Pace Environmental Law Review

Volume 31
Issue 2 *Spring 2014*
Special Issue on Animal Law

Article 3

April 2014

Using Emerging Pollution Tracking Methods to Address the Downstream Impacts of Factory Farm Animal Welfare Abuse

Tarah Heinzen
Environmental Integrity Project

Abel Russ
Environmental Integrity Project

Recommended Citation
Tarah Heinzen and Abel Russ, *Using Emerging Pollution Tracking Methods to Address the Downstream Impacts of Factory Farm Animal Welfare Abuse*, 31 Pace Envtl. L. Rev. 475 (2014)
DOI: https://doi.org/10.58948/0738-6206.1744
Available at: https://digitalcommons.pace.edu/pelr/vol31/iss2/3

ARTICLE

Using Emerging Pollution Tracking Methods to Address the Downstream Impacts of Factory Farm Animal Welfare Abuse

TARAH HEINZEN* & ABEL RUSS*

I. INTRODUCTION

The vast majority of the meat, eggs, and dairy products produced in the United States originate not in the farmyards and pastures you see on packages and in advertisements, but in industrial factory farms, also known as concentrated animal feeding operations (CAFOs).[1] Factory farming, well known for its

* Attorney, Environmental Integrity Project.

1. EPA defines a large CAFO as an animal feeding operation that

   stables or confines as many as or more than the numbers of animals specified in any of the following categories:

   (i) 700 mature dairy cows, whether milked or dry;

   (ii) 1,000 veal calves;

   (iii) 1,000 cattle other than mature dairy cows or veal calves. Cattle includes but is not limited to heifers, steers, bulls and cow/calf pairs;

   (iv) 2,500 swine each weighing 55 pounds or more;

   (v) 10,000 swine each weighing less than 55 pounds;

   (vi) 500 horses;

   (vii) 10,000 sheep or lambs;

   (viii) 55,000 turkeys;

   (ix) 30,000 laying hens or broilers, if the AFO uses a liquid manure handling system;

   (x) 125,000 chickens (other than laying hens), if the AFO uses other than a liquid manure handling system;

   (xi) 82,000 laying hens, if the AFO uses other than a liquid manure handling system;

   (xii) 30,000 ducks (if the AFO uses other than a liquid manure handling system); or

   (xiii) 5,000 ducks (if the AFO uses a liquid manure handling system).

40 C.F.R. § 122.23(b)(4) (2014). A medium CAFO includes

widespread animal welfare abuses, is also one of the largest sources of surface and ground water pollution in the United States. In fact, the practices adopted to keep animals alive and boost profits in unsanitary CAFOs also affect the scale and nature of pollution discharged from these facilities.

CAFO manure contains many toxic pollutants, including pharmaceuticals, hormones, heavy metals, and pathogens that compromise animal welfare. In addition, stressful and crowded confinement conditions foster disease, necessitating the

> any AFO with the type and number of animals that fall within any of the ranges listed in paragraph (b)(6)(i) of this section and which has been defined or designated as a CAFO. An AFO is defined as a Medium CAFO if:
>
> (i) The type and number of animals that it stables or confines falls within any of the following ranges:
>
> (A) 200 to 699 mature dairy cows, whether milked or dry;
>
> (B) 300 to 999 veal calves;
>
> (C) 300 to 999 cattle other than mature dairy cows or veal calves. Cattle includes but is not limited to heifers, steers, bulls and cow/calf pairs;
>
> (D) 750 to 2,499 swine each weighing 55 pounds or more;
>
> (E) 3,000 to 9,999 swine each weighing less than 55 pounds;
>
> (F) 150 to 499 horses;
>
> (G) 3,000 to 9,999 sheep or lambs;
>
> (H) 16,500 to 54,999 turkeys;
>
> (I) 9,000 to 29,999 laying hens or broilers, if the AFO uses a liquid manure handling system;
>
> (J) 37,500 to 124,999 chickens (other than laying hens), if the AFO uses other than a liquid manure handling system;
>
> (K) 25,000 to 81,999 laying hens, if the AFO uses other than a liquid manure handling system;
>
> (L) 10,000 to 29,999 ducks (if the AFO uses other than a liquid manure handling system); or
>
> (M) 1,500 to 4,999 ducks (if the AFO uses a liquid manure handling system); and
>
> (ii) Either one of the following conditions are met:
>
> (A) Pollutants are discharged into waters of the United States through a man-made ditch, flushing system, or other similar man-made device; or
>
> (B) Pollutants are discharged directly into waters of the United States which originate outside of and pass over, across, or through the facility or otherwise come into direct contact with the animals confined in the operation.

40 C.F.R. § 122.23(b)(6) (2014).

prophylactic use of antibiotics; antibiotics are also routinely used because they enhance livestock growth. Even potentially useful nutrients in factory farm manure frequently become pollutants due to over-application, because the concentration of animals within facilities, as well as the geographic consolidation of the industry itself, creates more nutrients than crops can absorb. As a result, excess nutrients and other toxic pollutants leach or run off into surrounding waters, threatening public health and ecosystems downstream.

Despite growing evidence of the environmental, animal welfare, and public health threats of factory farming, the animal agribusiness industry continues to exert its political influence to escape the pollution control regulations that have dramatically reduced pollution in almost every other industry. Regulators and citizens face many legal and evidentiary hurdles in their efforts to hold factory farm operators accountable for their water pollution. Overcoming these hurdles and proving that a CAFO is polluting surface or groundwater therefore requires extensive evidentiary support and novel evidentiary techniques.

CAFOs present numerous interconnected ethical, environmental, and public health threats, and this article will discuss opportunities to address the multiple adverse impacts of factory farming through advances in pollution tracking methodologies. The first section will introduce the factory farm issue, and the relationship between its environmental and welfare consequences. We then review approaches to establishing liability for surface and groundwater contamination under existing pollution control laws and describe the unique challenges of using these approaches in the context of CAFO pollution. We then discuss techniques that have been used to more precisely identify sources of pollution, including measurements of a range of chemicals and bacteria, pharmaceuticals used in livestock operations, antibiotic resistance, microbial source tracking, and fecal source tracking. We continue with a discussion of the state of the science and law with regard to these novel pollution tracking methods. To better understand the remaining barriers to effective use of emerging science in this arena, we conclude with a review of judicial acceptance of novel analytical techniques in CAFO-related and other contexts.

