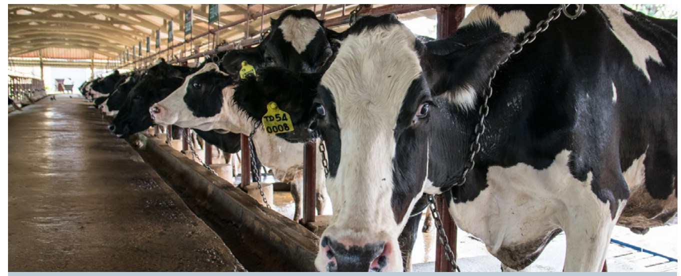
SECTION 1

What are CAFOs and How Do They Pollute Michigan's Waters?

I. The Rise of the CAFO Business Model — "Get Big or Get Out"

Over the last 40 years, CAFOs have transformed animal agriculture. Unlike traditional, family-scale farms that kept a manageable number of animals at pasture and used their manure to fertilize crops on the farm, the CAFO model — in which animals are confined indoors most of the time — creates an imbalance between nutrient intake (grazing) and nutrient output (manure). This means that the animals confined on a CAFO generate more waste than the nearby land can absorb. Even the USDA recognizes that CAFOs are not farms in this traditional sense and refers to them as "large, industrialized livestock operations."

Industrialization of agriculture became a national priority in the 1970s under USDA Secretary Earl Butz, who was known for saying that farmers should "get big or get out" of agriculture. By the end of the 1990s, much of agricultural production had, indeed, gone "big" and many farms have, indeed, gotten out. The CAFO business model now dominates livestock production. In 1964, more than 1 million farms nationwide were raising about 54 million hogs; by 2022, just 56,000 farms were raising more than four times that many hogs (240 million).[1] Michigan's fate was no different: as the number of farms has shrunk dramatically, the number of animals being raised has risen over time — see Figures 1 & 2 below.



Under Michigan law, an '[a]nimal feeding operation (AFO)' means a lot or facility . . . where the animals . . . will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period." Michigan Administrative Code Rule 323.2102(i).

A large CAFO is an AFO that confines a minimum number of animals, including: 700 dairy cows; 1,000 cattle; 2,500 swine over 55 pounds; 125,000 chickens, and/or discharges pollutants from its production area.

Figure 1: Michigan has gained 91,704 dairy cows while losing 5,018 dairy farms since 1987

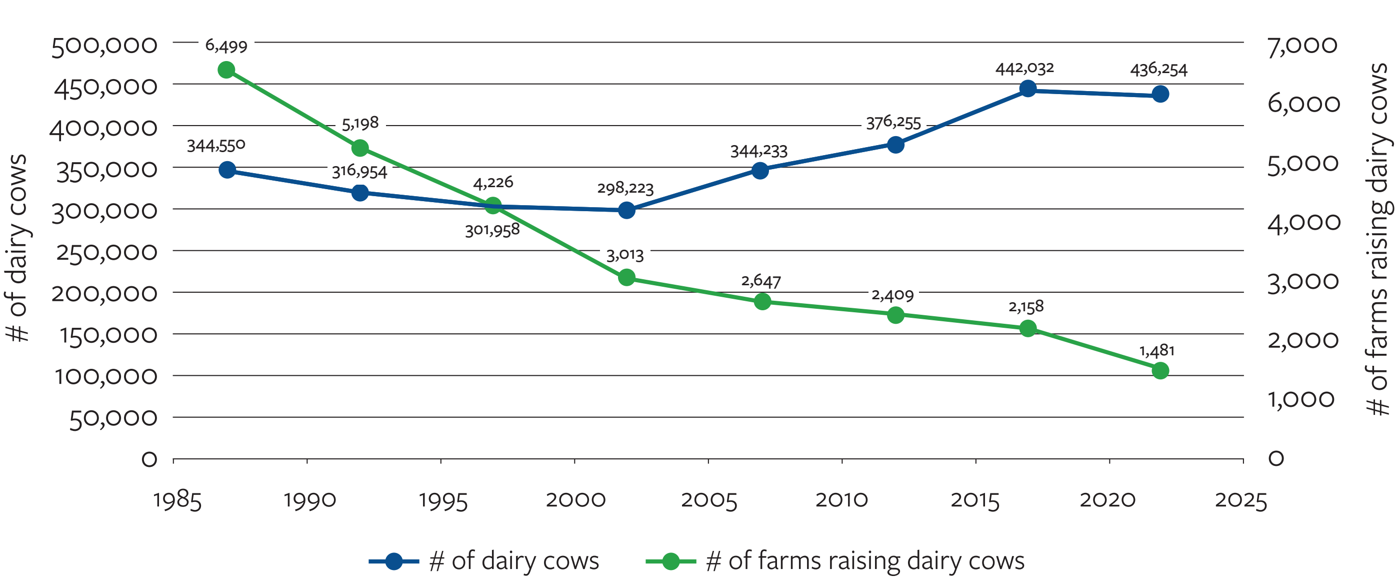
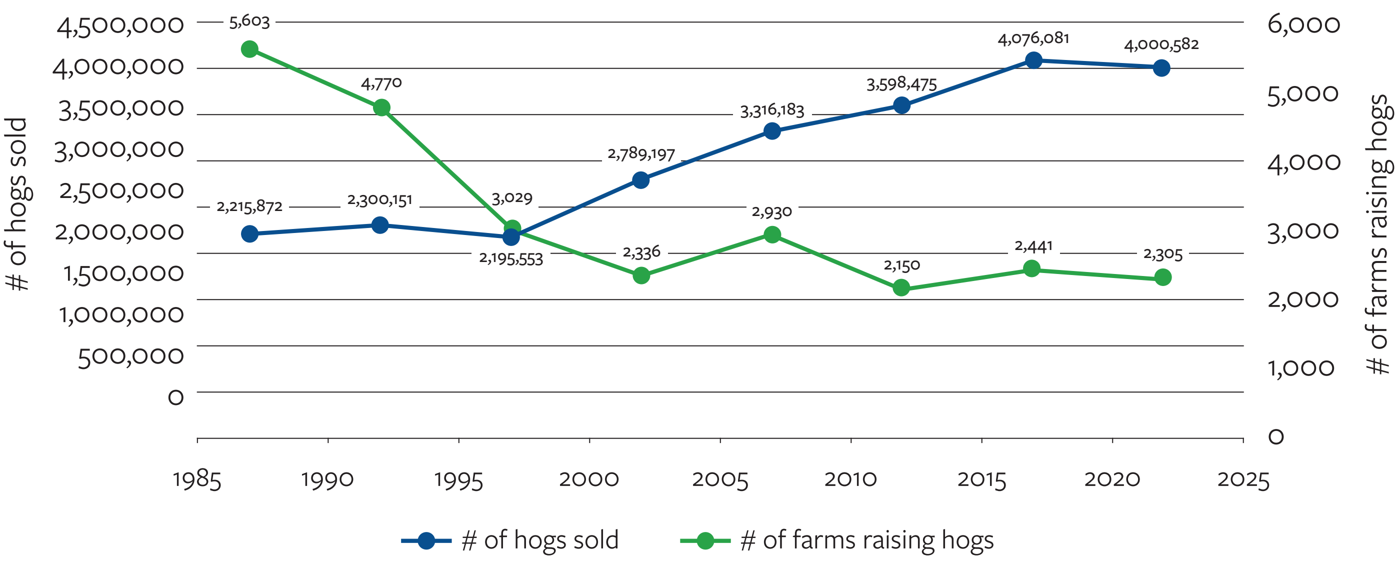


