for each type of livestock CAFF. Given this is for the maximum stocking amount allowed under each permit, it was useful to determine how much they may depart from amounts listed in the annual reports, since those may be closer approximations to determine what the CAFF generates. First, a multi-year average was calculated from all 2011-2015 reports. It was soon evident, however, that the 2015 annual report was likely to be a more accurate representation of current generation due to numerous variations in operations and changes in status throughout time, such as facilities not being stocked during certain years, or closing their operations, or switching their type of livestock altogether. Therefore, this report compares the amount of manure each CAFF listed in its 2015

annual report with the amounts from their fact sheets (or MMPs as applicable). These comparisons show the variability between reported amounts and those in each CAFF's MMP, which provides useful insight into probable manure production.

To determine the amount of phosphate a CAFF would generate, most MMPs contain a Total Nutrient Budget that estimates the pounds of phosphate applied by the CAFF to available acres it controls, and the pounds of phosphate in the manure sold or transferred through D&U. These are estimates since acres change and market conditions drive D&U applications. However, combining these together provides a reasonably accurate total annual phosphate production number. At the time of writing, only those MMPs for facilities in the WLEW had been fully analyzed so the amounts of phosphate were only summed for these facilities.

Finally, gallons of manure and pounds of phosphate each CAFF could generate were calculated using the conversion table from the OAC Appendix. This provided another metric for assessing potential manure generation and offered a point of comparison with the annual phosphorus production listed in the MMPs. These calculations are explained in detail below.

Unfortunately, no precise or verifiable method exists to definitively determine manure and phosphorus generation. For example, the White Oak Farm MMP shows a 600 lb. boar producing the same amount of manure as a 450 lb pregnant sow. In other words, the MMPs are not always the most accurate means to determine manure production. Therefore, regardless of the source or method, determining the amount of manure and phosphate each CAFF produces is an approximation rather than a direct measure, not only because of potentially inaccurate information in the permits themselves, but also because there are numerous factors that affect manure production, including animal weight, breed, type of feed and feed additives. Additionally, the number of animals present at each CAFF during any given time varies. While a CAFF has a maximum number allowed under its permit, the actual count can vary throughout the year, as will the age or production stage of the animal, and thus, its manure generation potential. Furthermore, as explained earlier, the term "manure" includes much more than the actual waste produced by each animal. This includes water used as part of the operation to flush waste from the housing structures, to wash animals or rinse eggs. Rain or snow that comes into contact with any material or contaminated water is also considered "manure." Dead animals are part of each CAFF's mortality management plan and the remains are typically turned into mortality compost, which is considered "manure" as well.

Given this broad definition of manure, there is a distinct difference between the amount of waste animals produce versus the overall manure a CAFF must manage. Another complicating factor is the fact that manure managed as a solid is often dried so the moisture content is much lower compared to when it is initially produced. In other words, dried manure stored or sold is not the same as the amount generated. However, in these cases the phosphate content would still concentrate in the dried manure.

The OAC Appendix conversions only account for manure and nutrients "as produced", so it does not account for all the waste a CAFF must manage. All the manure calculations were done in gallons to maintain consistency. Had the calculations been performed in tons for livestock types where the manure was stored as a solid, the amounts would still not account for all the solid waste a CAFF generates, nor would they account for any liquid process wastewater such as

contaminated stormwater. In order to sum all the calculated amounts, one value (gallons) was chosen for all conversions. While it is useful to calculate amounts of phosphate and manure produced by the animals to know what the CAFF may generate, the exercise is mostly academic since each CAFF is responsible for appropriately managing the total amount of "manure" generated.

Ultimately, for the purposes of assessing phosphorus pollution risks, the amount of manure generated is less informative than the amount of phosphate each CAFF generates. Since phosphate is spread on land under the control of the CAFF owner or operator or on farms that receive the manure, the calculated amounts of phosphates themselves are not as informative as the soil phosphorus levels at the time of application and the corresponding rates of application.