II. FACTORY FARMS ARE SIGNIFICANT SOURCES OF WATER POLLUTION

Factory farms concentrate hundreds or thousands of animals in small areas, and as a result generate, store, and must ultimately dispose of tremendous volumes of manure and other waste. In fact, the U.S. Environmental Protection Agency (EPA) estimates that animals raised in confinement in the United States produce three times the waste humans do – more than 300 million tons per year.[2] Factory farms store waste in large pits or lagoons and dispose of it on cropland. The production methods employed by these facilities have changed not only the volume and management, but also the nature of the waste: factory farm waste streams are a toxic brew of manure pollutants such as nitrogen, phosphorus, and bacteria, as well as antibiotics and other pharmaceuticals, pathogens resistant to antibiotics, hormones, and toxic metals.[3]

Discharged pollutants can contaminate drinking water resources, impair surface water quality, and damage ecosystems while endangering human health and welfare. EPA has concluded that "[a]gricultural operations, including CAFOs, now account for a significant share of the remaining water pollution problems in the United States,"[4] and that agriculture "is the leading contributor of pollutants to identified water quality impairments in the Nation's rivers and streams."[5] Twenty-nine states have recently made similar findings, identifying animal feeding operations as contributors to water quality impairment in EPA's 2009 National Water Quality Inventory.[6]

2. National Pollutant Discharge Elimination System (NPDES) Concentrated Animal Feeding Operation (CAFO) Reporting Rule, 76 Fed. Reg. 65,431, 65,433 (Oct. 21, 2011) [hereinafter NPDES CAFO Reporting Rule].

3. *Id.* at 65,433-34.

4. National Pollutant Discharge Elimination System (NPDES) Permit Regulation and Effluent Limitation Guidelines and Standards for Concentrated Animal Feeding Operations (CAFOs), 68 Fed. Reg. 7176, 7181 (Feb. 12, 2003).

5. *Id.*

6. *Id.* at 7237.

III. ANIMAL WELFARE ON FACTORY FARMS IS INSEPARABLE FROM THE INDUSTRY'S POLLUTION

Factory farming developed as a method for increasing production and lowering costs through industry and facility-level consolidation, and this consolidation has occurred at a rapid rate. Just four meatpacking companies control more than 80% of beef catting processing and more than 60% of hog processing in the United States.[7] This corporate consolidation has also led to geographic clustering of factory farms and their waste.[8]

The artificial efficiencies gained by externalizing social, environmental, public health, and animal welfare costs have allowed the industrial livestock production model to proliferate, rapidly replacing traditional family farms that use pasture-based production systems throughout the United States. A lack of adequate federal and state oversight has facilitated this process, including incomplete and inconsistent regulation by environmental laws, exemptions from local control regulations and nuisance liability through "right to farm" laws and other policies, and a complete vacuum in animal welfare protections with regard to farmed animals.

The Animal Welfare Act is the primary federal law meant to prohibit animal cruelty, yet its definition of "animal" expressly excludes all birds and livestock animals.[9] The Humane Slaughter

7. FOOD & WATER WATCH, TURNING FARMS INTO FACTORIES: HOW THE CONCENTRATION OF ANIMAL AGRICULTURE THREATENS HUMAN HEALTH, THE ENVIRONMENT, AND RURAL COMMUNITIES 1 (2007), *available at* http://documents.foodandwaterwatch.org/doc/FarmsToFactories.pdf.

8. U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-08-944, CONCENTRATED ANIMAL FEEDING OPERATIONS: EPA NEEDS MORE INFORMATION AND A CLEARLY DEFINED STRATEGY TO PROTECT AIR AND WATER QUALITY FROM POLLUTANTS OF CONCERN, 18-23 (2008), *available at* http://www.gao.gov/new.items/d08944.pdf.

9. 7 U.S.C. § 2132(g) (2012) (defining "animal" as "any live or dead dog, cat, monkey (nonhuman primate mammal), guinea pig, hamster, rabbit, or such other warm-blooded animal, as the Secretary may determine is being used, or is intended for use, for research, testing, experimentation, or exhibition purposes, or as a pet; but such term excludes (1) birds, rats of the genus Rattus, and mice of the genus Mus, bred for use in research, (2) horses not used for research purposes, and (3) other farm animals, such as, but not limited to livestock or poultry, used or intended for use as food or fiber, or livestock or poultry used or intended for use for improving animal nutrition, breeding, management, or production efficiency, or for improving the quality of food or fiber. With respect

Act only regulates slaughter practices and therefore provides no animal welfare protections on the farm. To make matters worse, the law's implementing agency, the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) has inexplicably determined that the law's limited protections of "livestock" do not extend to poultry.[10] Poultry comprise more than 95% of non-fish farmed animals raised in the United States.[11] As a result, our federal laws provide no protections against animal cruelty on the factory farm, even though farmed animals represent a staggering 98% of domesticated animals in the country.[12]

Unsurprisingly, absent regulation, the intense confinement and mechanized production methods of the factory farm system lead to widespread animal abuses. Confinement conditions themselves pose clear welfare problems; the use of gestation crates for hogs, veal crates for calves, and battery cages for hens are particularly extreme examples of confinement conditions preventing animals from even turning around, much less engaging in natural activities.[13] Factory farms conditions are crowded and often unsanitary – breeding grounds for stress and disease. Animals crowded into such conditions are unable to express their natural behaviors, and may become aggressive. Factory farms use a variety of "physical alterations" to prevent animals from harming themselves and others, including de-beaking hens and broiler chickens, removing cattle horns, docking hogs' and dairy cows' tails, and castrating bulls, all without anesthesia.[14] The stress of confinement conditions and

to a dog, the term means all dogs including those used for hunting, security, or breeding purposes…").