Figure 2: Michigan gained 1.78 million hogs while losing 3,298 hog farms since 1987. Source: USDA Agricultural Census



II. CAFOs Generate Massive Volumes of Dangerous Waste

As of 2012, large CAFOs in the United States produced more than 20 times the volume of fecal wet mass produced by all of the country's humans.[2] In Michigan, permitted CAFOs (not including small and medium-sized AFOs which do not have to get permits) reported producing 3.9 billion gallons of liquid waste and 1.3 million tons of dry waste in 2020 alone.[3] According to MSU calculations, that translates to approximately 62.7 million pounds of fecal waste per day,[4] which is 17 million pounds per day more than is produced by the state's entire human population of over 10 million.[5] Fecal waste can be dangerous in small amounts, but it is far worse in vast concentrations, especially in the way it is collected, stored, and disposed of on CAFOs.

Most dairy and many hog CAFOs use wet manure systems, storing manure and other waste in liquid form, often in open cesspits euphemistically called "lagoons." As the lagoons fill up, CAFO operators or third-party manure haulers apply the untreated waste to crop fields—ostensibly as fertilizer since manure does contain some nutrients that crops need, like nitrogen and phosphorus.

But liquid CAFO waste is costly to transport and hauling costs generally exceed fertilizer value whenever waste is hauled farther than one mile. As a result, CAFOs apply far more nutrients to nearby agricultural fields than crops need. This is particularly true for phosphorus, which accumulates in soil. And when there are more nutrients than the soil can absorb, those excess nutrients can more easily end up in our water, as we explain on pages 10-13.

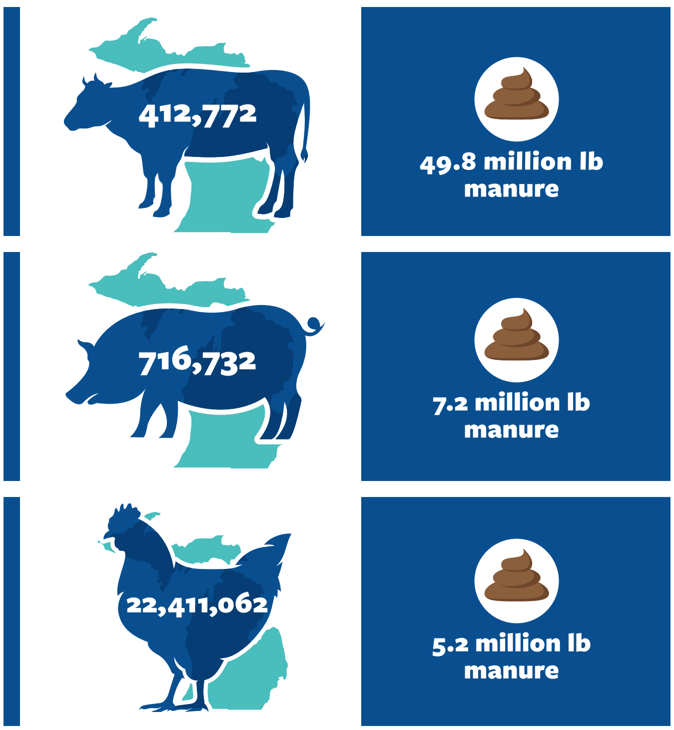
Making matters worse, CAFO waste also contains many components which have no agronomic benefit at all or are affirmatively harmful, including wastewater runoff, detergents, antibiotics, *E. coli* and other pathogens, and PFAS.

Figure 3: Michigan's 290 permitted CAFOs produce 17 million pounds more waste per day than the state's population of 10 million people.

Sources: EGLE & MSU Extension.

The reality is that the primary goal of CAFO waste spreading is waste disposal, not crop fertilization. CAFOs gain a significant economic advantage by concentrating their industrial production and offloading their waste in this way. This comes at the expense not only of smaller family-scale farmers, but also the environment.

Figure 4: Pounds of manure per day produced by animal categories: dairy cows, beef cattle; swine; turkeys, roasting chickens, and laying hens.



Source: EGLE.

What Pollution do CAFOs Cause?

Excess nutrients and *E. coli* are the CAFO waste components that pose the biggest threat to water quality and human health, both in Michigan and nationally.[6] Indeed, public health agencies have been warning about the dangers of CAFOs for years. In 2010, at the encouragement of the CDC, National Association of Local Boards of Health wrote a report outlining the human health consequences of CAFO-caused pollution. In 2017 and again in 2022, public health organizations signed onto legal petitions asking the U.S. EPA to better regulate CAFOs. These documents and others[7] provide extensive information about the myriad public health and environmental threats created by the CAFO business model. We provide only a high-level summary of CAFO threats to water quality here, focusing on Michigan-specific impacts.

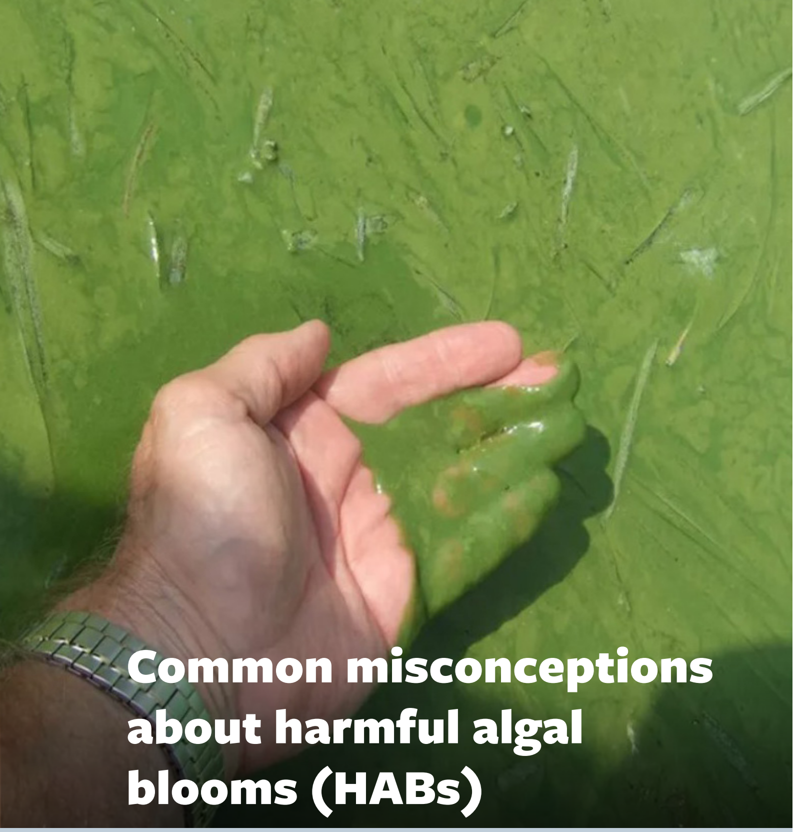
Excess Nutrients (Phosphorus & Nitrates)

Two primary nutrients can pollute water in excessive amounts: phosphorus and nitrogen. Both are essential for plant growth, but there are limits to their benefits. CAFO waste is often overapplied or misapplied, leading to nutrient loss into water. When that happens, nutrients shift from helpful soil additives to harmful contaminants.