Phosphate Applications

Each inspection report was evaluated to determine the number of fields each year that received manure applications when the soil tests showed levels at or above 40 ppm. Of the 64 CAFFs in the WLEW, 11 did not have inspection reports available, two did not specify the pounds of phosphate applied, and 5 managed all their manure through D&U so no application data were required.

Unfortunately, not all inspection reports utilize the same formats. Some detail the actual pounds of phosphate applied to specific fields, while others do not, making the determination of actual rates of application for all facilities impossible. State rules only require soil tests every three years and only one sample per each 25 acre area of the field.[51] Therefore, most soil phosphorus levels in each CAFF's inspection report are based on only one soil test.

Determining Available Cropland

In an attempt to provide the most accurate measure possible, this report uses acres from each CAFF's most recent inspection report if available.[52] These reports divide cropland into the categories of acres owned, acres leased, and "other." The latter often refers to acres where manure application was done through D&U. However, this is not always true. If the permitted livestock producer makes the decisions and applies the manure to another farmer's crop ground, the permitted livestock producer is considered responsible for the manure application and must have manure tests, soil tests, crops, yields, meet all the application requirements and is responsible for all recordkeeping.[53] This means the manure was not managed through D&U and the CAFF owner or operator is still liable for any misapplication or discharge. Therefore, simply totaling the "other" acres and labeling them as D&U would be inaccurate. Most times fact sheets and inspection reports will omit D&U acres since they are done through a third party certified livestock manager or another manure applicator- as is the case with most poultry facilities.

[51] See 901:10-2-13. Compare this to precision application that uses 2.5 acre grid sampling to determine soil phosphorus levels.
[52] Some CAFFs did not have inspection reports available at the time of the March 2016 public records request.So for those facilities this report uses available acres listed in the fact sheets.
[53] Based on email correspondence with ODA DLEP Chief Kevin Elder, dated 12/2/16.

Calculations Explained

The OAC Appendix provides a tool to estimate what the CAFF actually produces in terms of raw manure it produces and the phosphate (P_2O_5) it contains. Each type of livestock had to be separated into specific subcategories and weight classes in order to use the OAC Appendix. Fact sheets often did not provide specific weight classes, or even in some cases the livestock subtype. For example, at no time did the fact sheet specify the number of gestating or lactating swine, or if immature dairy cows were calves or heifers. In these cases, the inspection reports or MMPs were used to determine subtypes. The NRCS Handbook and the OSU Extension 604 Bulletin was used to inform which weight class to use in the calculations. In some cases, the heavier weight classes in the OAC Appendix aligned more closely with the lighter classes in the Handbook and 604 Bulletin. Below is a discussion for each livestock category. Additionally, the OAC Appendix does not have a category for poultry pullets so a custom formula was generated.

With the weight classes determined, the number of animals was multiplied by the daily manure and phosphorus production numbers and then multiplied by 365 to determine annual production. Again, values for manure and phosphorus production are only estimates since they do not account for animal breeds, types of feed or feed additives, so the calculations may significantly differ from actual production. Nor do the estimated values account for different manure treatment systems such as anaerobic digesters that concentrate phosphorus in the solids and dilute it in the treated liquid.

Dairy Cows

Dairy cows have five separate categories in the OAC Appendix: calf, heifer, lactating cow, dry cow and veal. The fact sheets for dairy CAFFs will typically indicate the number of mature dairy cows, calves and heifers. However, it will not specify the number of lactating and dry cows. Typically the ratio is 85 percent lactating and 15 percent dry, which is supported by the Ohio Dept. of Agriculture's Division of Environmental Livestock Permitting. Weights also vary for several of the categories.