10. 7 U.S.C. § 1901 (2012) (regulating only slaughter and interpreted not to apply to chickens. *See* definition of "livestock" in 9 C.F.R. § 301.2 (2014)).

11. David J Wolfson & Mariann Sullivan, *Foxes in the Hen House: Animals, Agribusiness, and the Law: A Modern American Fable*, *in* ANIMAL RIGHTS, 205, 206 (Cass R. Sunstein & Martha C. Nussbaum eds., 2004).

12. *Id.* at 207.

13. The Humane Soc'y of the U.S., An HSUS Report: The Welfare of Intensively Confined Animals in Battery Cages, Gestation Crates, and Veal Crates 2, 9 (July 2012), available at http://www.humanesociety.org/assets/pdfs/farm/hsus-the-welfare-of-intensively-confined-animals.pdf.

14. Pew Comm'n on Indus. Farm Animal Prod., Putting Meat on the Table: Industrial Farm Animal Production in America 33-35 (Apr. 29, 2008), available at http://www.pewtrusts.org/uploadedFiles/wwwpewtrustsorg/Reports/Industrial

the use of unnatural feeds also promote illness in confinement buildings. For example, cows are fed a diet of corn and soy that they are unable to properly digest, and that often causes abscesses to develop.[15] This feed also creates an acidic digestive environment in which the pathogen Escherichia coli thrives, adding another dangerous contaminant to the factory farm waste stream.[16] Over-milking facilitated by the use of growth hormones has also been linked to increased incidence of mastitis and udder sores on dairy cows.[17]

Factory farms address the health – and therefore financial – threats posed by sick animals through the prophylactic use of low levels of antibiotics, arsenicals, and other antimicrobials in livestock feed.[18] The drugs prevent many disease outbreaks with the added benefit of promoting accelerated animal growth with the same amount of feed, thereby boosting profits. In fact, an estimated 70% of all antibiotics in the United States are used in livestock production, rather than human medicine.[19] This widespread misuse promotes the development of antibiotic-resistant bacteria, which poses a growing public health threat.[20] The majority of pharmaceuticals and arsenic consumed by farm animals ends up in the manure,[21] risking contamination of

_Agriculture/PCIFAP_FINAL.pdf.

15. Anastasia S. Stathopoulos, You Are What Your Food Eats: How Regulation of Factory Farm Conditions Could Improve Human Health and Animal Welfare Alike, 13 N.Y.U. J. Legis. & Pub. Pol'y 407, 417 (2010) (citing They Eat What? The Reality of Feed at Animal Factories, Union of Concerned Scientists, http://www.ucsusa.org/food_and_agriculture/our-failing-food-system/ industrial-agriculture/they-eat-what-the-reality-of.html (last visited Mar. 10, 2014)).

16. FOOD & WATER WATCH, *supra* note 7, at 8.

17. Stathopoulos, *supra* note 15, at 420.

18. NPDES CAFO Reporting Rule, *supra* note 2, at 65,434.

19. MARGARET MELLON ET AL., UNION OF CONCERNED SCIENTISTS, HOGGING IT!: ESTIMATES OF ANTIBIOTIC ABUSE IN LIVESTOCK (2001), *available at* http://www.ucsusa.org/food_and_agriculture/our-failing-food-system/industrial-agriculture/hogging-it-estimates-of.html; *see also* EPA, LITERATURE REVIEW OF CONTAMINANTS IN LIVESTOCK AND POULTRY MANURE AND IMPLICATIONS FOR WATER QUALITY 29 (July 2013) [hereinafter LITERATURE REVIEW] (estimating that sales of antimicrobials for livestock in the United States are four times greater than sales for human use).

20. PEW COMM'N ON INDUS. FARM ANIMAL PROD., *supra* note 14, at 5.

21. EPA estimates that 80-90% of some antibiotics administered to livestock end up in the animals' waste. NPDES CAFO Reporting Rule, *supra* note 2, at 65,434; *see also* Scott A. Bradford et al., *Reuse of Concentrated Animal Feeding*

waterways downstream, but also offering the possibility of tracking factory farm discharges through these unique markers.

Many of the same practices that exacerbate animal welfare problems at factory farms also lead to increased and more hazardous water pollution. By exposing this pollution as more than just "manure" containing the euphemistic "nutrients" that are often the sole focus of CAFO water pollution regulation and enforcement, environmental and animal advocates can more effectively enforce the Clean Water Act (CWA)[22] and lobby for stronger regulation over the use and disposal of pharmaceuticals, metals, hormones, and pathogens. These practices prop up this unsustainable industry and enable it to turn a blind eye to animal welfare. Therefore, environmental litigation that uses the unique characteristics of CAFO pollution to track and identify that pollution and thereby hold CAFOs accountable under the CWA and other laws can play an important role in a larger effort to end factory farming, and can ultimately benefit animal welfare as well as water quality.

IV. TRACKING CAFO WATER POLLUTION POSES UNIQUE CHALLENGES

Both the Clean Water Act (CWA)[23] and the Resource Conservation and Recovery Act (RCRA)[24] provide citizens and regulators with frameworks to hold factory farms liable for water pollution, but the nature of CAFO waste and CAFO discharges as well as inadequacies in EPA's current regulations makes identifying illegal CAFO discharges and proving their origin particularly difficult compared with other industries.

The CWA is the principal federal statute enacted to protect and restore the waters of the United States. The primary objectives of the CWA are "to restore and maintain the chemical, physical and biological integrity of the Nation's waters" and to "eliminate" "the discharge of pollutants into the navigable

Operation Wastewater on Agricultural Lands, 37 J. ENVIRON. QUAL. S-97-98, S-100 (2008) (estimating that up to 80% of antibiotics are excreted unmetabolized).

22. 33 U.S.C. § 1251-1274 (2012).