Phosphorus

Phosphorus — in particular, dissolved reactive phosphorus (DRP) — is driving the formation of harmful algal blooms (HABs) in many surface waters.[8] Known for their green sludgy appearance and foul odor, HABs are large accumulations of cyanobacteria. HABs are not just aesthetically unappealing; they can also generate dangerous hepatotoxins and neurotoxins which, if consumed, have been linked to kidney and liver damage, gastrointestinal distress, infections, dementia, amnesia, other neurological damage, and even death. As reflected in Figure 5, algal toxins (also called cyanotoxins) are more toxic by orders of magnitude than other toxic compounds, including cyanide and DDT. Even after HABs are no longer visible, the cyanotoxins they generate can persist and even travel downstream.

HABs have become a regular occurrence in western Lake Erie, Saginaw Bay in Lake Huron, and elsewhere across the state, harming local businesses, outdoor recreation, and public health. In 2014, a HAB outbreak forced a shutdown of the Toledo water supply, cutting off water access to 400,000+ people. Under Annex 4 of the Great Lakes Water Quality Agreement,[9] the U.S., Canada, Michigan, Ohio, Indiana, and the Province of Ontario agreed to reduce phosphorus loading into Lake Erie by 40% from 2008 levels by 2025. The region is far from achieving this goal. ELPC and local communities have been fighting to hold state and federal authorities responsible for cleanup ever since. Lake Erie is one of the most visible waterways harmed by HABs, but it is not alone.



Common misconceptions about harmful algal blooms (HABs)

HABs are only a problem if you can see green sludge.

FALSE: Toxicity and visibility are not directly related. Some HABs that are sludgy and highly visible can contain few or no cyanotoxins, while crystal clear water can contain dangerous levels of cyanotoxins.

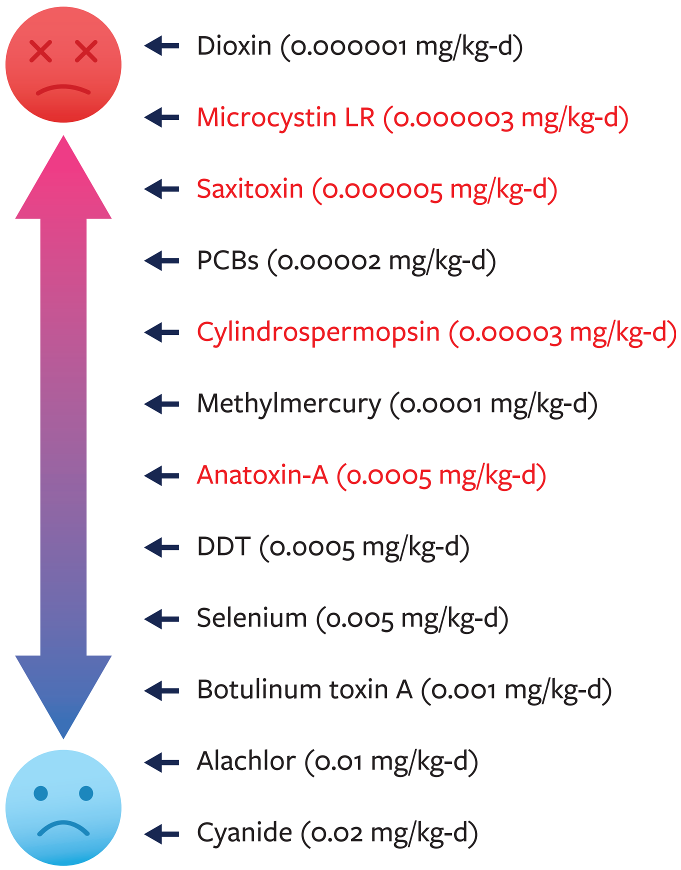
HABs only form in relatively warm, shallow waters like Lake Erie, the shallowest and warmest Great Lake.

FALSE: HABs can form in any temperature or depth of water; recent studies have discovered HABs in Lake Superior (the deepest and coldest Great Lake) and even the Arctic Ocean.

HABs are only a problem in a few places, like Lake Erie.

FALSE: HABs have been documented across the state, including in numerous inland waterbodies and even in the Upper Peninsula, and across the country. HABs can occur in moving water bodies (streams and rivers), not just lakes.

Figure 5: Algal toxins (indicated by red text) are more toxic than other compounds found in water.



Reference dose = amount that can be ingested orally by a person, above which a toxic effect may occur, on a milligram per kilogram body weight per day basis.

Cyanotoxins are not currently subject to regulation under the federal Safe Drinking Water Act, and Michigan has not created water quality standards for them either. Unlike the City of Toledo, Michigan water utilities do not routinely conduct routine water testing for cyanotoxins. The Michigan Department of Health and Human Services (MDHHS) developed a mapping tool to track cyanobacteria blooms, but MDHHS is only made aware of these incidents, by and large, through citizen reporting, not by any systematic water testing program. As a result, the MDHHS mapping data almost certainly understates the HAB threat.

Most people are not even aware of these risks, because cyanotoxins can contaminate water without visible indicators. For example, in Adrian, Michigan, which is in a CAFO-heavy watershed, Wayne State University conducted a study of home tap water and found disturbing results. Dangerous neurotoxins and liver toxins were detected in an inlet to the city's drinking water system, the Lake Adrian reservoir. And even though the tap water had undergone treatment for safety and potability, samples contained Microcystis aeruginosa (harmful algae), a species of cyanobacteria, and two algal toxins it can produce, microcystin and anatoxin-a.[10]

Nitrogen

HABs generally impact surface waters, but Michigan's groundwater is also at risk from CAFO pollution. Nearly half of Michigan households depend on groundwater aquifers for drinking water.[11] Nitrates from CAFO waste can leach into groundwater — indeed, the "lagoons" that CAFOs use to store millions of gallons of waste unavoidably leak underground.[12] That puts the groundwater aquifers at risk.[13]