For our purposes, we use 1,400 lbs. as a standard weight for lactating dairy cows and 1,700 lbs. for dry cows. Though these are the heaviest weights, they better reflect the values used in both the NRCS Handbook and the OSU Extension 604 Bulletin. To explain, the former assumes the average dairy cow weight to be 1,375 lbs. for a lactating cow and the latter 1,400 lbs. These are closer to the heavier weight class in the OAC Appendix. Dry cows are more complicated since the OAC Appendix has three weight classes: 1,000, 1,400 and 1,700 lbs. The NRCS Handbook only uses 1,660 lbs. for a dry cow and the OSU Extension 604 Bulletin uses two weight classes: 1,000 and 1,400 lbs. To determine which weight class to use, the manure generated by each class was more informative. The NRCS Handbook shows a dry cow produces 85 lbs./day and the OSU Bulletin lists 82 lbs/day for a 1,000 lb dry cow and 115 lbs./day at 1,400 lb. However, the OAC Appendix shows a dry cow at 1,400 lbs. produces 71 lbs., which is significantly lower than the OSU Bulletin and the NRCS Handbook. At 1,700 lbs. the OAC Appendix shows the dry cow produces 87 lbs. Therefore, the heavier weights from the OAC Appendix more closely aligns with the amount of manure produced at lighter weights in the other two conversion charts.

For dairy calves and heifers we used the lowest weight number available for each category. It is important to note these values are not averages, rather they are the lightest categories available in the Rule Table and we used them because they are closer to a calculated average. For example, a calf has a range beginning with its birth weight up to 250 lbs., so if a Jersey calf at birth weighs 55 lbs. the average weight would be 152.5 lbs. However, since the appendix only offers 150 lbs. and 250 lbs., we used the lighter classification since this is the published value. Similarly, a weight range for heifers could be between 150 lbs. and 1000 lbs., but the Rule Table provides only two weight classes of 750 lbs. and 1000 lbs., so we used the lowest weight class available. The ST Ohio Heifer Center CAFF deserves a special note. This CAFF was converted from a beef operation formerly known as Ohio Feedlots into a breeding CAFF for dairy cows. Therefore, it keeps bulls for breeding purposes, and for our calculations we use the finishing weights for beef cattle since the OAC Appendix lacks a bull category for dairy CAFFs.

Dairy cow manure produced formulas

(lactating) = (number of mature dairy cows) * (.85 lactating cow) * (18.7 gal.manure) * (365 days) = annual manure generated
(dry) = (number of mature dairy cows) * (.15 dry cow) * (10.45 gal. manure) * (365 days) = annual manure generated

annual lactating + annual dry = total annual manure generated for mature dairy cows

(number of calves) * (1.38 gal. manure) * (365 days) = annual manure generated - dairy calves
(number of heifers) * (5.21 gal.manure) * (365 days) = annual manure generated - dairy heifers

Dairy cow phosphate (P_2O_5) produced formulas

(number of mature dairy cows) * (.85 lactating cow) * (0.52 lbs. P_2O_5) * (365 days) = annual P_2O_5 generated (lactating)
(number of manure dairy cows) * (.15 dry cow) * (0.18 lbs. P_2O_5) * (365 days) = annual P_2O_5 generated (dry)

annual lactating + annual dry = total annual P_2O_5 generated for mature dairy cows
(number of calves) * (0.01 lbs. P_2O_5) * (365 days) = annual P_2O_5 generated - dairy calves
(number of heifers) * (0.08 lbs. P_2O_5) * (365 days) = annual manure generated - dairy heifers

Beef Cattle

Beef cattle have three categories: calf, finishing (steers), and cow. Looking at the manure production for finishing cattle, the OAC Appendix lists two weight classes of 750 lbs. and 1,100 lbs. with 34 lbs./day and 54 lbs./day of manure produced respectively. Comparing these values to the 604 Bulletin, the numbers appear much lower. Specifically, a 750 lb. high forage steer shows 62 lbs./day of manure produced, a 750 lb. high-energy steer produces 54 lbs./day. The NRCS Handbook uses an average finishing weight of 983 lbs. producing a calculated daily average of 64 lbs. of manure. Therefore, we used the 1,100 lb. finishing weight class in the OAC Appendix that produces manure at 54 lbs./day since that aligns with the lightest steer and lowest manure

produced in the 604 Bulletin.