23. *Id.*

24. 42 U.S.C. § 6901-6992k (2012).

waters."[25] The primary CWA program to restore and maintain water quality is the National Pollutant Discharge Elimination System (NPDES) program, which prohibits discharges of pollutants from point sources to navigable waters without a NPDES permit.[26] However, although the CWA defines CAFOs as point sources,[27] EPA estimates that fewer than half of CAFOs in the United States have NPDES permits.[28]

Traditional point sources, such as municipal wastewater treatment plants and factories, typically discharge continuously or under predictable circumstances and clearly require NPDES permits. CAFOs, on the other hand, most frequently discharge from land application areas due to wet weather events following manure spreading or over-application of waste, application too close to ditches, sinkholes, tile inlets, or other conduits that carry pollution to navigable waters, or application on frozen or saturated ground unable to take up manure nutrients. CAFOs can also discharge from their production areas, such as when manure pumps break, lagoons or pits overflow, feed piles leach, or pollutants blown or vented from confinement buildings contaminate process wastewater and lead to discharges into waterways.[29] The CWA only requires permits of dischargers, however, so if a CAFO has an isolated discharge and demonstrates that its discharges will not recur, it does not have a duty to apply for a permit under EPA's regulations. Moreover, citizens attempting to bring a CWA citizen suit for unpermitted discharges must demonstrate that the violations are ongoing at the time the complaint is filed.[30] Such a demonstration is difficult when discharges are sporadic, influenced by external

25. 33 U.S.C. § 1251(a) (2012).

26. 33 U.S.C. § 1342 (2012).

27. 33 U.S.C. § 1362(14) (2012).

28. NPDES CAFO Reporting Rule, *supra* at note 2, at 65,447.

29. *See*, *e.g.*, EPA, *Implementation Guidance on CAFO Regulations – CAFOs That Discharge or Are Proposing to Discharge* (May 28, 2010) at 15-16 (explaining that CAFOs with production areas designed to channel precipitation from the site may have a duty to apply for a permit if ventilation systems contaminate the diverted water, and it is subsequently transported to a water of the United States).

30. *See Gwaltney of Smithfield, Ltd. v. Chesapeake Bay Found, Inc.*, 484 U.S. 49, 50, 59, 67 (1987).

circumstances such as weather, and unpredictable, making them difficult to document.

EPA's agricultural stormwater exemption[31] makes proving ongoing unlawful CAFO discharges significantly more challenging still, by interpreting many precipitation-related discharges from land application areas as outside the definition of a "point source" discharge and therefore not subject to regulation.[32] Under EPA's current rules, most wet-weather discharges (i.e. most discharges) are not subject to regulation under the CWA, and demonstrating that a CAFO is a discharger and its violations are ongoing poses a significant challenge.

Even demonstrating that permitted CAFOs discharge or are in violation of permit requirements presents unique hurdles. CAFO permits lack key components of NPDES permits issued to dischargers in almost every other sector. EPA regulations require CAFOs to implement Comprehensive Nutrient Management Plans (CNMP) that "ensure appropriate agricultural utilization" of nutrients,[33] and EPA's CAFO effluent guidelines (ELG) require CNMPs to "minimize[e] nitrogen and phosphorus movement to surface waters."[34] These narrative limits are more difficult to enforce than numeric restrictions on pollution. Moreover, CAFOs are not required to monitor receiving waters to demonstrate they are not discharging when prohibited, nor are they required to monitor vulnerable groundwater resources beneath application fields or manure lagoons. Finally, the Gwaltney bar on citizen enforcement of wholly past violations presents the same complications in developing a citizen suit against a permitted discharger that it does in the case of an unpermitted one.

This "catch me if you can" scheme puts the burden on regulators and citizens to prove illegal discharges, rather than on CAFOs to self-report violations like most other industry sectors.

31. The CWA exempts discharges of "agricultural stormwater" from its definition of point sources, and EPA has interpreted this category of discharges to include certain precipitation-related discharges from CAFO land application areas. 33 U.S.C. § 1362(14) (2012); 40 C.F.R. §122.23(e) (2014).

32. Large CAFOs may only avail themselves of the agricultural stormwater exemption if they are in compliance with a site-specific nutrient management plan at the time of the discharge. 40 C.F.R. §122.23(e) (2014).

33. 40 C.F.R. § 122.42(e)(1)(viii) (2014).

34. 40 C.F.R. § 412.4(c)(1) (2014).

Being in the right place at the right time is particularly critical when efforts to prove a CAFO is polluting focus on ubiquitous agricultural pollutants like nitrogen and phosphorus. Without strong documentation that a discharge originated from the CAFO, an operator can claim that nutrients or even bacteria came from another farm, commercial fertilizer, or wildlife.

RCRA provides a framework to hold CAFOs accountable for groundwater pollution that is typically beyond the reach of the CWA, though its use to address factory farm pollution has been limited to date. RCRA's main purpose is to ensure that waste generated is "treated, stored, or disposed of so as to minimize the present and future threat to human health and the environment."[35] Toward that end, regulators and citizens may take enforcement action against any person "who has contributed or who is contributing to the past or present handling, storage, treatment, transportation, or disposal of any solid or hazardous waste which may present an imminent and substantial endangerment to health or the environment,"[36] or who violates the statute's Subtitle D prohibition on "any solid waste management practice . . . which constitutes the open dumping of solid waste."[37]

These provisions can apply to CAFO pollution, including groundwater contamination, but as in the CWA context, citizens must overcome significant hurdles to establish liability. To demonstrate that a CAFO has contaminated groundwater and thereby may present an imminent and substantial endangerment, one must demonstrate that the manure and other pollutants are "solid waste"[38] and that the pollutants originated from the CAFO. This language is expansive, and one could bring an imminent and substantial endangerment claim against a

35. 42 U.S.C. § 6902(b) (2012).

36. 42 U.S.C. § 6972(a)(1)(B) (2012).

37. 42 U.S.C. § 6945(a) (2012).