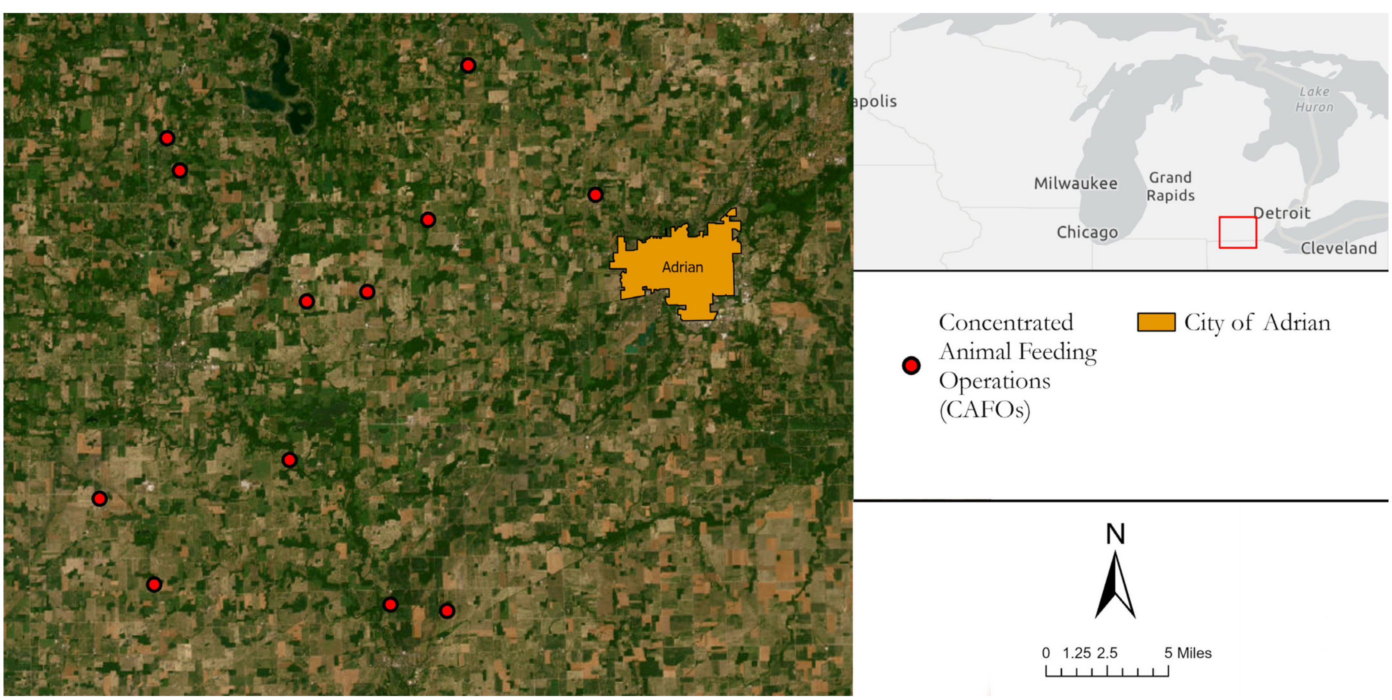
When consumed, nitrates in well water can hinder the ability of blood to carry oxygen, and nitrate exposure has been linked to birth defects, miscarriage, and cancer. Nitrates can be especially harmful to infants, leading to a potentially fatal condition called blue baby syndrome. The public is increasingly paying attention to nitrate pollution and its link to cancer across the Midwest. [14] In June 2023, U.S. EPA agreed to restart its human health assessment of nitrate and nitrite, which had been suspended under the Trump administration, though that process is likely to take years.

E. Coli and Other Pathogens

E. coli is a fecal coliform that lives in the intestines of warm-blooded animals. The Department of Environment, Great Lakes, and Energy (EGLE), which is responsible for regulating CAFOs in Michigan, estimates that approximately 50% of the state's rivers and streams exceed water quality standards for *E. coli*. Because so many waterways are impaired by *E. coli*, Michigan has prepared a statewide pollution diet plan, known as a TMDL (total maximum daily load), specifically for *E. coli*. See Section 2 for more on TMDLs.

Even partial body contact with water containing elevated *E. coli* levels can cause illness by infection of wounds, or indirect entry to the body (e.g., hand to mouth, hand to eyes, etc.). Total body contact can cause gastroenteritis, cryptosporidiosis, cholera, and other intestinal parasites. Given how many of Michigan's waterways are impaired by *E. coli*, Michiganders are at particularly high risk of infection.

Figure 6: Map showing CAFOs near the city of Adrian, in Southeast Michigan."



CAFO Pollution Causes Other Significant Environmental Harms

CAFO-caused water pollution damages biodiversity. HABs deplete dissolved oxygen levels and fuel the growth of toxic organisms, leading to major fish kills, harming the endocrine and reproductive systems of fish, and reducing diversity of fish species. In Michigan, the threatened piping plover bird is sensitive to pollutants from CAFOs, and its range overlaps significantly with areas where CAFOs are concentrated.

CAFOs not only threaten water *quality*; they are also a significant burden on water *quantity*. Livestock production is extremely water-intensive: not only is water needed to irrigate the animals' feed crops, but also to manage and clean CAFOs. Beef and dairy operations are particularly heavy water consumers, with wash water consisting of up to 50% of lagoon volume on a dairy CAFO. Altogether, agriculture uses 70% of the world's fresh water supply.

The Great Lakes provides 90% of the United States' surface fresh water, so access to clean, abundant water may not feel like a concern in coastal regions of Michigan, but MSU and others warn that such security may not last forever. Inland areas of the state, including Ottawa County, are already running out of groundwater, prompting a group of academics, environmentalists, and regulators to release an October 2021 report highlighting the problem. If the region becomes a "climate haven," as many predict, water resources will be further strained.

Water pollution exacerbates water scarcity. Water scarcity has historically been measured from a purely quantitative perspective: how much water by volume will be available under different modeling scenarios. But "clean water scarcity" accounts for not only quantity but also the quality of water, and whether it is able to support human, plant, and animal life. A recent study found that global clean water scarcity would *triple* due to nitrogen pollution worldwide. This translates into an additional three billion more people potentially facing water scarcity by 2050.

Currently, Michigan only requires water withdrawal permits for operations using more than two million gallons per day. A review of MiEnviro, the state's public access website for water permit information, suggests that Michigan does not currently require any CAFOs to carry withdrawal permits, even though collectively, the beef cattle and dairy cows raised on the state's CAFOs consume 20 million gallons of water per day.[15]

CAFO pollution is also linked to other significant environmental and human health harms, including:

- Disease transmission;[16]
- Antibiotic resistance;[17]
- Air pollution;[18]
- Climate impacts;[19]
- PFAS transport.[20]

Figure 7: Piping Plover

How do CAFO Pollutants Travel into Water?