Manure production for beef calves in the OAC Appendix also has two weight classes: 450 lbs. and 650 lbs. producing 48 lbs. and 69 lbs. of manure respectively. The NRCS Handbook uses a range of 450-750 lbs. with just one value of 50 lbs./day, and the 604 Bulletin just uses one weight class of 450 lbs. producing just 26 lbs./day. Its unclear why the 604 Bulletin shows less manure produced, but given the OAC Appendix closely aligns with the Handbook at 450 lbs., this is the weight class we used. Finally, one CAFF, Mill Creek Dairy LLC, explained in the fact sheet it was converting its operation to a cattle feeder CAFF, which are weaned calves that have been raised to a certain weight and then sent to feedlots to be fattened before they are slaughtered. However, the OAC Appendix does not include a category for feeder cattle, so we used the higher calf weight of 650 lbs. for this CAFF. Since the OAC Appendix only lists one weight class for cows, there was no need to consult the other conversion tables.

Beef cattle manure produced formulas

(number of finishing cattle) * (6.46 gal.manure) * (365 days) = annual manure generated
(number of cows) * (10.91 gal.manure) * (365 days) = annual manure generated
(number of calves) (5.66 gal.manure) * (365 days) = annual manure generated

Beef cattle phosphate (P_2O_5) produced formulas

(number of finishing cattle) * (0.12 lbs. P_2O_5) * (365 days) = annual P_2O_5 generated
(number of cows) * (0.18 lbs.P_2O_5) * (365 days) = annual P_2O_5 generated
(number of calves) (0.09 lbs.P_2O_5) * (365 days) = annual P_2O_5 generated

Poultry

The OAC Appendix lists layer, broiler, turkey (male, female) and duck for its poultry categories and lists one weight category for each. However, it does not have a section for pullets so we chose to generate our own conversion rather than use the listed layer weight that represents a full-grown, egg-producing chicken. In choosing a pullet weight, we looked at several manure management plans for pullet CAFFs and found an average weight of 1.5 lbs. Since the OAC Appendix uses 3 lbs. as the average layer weight, we divided the daily manure production of 0.15 lbs. by two to derive the daily pullet manure production of 0.0085 gallons. We used the same approach to determine phosphorus production for each pullet.

To determine phosphate production we used the value for a 3 lb layer in the OAC Appendix (0.0008 lbs./day) so as to maintain a consistent source for our calculations. However, it is important to note a wide variability exists among the conversion tables. For instance, the OAC Appendix is slightly lower compared to the NRCS Handbook which lists 0.0011 lbs./day for a 3 lb. layer, and much lower compared to the 604 Bulletin which lists 0.0027 for a 4 lbs. layer, which amounts to 0.002 lbs./day for a 3 lb. layer. Looking at the value for a broiler chicken, the phosphate value in both the 604 Handbook and the OAC Appendix is 0.0014 lbs./day for a 2 lb. animal. It's unclear why the OAC Appendix aligns with the 604 Bulletin for a broiler, but not for a layer. The NRCS Handbook is less helpful here because it lists 0.035 lbs./day phosphate for a 2.6 lb.

broiler, which amounts to 0.269 lbs./day phosphate for a 2 lb. broiler, nearly double the values in the OAC Appendix and NRCS Handbook.

The OAC Appendix has two categories for turkeys, (male at 20 lbs. and female at 10 lbs.), but unfortunately the fact sheets and reports do not list the CAFF's stocking distribution between the two. The NRCS Handbook assumes equal distribution and determines manure production based on finished animal, not a per day calculation. The Rule Table lists manure production for males as 0.74 lbs./day and for females 0.47 lbs./day. The 604 Bulletin just uses one weight class of 20 lbs. producing 0.90 lbs./day of manure. Given the variation between the different conversions of a 20 lb. turkey, and CAFFs produce turkeys for meat production, thereby growing turkeys toward a larger weight, we used the OAC Appendix value for a male turkey for our calculations.