38. "Solid waste" includes "…discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from…agricultural operations" but does not include "industrial discharges which are point sources subject to permits" under the CWA NPDES program. 42 U.S.C. § 6903(27) (2012). This RCRA claim requires demonstrating that waste has been discarded, rather than applied as a fertilizer. However, this article focuses on the causation element of a RCRA claim, and the non-duplication and fertilizer exemption provisions of the law are beyond its scope.

CAFO based on nitrate, bacteria, or even possibly arsenic contamination of a drinking water resource; each contaminant poses human health threats.[39]

The elements of an open dumping claim are more specific, but also more straightforward than demonstrating that an imminent and substantial endangerment may exist. Open dumping is (1) disposing of (2) solid waste (3) at a facility or site that is not a sanitary landfill, otherwise known as an "open dump."[40] An open dump is "any facility or site where solid waste is disposed of which is not a sanitary landfill which meets [EPA] criteria."[41] The primary landfill criterion of concern for CAFO regulation relates to groundwater, and states that a facility or practice "shall not contaminate an underground drinking water source beyond the solid waste boundary."[42] The regulations define the three elements of the groundwater criterion. First, contaminate means to "introduce a substance that would cause . . . the concentration of that substance in the ground water to exceed the maximum contaminant level specified in Appendix I."[43] Second, an underground drinking water source means either an active or a potential drinking water source, "an aquifer supplying drinking water for human consumption . . .," or an aquifer with less than 10,000 mg/L of total dissolved solids.[44] The solid waste boundary means "the outermost perimeter of the solid waste (projected in the horizontal plane) as it would exist at the completion of the disposal activity."[45] Of relevance to CAFO pollution, EPA has established a Maximum Contaminant Level (MCL) for nitrates of 10.0 mg/L.[46]

39. Integrated Risk Information System: Nitrate, EPA, http://www.epa.gov/iris/subst/0076.htm (last updated Aug. 9, 2012); Integrated Risk Information System: Arsenic, EPA, http://www.epa.gov/iris/subst/0278.htm (last updated Aug. 9, 2012); Basic Information about Pathogens and Indicators in Drinking Water, EPA, http://water.epa.gov/drink/contaminants/basicinformation/pathogens.cfm (last updated Jan. 24, 2013).

40. 42 U.S.C. § 6903(14) (2012).

41. *Id.*

42. 40 C.F.R. § 257.3-4(a) (2014).

43. *Id.* at § 257.3-4(c)(2)(ii).

44. *Id.* at § 257.3-4(c)(4)(i),(ii).

45. *Id.* at § 257.3-4(c)(5).

46. 40 C.F.R. §§ 141, Appendix I to § 257 (2014).

If one can overcome the obstacles posed by RCRA's definition of solid waste, its fertilizer exemptions,[47] and its non-duplication provisions, CAFOs still pose unique difficulties for similar reasons to those discussed above. Many CAFOs do not have permits, and those that do are typically not required to conduct water monitoring – this lack of monitoring also extends to groundwater, despite evidence of widespread leaching and contamination from unlined manure lagoons and over-application on fields.[48] Thus prospective citizen-plaintiffs must obtain groundwater monitoring samples showing contamination with CAFO pollutants down-gradient from, and outside the solid waste boundary of, the facility. Once this has been accomplished, the problem of ubiquitous agricultural pollutants again arises.[49] CAFOs in agricultural areas are typically near fields spread with manure or commercial fertilizers, and non-CAFO animal agriculture – all sources of nitrate that can easily complicate efforts to prove causation. New pollution monitoring methods have been developed that can link various contaminants unique to the factory farm industry to a CAFO source, however, improving prospects for both CWA and RCRA enforcement.

47. The regulations provide that "[t]hese criteria apply to all solid waste disposal facilities and practices with the following exceptions: (1) The criteria do not apply to agricultural wastes, including manures and crop residues, returned to the soil as fertilizers or soil conditioners." 40 C.F.R. § 257.1(c)(1) (2014). A successful RCRA claim requires establishing that CAFO waste was discarded, rather than used as fertilizer, because its over-application or leaching into a groundwater resource will prevent its beneficial use as a fertilizer. Washington plaintiffs recently survived a motion to dismiss relying on such an argument in ongoing CAFO RCRA litigation. In the order, the district court judge determined that it is "plausible for manure to be 'solid waste' after it has ceased to be 'beneficial' or 'useful' when it is over-applied to the fields and when it has leaked away from the lagoons." Cmty. Ass'n for Restoration of the Env't, Inc. v. Cow Palace, LLC, No: 13-CV-3016-TOR, at 11 (E.D. Wash. Jun. 21, 2013) (order denying defendants' joint motion to dismiss).

48. *See, e.g.*, JERRY L. HATFIELD, EPA, METRICS FOR NITRATE CONTAMINATION OF GROUND WATER AT CAFO LAND APPLICATION SITES – IOWA SWINE STUDY, at 1 (June 2009) (stating that "[s]urveys of ground water in areas with… [CAFOs] have reported higher than normal nitrate levels," and that "[n]itrate derived from the N in swine manure that has been applied to agricultural fields has been found in shallow ground-water wells…").

49. *See generally*, Michael Somers, Note, *RCRA's New Causation Question: Linking Ubiquitous Wastes To Specific Defendants*, 38 B.C. ENVTL. AFF. L. REV. 193 (2011).

V. NOVEL WAYS OF IDENTIFYING CAFO POLLUTION MAKE USE OF CAFOS' UNIQUE POLLUTANT PROFILES

As discussed above, CAFO-related water pollution can come from leaking manure storage areas or from fields where manure is applied as fertilizer.[50] The pollution may discharge directly into surface water or it may percolate into groundwater. Contaminated groundwater, while clearly posing a public health threat in its own right, also poses a threat to down-gradient, hydrologically connected surface water. The pollutants that come with manure include nitrogen compounds (e.g., ammonia and nitrate), phosphorus compounds, bacteria, and all of the pharmaceuticals that are used in the industrial animal-raising process, mainly antibiotics and hormones. Other pollutants are concentrated in animal feed, and therefore concentrated in animal manure. The following paragraphs describe some of these pollutants and summarize the strengths, weaknesses, and nuances of using them as "fingerprints" of CAFO pollution in ambient water.