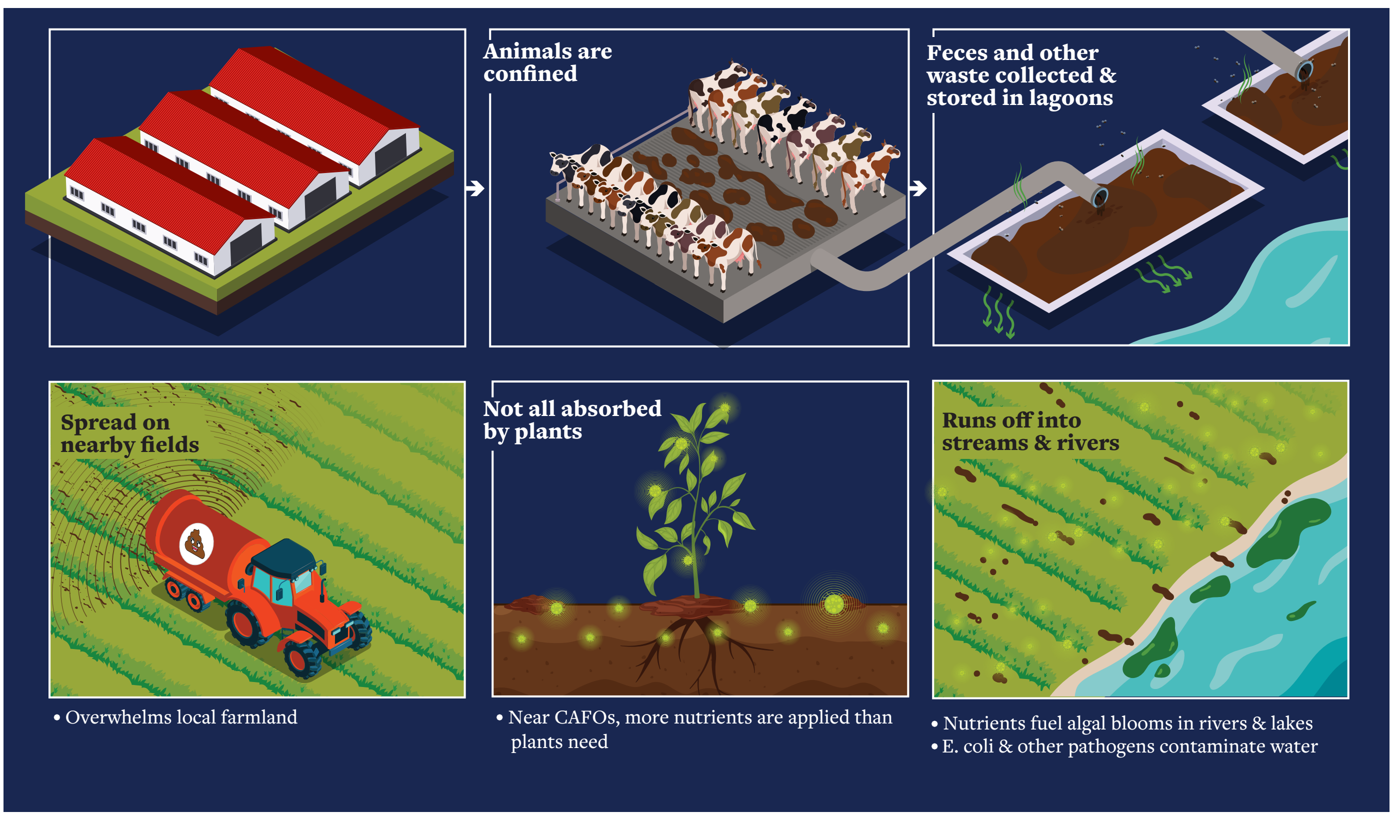
Livestock pollution travels into Michigan's surface waters through two primary pathways: 1) overland runoff and 2) underground tile drainage systems. CAFO pollution can also leach into groundwater, which flows through underground geologic formations of soil, sand, and rocks called aquifers. The excess nutrients and pathogens from CAFO waste can either come directly from the "production area" where animals are confined and waste is stored or from "land application areas," which refers to fields where CAFO waste is spread. Each source and pathway present unique challenges to reducing risk of pollution; we'll get into each of these here.

Overland Runoff

Overland runoff is water that has flowed over farm soil and into an adjacent surface water body. Runoff from fields can carry soil, as well as anything else that was applied to the field, including nutrients, pesticides, pathogens, and other contaminants. When these pollutants run off the field, they don't just disappear. They follow the path of the water in which they are suspended. In Michigan, that means they flow into the statewide system of manmade and natural ditches — also called drains — which all flow into the state's rivers, lakes, and streams.

Runoff is generally associated with land application areas: agricultural fields on which CAFO waste has been applied. But pollutants can also run off from the production area of a CAFO — the barns, milkhouses, lagoons (animal sewage cesspits), and other structures that constitute a CAFO's operations.

Figure 8: Runoff from industrial-scale animal production



Tile Drainage

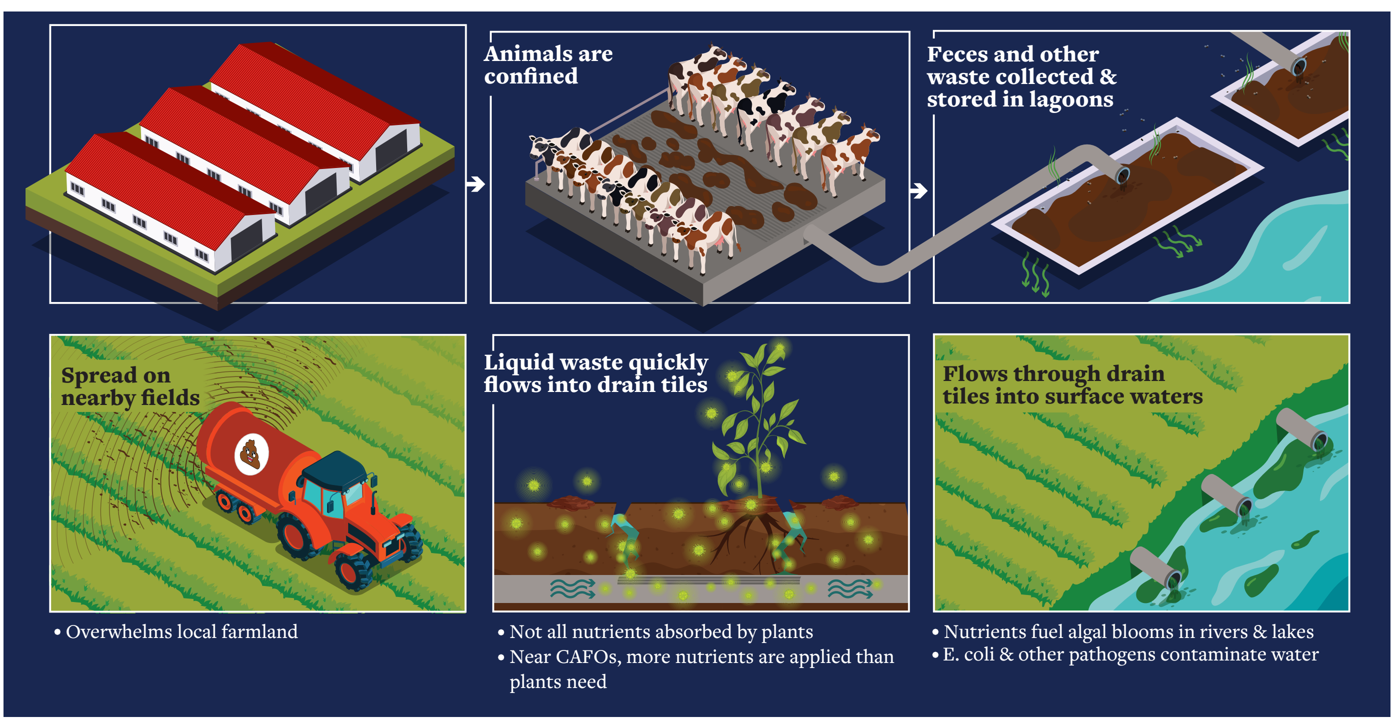
Tile drainage is an often overlooked but critically important pollution pathway, particularly for liquid CAFO waste and particularly in Michigan. Historically, wetlands covered big swaths of Michigan, including major parts of the Western Lake Erie Basin (southeastern corner of the state), and the Thumb (northeastern peninsula in Lake Huron). Tile drainage was installed to make agriculture possible in these once-wet, swampy areas. Tile drainage systems work by drawing liquid from the land's surface into underground pipes. Those pipes discharge into human-made ditches or streams, and eventually into surface waters.