Pullet manure and phosphate (P_2O_5) generation

3 lb. layer generates 0.0.17 lbs. manure per day, (0.017 ÷ 2 = 0.0085 gal. manure/day)
3 lb. layer generates 0.0008 lbs. P_2O_5 per day (0.0008 ÷ 2 = 0.0004 lbs. P_2O_5/day)

Poultry manure produced formulas

(number of pullets) * (0.0085 gal.manure) * (365 days) = annual manure generated
(number of layers) * (0.017 gal.manure) * (365 days) = annual manure generated
(number of broilers) * (0.023 gal.manure) * (365 days) = annual manure generated
(number of turkeys) * (0.088 gal.manure) * (365 days) = annual manure generated

Poultry phosphate (P_2O_5) produced formulas

(number of pullets) * (0.0004 lbs.P_2O_5) * (365 days) = annual P_2O_5 generated
(number of layers) * (0.0008 lbs.P_2O_5) * (365 days) = annual P_2O_5 generated
(number of broilers) * (0.0014 lbs.P_2O_5) * (365 days) = annual P_2O_5 generated
(number of turkeys) * (0.0074 lbs.P_2O_5) * (365 days) = annual P_2O_5 generated

Swine

The OAC Appendix separates swine into five different categories: nursery, finishing, gestating, lactating and boar. Weight classes for each of the categories vary with nursery and boar containing two classes, gestating and lactating with three, and finishing swine divided into five weight classes. Additionally, CAFFs categorize swine as either greater than or less than 55 lbs., since this is the threshold for the number of animals that require a permit under Ohio law where the former is 2,500 swine and the latter 10,000 swine.

A special note must be made for breeding facilities since they have swine that fall under multiple categories. Unfortunately, fact sheets typically do not separate the number of animals by these categories, and the MMP's terminology does not align with the OAC Appendix. For instance, it is common for plans to label some swine as "acclimating," and others as "farrowing." The latter marks the end of the gestation period and logically would fall into the lactating category.[40]

[40] http://extension.psu.edu/courses/swine/reproduction/breeding-management/cycles-and-heat-determination and http://www.thepigsite.com/articles/1101/farrowing-and-lactation-in-the-sow-and-gilt/.

Acclimation refers to swine placed in insulation barns where they receive vaccinations and observation for signs of disease. Some are gilts for breeding, and others may be kept or sold for finishing. Since there is no set ratio for determining the number of swine in each category, we looked to individual MMPs to establish the precise numbers where it provided an animal inventory. We placed all swine marked "acclimation" into the finishing category since the plans we had available showed their weights at 200 lbs. Unfortunately, some MMPs did not specify the number of swine in gestation or farrowing stages, rather these were simply combined, as in the case of the Grand Republic LLC. CAFF. Here, the MMP listed one number for all breeding, gestating, boars, and farrowing swine. In instances such as this where we could not determine the number for each category, we kept all in the gestating category and acknowledge this is an underestimate since lactating swine produce much more manure and phosphorus than the other subtypes.

In short, this is the most complicated category, and in choosing weight classes we compared the OAC Appendix with the NRCS Handbook and 604 Bulletin. Generally the lowest weight classes aligned with OAC Appendix, except for the NRCS Handbook's listing for gestating swine. Still, in order to be conservative in our calculations, we used the lowest weight category for all types except boars and assumed all swine weighing less than 55 lbs. fell into the nursery category. The Handbook uses 440 lbs. for an average weight while the 604 Bulletin uses 350 lbs. Therefore we chose the 400 lbs. weight category in the OAC Appendix to use for our boar calculations.