Nitrogen, usually in the form of nitrate, is the most frequently measured manure pollutant. There are at least two reasons for this. First, it is a ubiquitous pollutant associated with known risks to human health. The EPA has established an MCL of 10 mg/L for nitrate to protect against methemoglobinemia in infants (also known as blue baby syndrome).[51] By contrast, natural concentrations of nitrate in shallow groundwater rarely exceed 1-2 mg/L, meaning that groundwater exceeding the MCL can be presumed contaminated.[52] In Wisconsin, where the dairy industry spreads many millions of gallons of manure on cropland every year, 9-11%

50. There are of course other sources of pollution from CAFOs, including production areas and feed (silage) storage areas, but manure is the overwhelming majority of a CAFO's waste stream and therefore the sole focus of this paper.

51. Integrated Risk Information System: Nitrate, EPA, http://www.epa.gov/iris/subst/0076.htm (last updated Aug. 9, 2012).

52. *See* EPA, RELATION BETWEEN NITRATE IN WATER WELLS AND POTENTIAL SOURCES IN THE LOWER YAKIMA VALLEY, WASHINGTON, at ES-2 (Sept. 2012).

of private wells have nitrate levels above the MCL.[53] Community water supplies have had to spend tens of millions of dollars to correct, treat, or replace groundwater with excess nitrate.[54] The Wisconsin Department of Natural Resources estimates that "[a]t least 90% of nitrate inputs into [Wisconsin] groundwater originate from manure spreading, agricultural fertilizers, and legume cropping systems."[55] On the national scale, the U.S. Geological Survey estimates that the number of wells with nitrate concentrations above the MCL increased from 16% to 21% between 1993 and 2003.[56]

A second reason that nitrate is widely measured is that it is affordable to do so. Nitrate can be measured instantly, if imprecisely, with a range of instruments ranging from colorimetric strips (like those commonly used for fish tanks) and photometers, can be measured by sending samples to laboratories for more exact analyses,[57] or can be measured with a combination of the two.[58]

The problem with using nitrate as an indicator of animal manure pollution is that it is so ubiquitous. Nitrate in any given location could have come from the land application of manure, but it could also have come from synthetic fertilizer application and/or septic tanks. Further complicating the issue is the fact that nitrate contamination can persist in groundwater for years or decades.[59] It is possible to narrow the range of possible sources using isotopic analysis – a measure of the ratio of different nitrogen isotopes in a sample – but this method will only

53. WIS. DEP'T OF NATURAL RES., GROUNDWATER COORDINATING COUNCIL, FY 2013 REPORT TO LEGISLATURE: NITRATE, at 2 (Aug. 2013), *available at* http://dnr.wi.gov/topic/groundwater/documents/GCC/GwQuality/Nitrate.pdf.

54. *Id.*

55. *Id.* at 1.

56. U.S. GEOLOGICAL SURVEY, NUTRIENTS IN THE NATION'S STREAMS AND GROUNDWATER, 1992–2004, CIRCULAR 1350, at 1 (2010).

57. *See, e.g.*, WATER MONITORING AND ASSESSMENT: NITRATES, EPA, http://water.epa.gov/type/rsl/monitoring/vms57.cfm (last updated Mar. 6, 2012).

58. *See, e.g.*, EPA, *supra* note 52, at 13 (describing a methodology that uses colorimetric test strips to screen for high nitrate concentrations, followed by lab analyses for the high-testing samples).

59. *See* U.S. GEOLOGICAL SURVEY, *supra* note 56, at 152.

differentiate between animal waste and synthetic fertilizers, not between animals (e.g., between humans and cows).[60]

Bacteria, and in particular fecal bacteria including Escherichia coli (E. coli), are another common indicator of manure pollution in groundwater.[61] In the Yakima Valley study, the EPA measured total coliform bacteria, fecal coliform, and E. coli.[62] E. coli is a good manure indicator in that it is usually present at much higher concentrations than other fecal pathogens.[63] There are two principal drawbacks to relying on E. coli, however. First, like isotopic nitrogen analysis, a positive E. coli reading will not distinguish between animal sources. Second, the movement and survival of E. coli in shallow groundwater is dependent on a number of factors, including characteristics of the waste stream and soil type, such that the correlation between E. coli and manure can be unpredictable.[64]

Advanced analysis of bacterial contamination to help identify a source is known as Microbial Source Tracking (MST). MST is a broad concept that includes many distinct methods, both genotypic (focused on bacterial DNA or RNA) and phenotypic (focusing on bacterial traits).[65] Genotypic methods use genetic "fingerprints" that are generated and identified using techniques such as pulsed-field gel electrophoresis, ribotyping, and polymerase chain reaction (PCR).[66] The latter method, microbial source tracking using PCR, was at the heart of the *Tyson* opinion discussed below. PCR methods often focus on the Bacteroides

60. *See* EPA, *supra* note 52, at 28-29, 42.

61. *See, e.g.*, Andrew VanderZaag et al., *Survival of Escherichia coli in Agricultural Soil and Presence in Tile Drainage and Shallow Groundwater*, 90 CAN. J. SOIL SCI. 495, 495 (2010).

62. *See* EPA, *supra* note 52, at 22.

63. *See* Troy M. Scott et al., *Microbial Source Tracking: Current Methodology and Future Directions*, 68 APPLIED & ENVTL. MICROBIOLOGY 5796, 5796 (2002).

64. *See, e.g.*, VanderZaag et al., *supra* note 61, at 504 (concluding that "the presence and abundance of *E. coli* was not strongly related to the timing of manure application.").

65. Scott et al., *supra* note 63, at 5799-5780 (2002); TETRA TECH, INC. AND HERRERA ENVTL. CONSULTANTS, USING MICROBIAL SOURCE TRACKING TO SUPPORT TMDL DEVELOPMENT AND IMPLEMENTATION, PREPARED FOR U.S. EPA REGION 10, at 1 (Apr. 2011).