The problem with liquid CAFO waste is that it behaves like water.[21] When liquified manure and other CAFO waste is spread on a tile-drained field, some portion of it flows down into the tile system, bringing dissolved nutrients and other contaminants along with it. Those contaminants are then discharged into surface waters along with the liquid that contains them. Billions of gallons of liquid CAFO waste are applied to Michigan farmland every year. Studies have shown that more pollutants leave the field through subsurface drainage than through overland runoff, and that tile drainage discharges happen even during times of low precipitation, making them particularly challenging to control using conventional methods.

The science on this is well-established and new studies continue to affirm: when liquid waste is spread on tile-drained land, some of its nutrients/pathogens/other pollutants will inevitably end up in the state's waters.[22] This transport can happen even if the waste is applied at what is referred to as the "agronomic rate," or the amount of nutrient that the soil needs to maintain growing crops. But CAFO waste is often applied far in excess of agronomic need; indeed, Michigan's CAFO permit allows waste to be applied at levels five times higher than what plants actually need. These high limits serve no agronomic purpose but instead facilitate CAFOs' ability to cheaply dispose of their waste, as discussed in further detail in Section 2.

Understanding tile drainage is critical to understanding why there has been so little progress in reducing nutrient pollution so far. Rather than grappling with its unique challenges, most proposed solutions understate or ignore the realities of tile drainage. For example, many models used by universities and research institutions to estimate nutrient loss do not account for tile drainage, and the vast majority of voluntary BMPs do not work on tile-drained fields; some BMPs make nutrient loss worse, as explained in further detail on page 23.

Figure 9: Tile drainage discharge from industrial-scale animal production



Tile Drainage 101

Photo credit: J. Frankenberger

What: Tile drainage systems ("tiles") are underground pipes that deliver liquid from the land's surface into human-made ditches or streams. The word "tiles" comes from early use of foot-long sections of clay pipe to accomplish drainage. Now, perforated plastic pipes are generally used.

Why: Tile drainage was installed in the WLEB and the Thumb because the land was too swampy and wet for agriculture without artificial drainage.[23]

How: Tile drainage systems lower the water table and make former swampland dry enough to grow crops. The easiest way to think of these drainage systems is like an underground sewage system that is transporting rain, CAFO waste, fertilizers, and anything else that is applied to tile-drained land from the surface down into the underground drainage system.

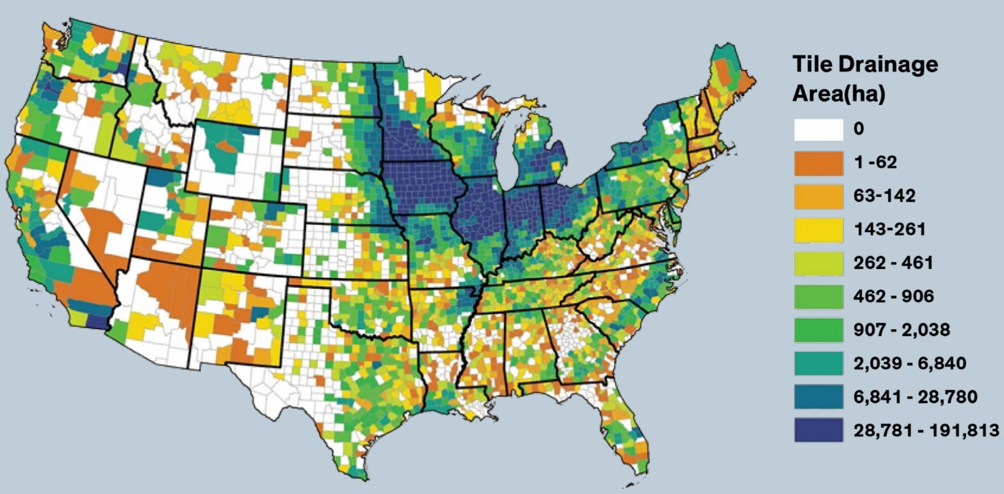
Liquid can enter subsurface drainage systems in two ways. First, it can flow down through the extensive cracks, root holes, earthworm burrows, or other "preferential flow paths" that pervade many of Michigan's soils. Second, liquid can enter manmade devices (inlets, intakes, and risers) installed on field's lowest points which convey the liquid into the subsurface drainage system. Piping is installed at an angle so that it flows by gravity, emptying into a stream or other surface water, or into a manmade ditch (which will eventually flow into a stream or other surface water).

Where: As of 2017, over three million acres of Michigan farmland (about 38%) are drained by tile. The clay and clay loam soils found in the southwest portion of the Lake Erie watershed are among the most intensively drained regions of the United States. In the CAFO-heavy counties in the WLEB and the Thumb, between 60-72% of the agricultural land was tile-drained as of 2017.

Tiles don't just exist on fields. Tiling or other types of underground piping is also used on many livestock production sites to manage waste flow. For example, CAFOs need to move manure, urine, and other waste away from milkhouses and animal barns and into manure storage lagoons. That is often accomplished via underground piping. Even though federal and Michigan regulations require production area waste to drain into lagoons or other waste storage structures, Michigan CAFOs have been caught discharging production area waste into surface waters through tile drainage systems.

WHAT'S THE SOLUTION? When liquid travels through soil into tile pipes and discharges into surface waters, the system is working exactly as designed. The problem is not with the system itself. The problem is with what is being applied to the land's surface: highly liquified, hazardous waste. The only way to prevent water pollution through tile drainage is to not apply liquid waste onto tile-drained fields at all. If CAFO waste is going to applied on tile-drained fields, it needs to be less liquid.[25]