Swine manure produced

(number of nursery swine) * (0.23 gal.manure) * (365 days) = annual manure generated
(number of finishing swine) * (0.89 gal.manure) * (365 days) = annual manure generated
(number of gestating swine) * (0.82 gal.manure) * (365 days) = annual manure generated
(number of lactating swine) * (2.08 gal.manure) * (365 days) = annual manure generated
(number of boars) * (0.99 gal.manure) * (365 days) = annual manure generated

Swine phosphate (P_2O_5) produced

(number of nursery swine) * (0.01 lbs.P_2O_5) * (365 days) = annual manure generated
(number of finishing swine) * (0.03 lbs.P_2O_5) * (365 days) = annual manure generated
(number of gestating swine) * (0.03 lbs.P_2O_5) * (365 days) = annual manure generated
(number of lactating swine) * (0.11 lbs.P_2O_5) * (365 days) = annual manure generated
(number of boars) * (0.05 lbs.P_2O_5) * (365 days) = annual manure generated

Equine

Each of the four equine facilities raise racing horses so all the animals were placed in the "Intense Exercise" category. The OAC Appendix only has one weight class so there was no need to consult the other conversion methods.

Equine manure produced

(number of horses) * (6.70 gal.manure) * (365 days) = annual manure generated

Equine phosphate (P_2O_5) produced

(number of horses) * (0.015 lbs.P_2O_5) * (365 days) = annual P_2O_5 generated

Livestock Manure Production Comparison Calculations

As stated in this report, the total annual manure summed from the fact sheets would fill the Ohio State football stadium more than two times over (2.3 to be exact). The stadium is the largest in Ohio holding 104,944 people, which also makes it the third largest in the nation. With dimensions of 919 ft. long, 679 ft. wide, and 136 ft. high, the stadium can hold 634,827,823 million gallons.[55] In order to compare the amount of manure produced annually by all the CAFFs in Ohio, it was necessary to first convert the amount of the manure listed as tons in the fact sheets and MMPs to gallon. The 604 Bulletin states one gallon of manure equals 8.3 lbs.[56] Each U.S. ton equals 2000 pounds, which we used to convert solid manure into pounds. This allowed for the following calculations:

899,310 total tons of manure/yr. * 2000 lbs./ton = 1,798,620,000 lbs. of manure/yr.
1,798,620,000 lbs. of manure/yr. ÷ 8.3 lbs./gal. = 216,701,205 gallons/yr.
216,701,205 gallons/yr. + 1,579,783,073 gal./yr. = 1,796,484,278 total gal./yr.

1,796,484,278 total gal./yr. ÷ 634,827,823 gal./yr. = 2.83 stadiums

The conversion for the facilities in the western Lake Erie Watershed follows the same format.

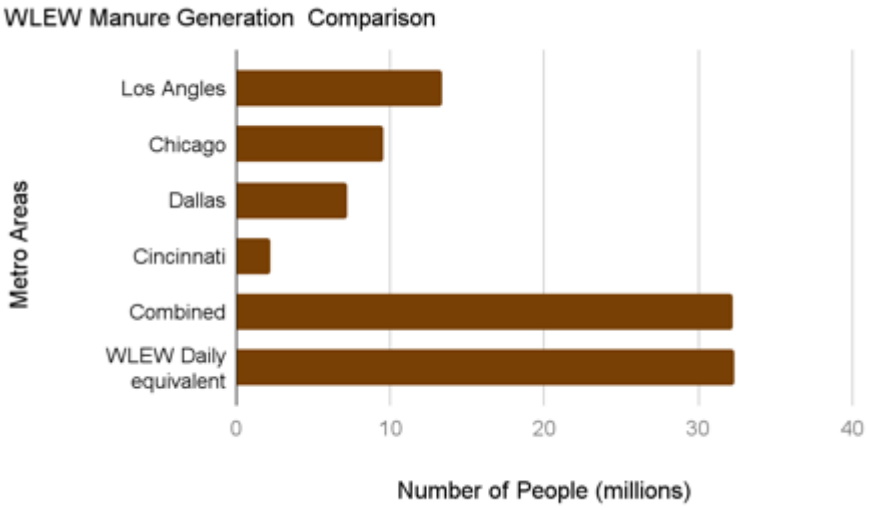
215,098 tons of manure/yr.* 2000 lbs./ton = 430,196,000 lbs./yr.
430,196,000 lbs./yr. ÷ 8.3 lbs./gal. = 51,831 gal./yr
51,831 gal./yr + 658,030,505 gal./yr = 658,082,336 gal.yr.
658,082,336 gal./yr. ÷ 634,827,823 gal./yr. = 1.04 stadiums