66. TETRA TECH, INC. AND HERRERA ENVTL. CONSULTANTS, *supra* note 65, at 6.

species, which make up 30-40% of fecal bacteria.[67] Bacteroides PCR assays can accurately attribute fecal bacteria to human, bovine, equine, or swine sources.[68]

Phenotypic methods of MST use the physical or biochemical characteristics of bacteria to identify sources of contamination.[69] Of particular relevance to this paper are methods that measure antibiotic resistance. As discussed above, antibiotics are commonly fed to livestock to prevent disease and promote growth.[70] When host animals are exposed to antibiotics, selective pressure will lead to resistant strains of bacteria in the host animals' digestive tracts.[71] The antibiotic resistance of bacteria in a groundwater sample can be characterized by culturing the bacteria with known quantities of antibiotics and measuring the results. This technique can successfully identify host species including wildlife, cattle, pigs, horses, chickens, and humans.[72] A hybrid MST approach, using PCR to identify genes that code for antibiotic resistance, has been used to successfully map the migration of contamination from swine lagoons to underlying groundwater.[73]

67. Alice Layton et al., *Development of Bacteroides 16S rRNA Gene TaqMan-Based Real-Time PCR Assays for Estimation of Total, Human, and Bovine Fecal Pollution in Water*, 72 APPLIED & ENVTL. MICROBIOLOGY 4214, 4215 (2006).

68. *See, e.g.*, *id*. at 4220 (showing 100% true-positive identification and 0% false-positive identification, for a bovine assay); Linda K. Dick et al., *Host Distributions of Uncultivated Fecal Bacteroidales Bacteria Reveal Genetic Markers for Fecal Source Identification*, 71 APPLIED & ENVTL. MICROBIOLOGY 3184, 3189 (2004) (reporting new markers for pig and horse sources of fecal pollution).

69. *See* TETRA TECH, INC. AND HERRERA ENVTL. CONSULTANTS, *supra* note 65, at 1.

70. *See* Joann Chee-Sanford et al., *Fate and Transport of Antibiotic Resistance Genes Following Land Application of Manure Waste*, 38 J. ENVTL. QUAL. 1086, 1086 (2009).

71. *See* LITERATURE REVIEW, *supra* note 19, at 49-56 (discussing that the escape of antibiotic resistant bacteria to the environment and the food supply is a substantial human health threat).

72. Scott et al., *supra* note 63, at 5799; Chee-Sanford et al., *supra* note 70, at 1098 (citing studies that have identified sources of fecal pollution in environmental samples using antibiotic resistance profiles).

73. *See* S. Koike et al., *Monitoring and Source Tracking of Tetracycline Resistance Genes in Lagoons and Groundwater Adjacent to Swine Production Facilities over a 3-Year Period*, 73 APPLIED & ENVTL. MICROBIOLOGY 4813, 4813 (2007).

Animal wastes can also be identified by chemicals that animals ingest and excrete. When antibiotics are administered to animals, up to 80% may be excreted as unmetabolized parent compounds.[74] Some antibiotics are used exclusively in animals, sometimes in specific types of livestock, but are not approved for human use, and can therefore provide evidence of animal waste contamination.[75] Hormones can be another indicator of animal waste contamination. More than 90% of the estrogen in the environment may come from land-applied animal manure.[76] As with antibiotics, there are certain hormones that are widely used by humans and animals, or are naturally occurring, and others that are more likely to be associated with specific animals sources.[77] Where antibiotic or hormone residues are too variable or too dilute to be reliably detected by grab samples, researchers have utilized in-stream monitors such as the Polar Organic Chemical Integrative Sampler (POCIS). A POCIS sampler can be left in place for several weeks, concentrating polar chemicals from large volumes of water to produce time-weighted average concentrations.[78] This method has been used, for example, to detect estrogens downstream of swine and poultry operations where estrogens were below detection in grab samples.[79]

Metals are another dietary additive that can be found in contaminated water. Arsenic is added to poultry feed to control intestinal parasites and promote growth, while copper and zinc

74. Bradford et al., *supra* note 21, at S-100. *See also* NPDES CAFO Reporting Rule, *supra* note 2, at 65,434 (estimating that 80-90% of some antibiotics administered to livestock end up in the animals' waste); LITERATURE REVIEW, *supra* note 19, at 35 (estimating that 67% and 80% of two types of antimicrobial are excreted unchanged).

75. *See* EPA, *supra* note 52, at 25.

76. Bradford et al., *supra* note 21, at S-101 (citing Samir K. Khanal et al., *Fate, Transport, and Biodegradation of Natural Estrogens in the Environment and Engineered Systems*, 40 ENVTL. SCI. & TECH. 6537 (2006)).

77. *See* EPA, *supra* note 52, at 27-28.

78. *See, e.g.*, Tammy L. Jones-Lepp et al., *Polar Organic Chemical Integrative Sampling (POCIS) and LC-ES/ITMS for Assessing Selected Prescription and Illicit Drugs in Treated Sewage Effluents*, 47 ARCHIVES ENVTL. CONTAMINATION & TOXICOLOGY 427 (2004); Ivo Cernoch et al., *POCIS Sampling in Combination with ELISA: Screening of Sulfonamide Residues in Surface and Waste Waters*, 14 J. ENVTL. MONITORING 250 (2012).

79. David A. Alvarez et al., *Bioassay of Estrogenicity and Chemical Analyses of Estrogens in Streams Across the United States Associated with Livestock Operations*, 47 WATER RES. 3347, 3358 (2013).

are added to swine feed; all of these metals can be toxic to animals and plants.[80] "Trace" amounts of these metals in feed can cumulatively amount to large quantities of metal. The EPA has estimated that 80-90% of the copper, zinc, and arsenic consumed by animals is excreted.[81] One author estimated that one year's worth of poultry waste on the Delmarva Peninsula (including parts of Delaware, Maryland, and Virginia) contained 26,000 kg of arsenic.[82]

Finally, it may be possible to directly identify the genetic material of source animals in their manure by analyzing mitochondrial DNA. One study, for example, was able to accurately identify the species from which sixteen out of twenty samples were obtained.[83] This is another application of PCR methods, but, in contrast to the microbial source tracking methods described above, this application is typically described as "fecal source tracking."