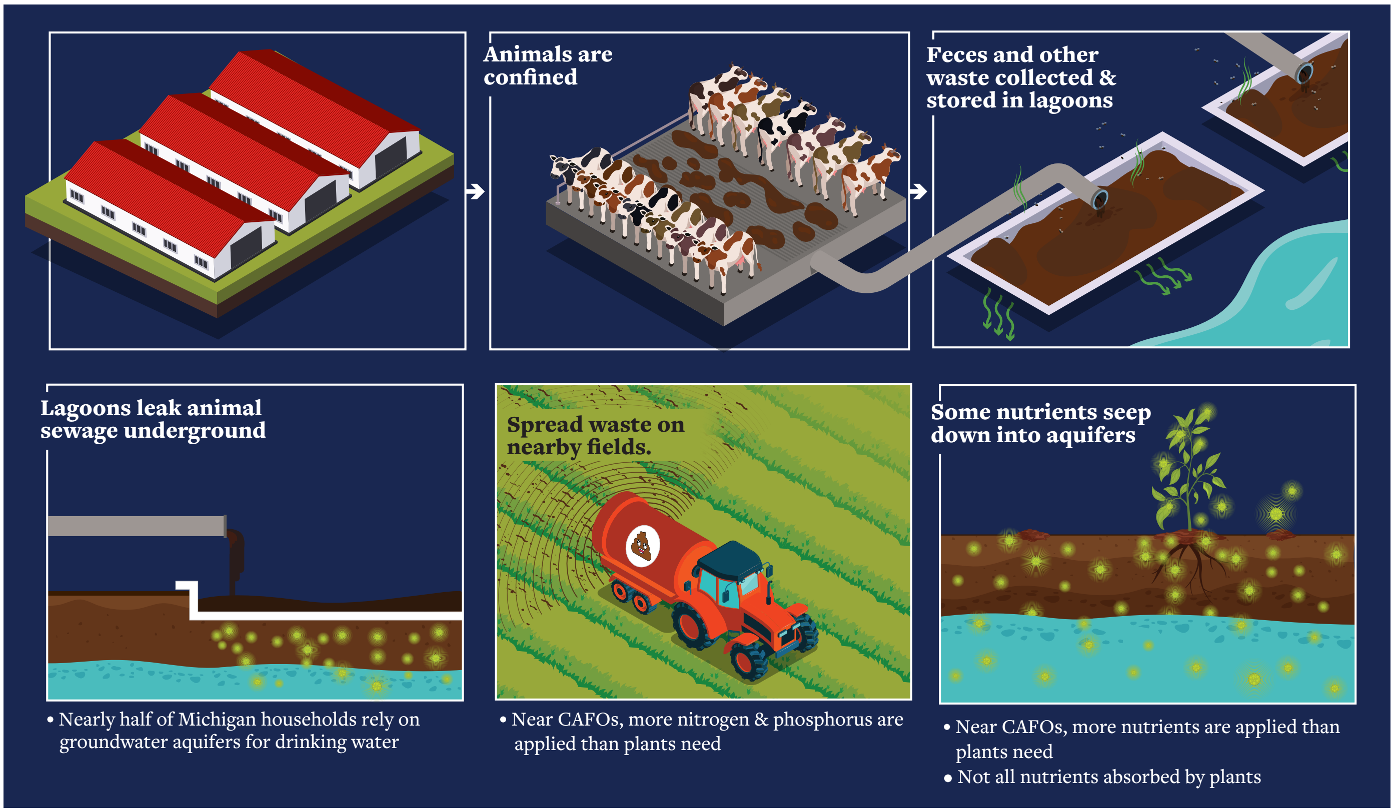
Figure 10: USDA Census of Agriculture tile drainage area, 2017.[24]



Groundwater Contamination

Like surface water, groundwater can also be contaminated by CAFO pollutants. Certain geographic and hydrologic regions are highly susceptible to groundwater contamination, including karstic regions and regions with a shallow depth to bedrock. Groundwater contamination can originate at either a land application area or the production area. When CAFO lagoons leak, their seepage can discharge pollutants directly into the aquifer from the production area. From land application areas, excess nutrients, pathogens, and other pollutants that are not taken up by crops or caught in tile systems can seep down into the soil and leach into groundwater, contaminating drinking wells. As referenced above, many Midwest states are struggling with nitrate pollution and are growing concerned about its link to cancer, blue baby syndrome, and other negative health consequences.

Figure 11: Groundwater contamination from industrial-scale animal production



III. Voluminous Evidence Links CAFOs with Water Pollution

The relationship between CAFOs and water pollution is well-established. The Department of Environment, Great Lakes, and Energy (EGLE) acknowledges that CAFOs contribute to phosphorus pollution in Michigan, and the data that they and others have gathered over the years backs that up.

Water Testing Data

Years of water testing data bears out the connection between CAFOs and water pollution. *E. Coli* is a strong indicator of fecal contamination, and EGLE has water testing data showing *E. Coli* present in Michigan waters for years. Of the 290 permitted CAFOs in Michigan, 83% (or 241) are located in a sub-watershed that EGLE has designated as "impaired" (not meeting water quality standards) by *E. coli* on EGLE's *E. coli* Pollution and Solutions Mapper. Given the large number of animals on a CAFO, even one or two operations can have a huge impact on water quality nearby.

According to the mapper, one impaired subwatershed in the center of the state[25] has just two CAFOs within its boundaries, but the humans are vastly outnumbered by animals (850 humans v. 800 hogs and 3,000 cattle). Another subwatershed in the Thumb[26] has five CAFOs within its boundaries, and the ratio of humans to animals is even more striking (2,100 humans v. 3,000 hogs and 10,000 cattle). Both have a "high" degree of land with subsurface tiling, and in both places, 100% of the water samples taken exceeded EGLE's 30-day total body contact thresholds for *E. coli*.[27]

Environmentally Concerned Citizens of South Central Michigan (ECCSCM) also conducts water testing in the Raisin River and Bean Creek watersheds — both of which feed into Lake Erie — for *E. coli*, and DNA analysis for different genera of cyanobacteria, cyanotoxins, and source species DNA from Bacteroides.[28] Of all sites tested, 85% of samples exceeded EGLE's "total body contact" maximum for *E. coli*—a level of exposure that is linked to serious illness, including cholera and other intestinal parasites. Animal and cyanobacteria DNA were found in a majority of the samples as well.

DNA (sample positive out of samples tested for that parameter)

- DNA Bacteroides – Cattle = 81%
- DNA Bacteroides – Swine = 40%
- DNA Cyanobacteria - Unidentified (2017) or Other than Tested (2018) = 64%
- DNA Cyanobacteria – Microcystis = 50%
- DNA Cyanobacteria – Planktothrix = 50%
- DNA Cyanobacteria – Anabaena = 36%
- DNA Microcystin = 78%
- DNA Anatoxin = 100%

Figure 12: Michigan map shows many areas battling *E. Coli* pollution have a lot of CAFOs as well. Pink areas indicate watersheds under a pollution management plan for *E. Coli*. Green dots represent CAFOs. About 83% of CAFOs exist in a current *E. Coli* TMDL watershed, and many waterbodies have not yet been assessed.