Looking at all the CAFFs within the western Lake Erie watershed, we determined the amount of manure produced annually equals the daily equivalent of all the people living in the Los Angeles,

[55] Admittedly, the Horseshoe is not a rectangular box, so the amount of manure it likely can hold is less than this amount, which means it would probably take more stadiums to hold all the manure.
[56] "Density of fresh manure is similar for all species at 62 to 65 lb/ft3 (water has a density of 62.4 lb/ft3). At these densities, a gallon of manure would weigh approximately 8.3 lb." p. 2 604 Bulletin.

Chicago, Dallas and Cincinnati metro areas.

We use a variety of calculations and sources of information to arrive at our determination. First, according to Encyclopedia Britannica, a human adult produces 100 to 250 grams (3 to 8 ounces) of feces daily.[57] For ease of calculations and to be conservative in our estimate, we use the 8 ounce value, so one pound of manure equals the equivalent of what two people produce in a day. A vast majority of the manure listed in the fact sheets and MMPs is recorded as gallons. In order to convert these amounts into pounds, we relied on a conversion from the 604 Bulletin that stated one gallon of manure equals 8.3 lbs.[58] Each U.S. ton equals 2000 pounds, which we used to convert solid manure into pounds. This allowed for the following calculations:



658,030,505 total gallons of manure/yr. * 8.3 lbs./gal. = 5,461,653,192 lbs./yr.
215,098 total tons of manure/yr. * 2000 lbs/ton = 430,196,000 lbs./yr.

5,461,653,192 lbs./yr. + 430,196,000 lbs./yr.. = 5,891,849,192 total lbs.of manure/yr.

Again, multiplying the total pounds of manure per year by 2 and dividing by 365 days provides a daily fecal production equivalent for people.

5,891,849,192 total lbs.of manure/yr. * 2 people ÷ 365 days = 32,284,105 people/day

The 382 Metropolitan Statistical Areas of the United States of America show the following population estimates: [59]

- Los Angeles-Long Beach-Anaheim, CA Metropolitan Statistical Area – 13,310,447 people
- Chicago-Naperville-Elgin, IL-IN-WI Metropolitan Statistical Area – 9,512,999 people
- Dallas-Fort Worth-Arlington, TX Metropolitan Statistical Area – 7,233,323 people
- Cincinnati, OH-KY-IN Metropolitan Statistical Area – 2,165,139 people

Totaling these metro areas populations together totals 32,284,105 million people, this is 62,197 thousand people under the calculated daily fecal production equivalent for CAFFs in the WLEW.

[57] See here for the Encyclopedia Britannica reference.
[58] "Density of fresh manure is similar for all species at 62 to 65 lb/ft3 (water has a density of 62.4 lb/ft3). At these densities, a gallon of manure would weigh approximately 8.3 lb." p. 2 604 Bulletin.
[59] See https://en.wikipedia.org/wiki/List_of_Metropolitan_Statistical_Areas

Appendix B. CAFF Review Data and Calculation Links

CAFF Review Data Sheet
Manure Calculations Spreadsheets
Phosphate Calculations Spreadsheets
Phosphate Applications - WLEW CAFFs