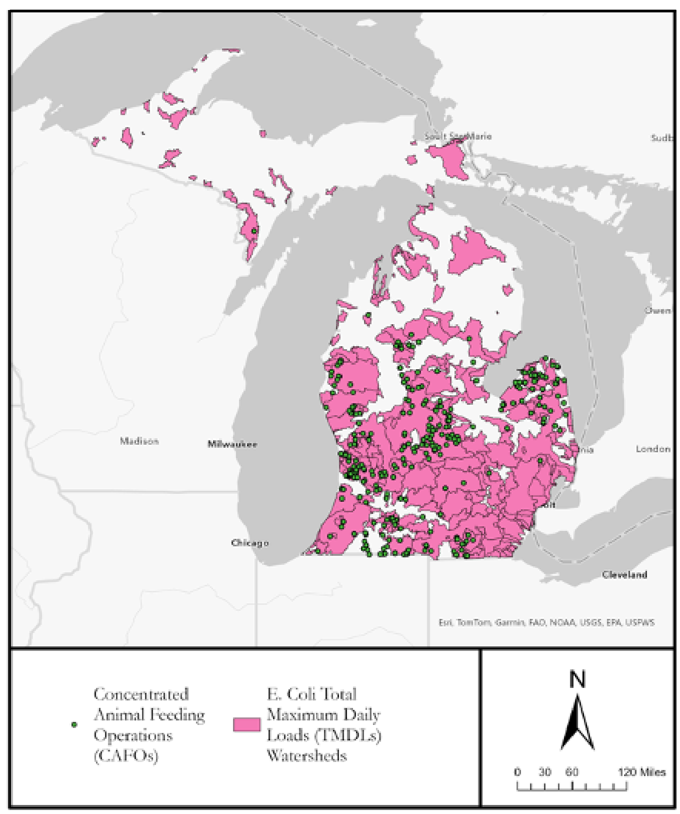
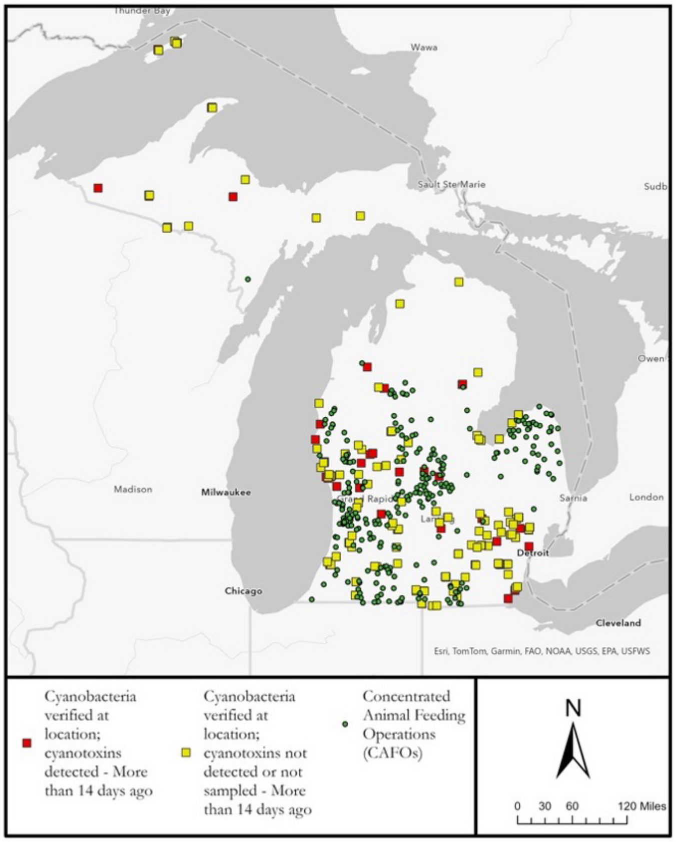


Figure 13: Parts of Michigan with many CAFOs often have abundant cyanobacteria, also known as Harmful Algal Blooms (HABs). HABs can also produce cyanotoxins, which are more dangerous than cyanide. Yellow squares indicate cyanobacteria, while red squares indicate the presence of cyanotoxins as well.



Enforcement Data

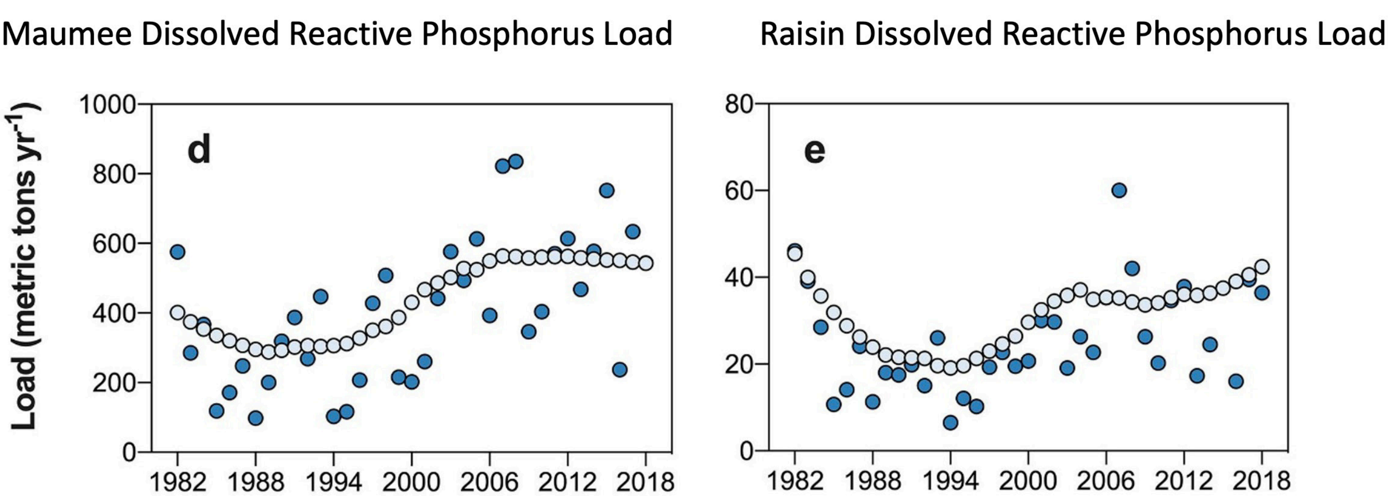
As discussed in further detail on pages 36-37, available enforcement data show that CAFOs frequently violate their permits and/or the environmental laws of the state. According to data available on EGLE's MiEnviro Portal, EGLE has logged over 2,000 violations against Michigan's permitted CAFOs since 2015.[29] This almost certainly underrepresents the problem because many CAFO waste discharges are never identified, and most water pollution is invisible.

Rise in CAFOs Coincides with Rise in Algal Blooms

After implementation of the Clean Water Act in the 1970s, dissolved phosphorus levels steadily decreased, due largely to better regulation of industrial polluters and wastewater treatment plants. But that decline reversed in the 1990s, when dissolved phosphorus levels began a steep rise. This correlated directly with the shift to the CAFO model of livestock agriculture and the use of liquid manure systems, which, as discussed above, deliver large loads of dissolved phosphorus through tile drainage systems.

The charts at Figure 14 show a correlation between the rise of dissolved reactive phosphorus loads into Lake Erie (which is the primary driver of HABs) and the rise of CAFOs in the 1990s.

Figure 14: Maumee River and River Raisin dissolved reactive phosphorus loading declined after the Clean Water Act, then rose again in the 1990s after the CAFO model took hold.



Source: ScienceDirect.

Dr. Tim Boring, the Director of Michigan's Department of Agriculture and Rural Development (MDARD) acknowledges that consolidation in livestock production is contributing to the phosphorus problems in the Western Lake Erie Basin. In a keynote address in December 2023, he noted that livestock production in Michigan has seen "tremendous consolidation," with "fewer and fewer livestock farms" housing "more and more cows and a limited [geographic] footprint."[30] Dr. Boring suggests that livestock producers will need to move away from a "waste disposal mindset" before things will get better. To put an even finer point on it, Dr. Boring noted that Michigan has "a manure location problem, not a manure quantity problem," and that "we are putting too much manure in too few places today." Without "structural" changes and serious thinking about "what the future of ag looks like," the situation is unlikely to get better.