The ideal, if impractical, way to prove that an animal confinement has contaminated the environment is to use a combination of the methods described above. In its study of nitrate contamination in the Yakima Valley, the EPA used measurements of nitrate and other forms of nitrogen, various metals ("inorganic trace elements" including arsenic, copper, zinc, and others), total coliform bacteria, fecal coliform, E. coli, genotypic microbial source tracking, pesticides, antibiotics, hormones, isotopic analysis of nitrogen, and age dating using sulfur hexafluoride, all to investigate the contribution of various land uses, including dairy manure storage and land application, to high nitrate levels in groundwater.[84]

80. EPA, RISK ASSESSMENT EVALUATION FOR CONCENTRATED ANIMAL FEEDING OPERATIONS, at 45 (May 2004).

81. *Id.* at 46.

82. John R. Garbarino et al., *Environmental Fate of Roxarsone in Poultry Litter. I. Degradation of Roxarsone During Composting*, 37 ENVTL. SCI. & TECH. 1509, 1509 (2003).

83. *See* W.B. Schill & M.V. Mathes, *Real-time PCR Detection and Quantification of Nine Potential Sources of Fecal Contamination be Analysis of Mitochondrial Cytochrome b Targets*, 42 ENVTL. SCI. & TECH. 5229, 5231 (2008).

84. *See* EPA, *supra* note 52, at 20-30, ES-1.

VI. COURTROOM ACCEPTANCE OF TECHNOLOGIES TO TRACK CAFO POLLUTION IS STILL EVOLVING

To successfully enforce the CWA and RCRA against factory farm polluters using these methods in federal court, the methods must meet the standards for admissibility and reliability of scientific evidence. In 1993, the Supreme Court issued its opinion in *Daubert v. Merrell Dow Pharmaceuticals*,[85] establishing a new analysis for determining the admissibility of novel scientific evidence at trial. The *Daubert* court determined that the 1923 *Frye*[86] "general acceptance" test for admissibility set too high a standard for introducing scientific evidence and had been superseded by the Federal Rules of Evidence (FRE).[87] The court determined that under FRE 702,[88] the judge "must ensure that any and all scientific testimony or evidence submitted is not only relevant, but reliable," and that "to qualify as "scientific knowledge," an inference or assertion must be derived by the scientific method."[89] Though the district court judge retains this "gatekeeper" role, however, the court further held that "it would be unreasonable to conclude that the subject of scientific testimony must be "known" to a certainty."[90]

Daubert set out four consideration factors for determining the scientific validity, and therefore the admissibility, of scientific evidence: (1) whether the theory or technique can be (and has been) tested, (2) whether it has been subjected to peer review, (3) the known or potential rate of error and the existence and maintenance of standards controlling the technique's operation, and (4) "general acceptance." Note that the fourth factor, while no longer the entire test as it was under *Frye*, is still relevant.

85. Daubert v. Merrell Dow Pharms., 509 U.S. 579 (1993).

86. Frye v. United States, 293 F. 1013 (D.C. Cir. 1923).

87. *Daubert*, 509 U.S. at 587.

88. FED. R. EVID. 702 (stating that "[a] witness who is qualified as an expert by knowledge, skill, experience, training, or education may testify in the form of an opinion or otherwise if: (a) the expert's scientific, technical, or other specialized knowledge will help the trier of fact to understand the evidence or to determine a fact in issue; (b) the testimony is based on sufficient facts or data; (c) the testimony is the product of reliable principles and methods; and (d) the expert has reliably applied the principles and methods to the facts of the case").

89. *Daubert*, 509 U.S. at 589-90.

90. *Id.* at 590.

Reliability assessment can allow "explicit identification of a relevant scientific community and an express determination of a particular degree of acceptance within that community."[91] It is against this framework that we consider the applicability of promising CAFO pollution tracking methods in enforcement actions.

Oklahoma v. Tyson[92] presents an important case study in *Daubert's* application to a CAFO enforcement action brought under RCRA. In *Tyson*, the state sought to hold a large poultry integrator liable for the alleged imminent and substantial endangerment posed by waste disposal from its many broiler chicken operations in the Illinois River Watershed. Oklahoma sought to introduce scientific testimony on the use of PCR methodology, described above but in this case applied with poultry-specific biomarkers, to show that poultry bacteria was contaminating the watershed and obtain a preliminary injunction on waste spreading.[93] The court held that the evidence was admissible, but then found it to have little evidentiary weight due to its insufficient reliability. The court reviewed the *Daubert* factors and held that, though PCR is a well-established method, its application with microbial source tracking and poultry litter biomarkers was "novel and untested," as the application was not published or peer-reviewed.[94]

The *Tyson* court and others have distinguished the scientific methodology in question itself (here, PCR) from the application of that method when determining admissibility. In *Tyson*, the court reasoned that because PCR is widely accepted the court should be able to consider evidence derived using it; questions as to the reliability of the method's application in the case go to the weight of the evidence, not its admissibility.[95] The circuits are split on this question: the Eighth and Third apply a conservative reading of *Daubert*, requiring an "each step" analysis under which every scientific procedure used, or application of a generally admissible method, must independently meet the *Daubert* reliability

91. *Daubert*, 509 U.S. at 593-94.
92. Attorney Gen. of Oklahoma v. Tyson Foods, Inc., 565 F.3d 769 (10th Cir. 2009).
93. *Id.* at 774-75.
94. *Id.* at 781.
95. *Id.*

criteria.[96] The majority of circuits, however, take a more liberal approach, applying a *Daubert* analysis to the scientific methodology in question in order to decide whether the method is admissible. Courts then assess the application of the method when weighing the evidence's reliability, thereby reserving a larger role for the fact-finder.[97] The Tenth Circuit's opinion in *Tyson* reflects this more liberal approach.

VII. BUILDING AN ADMISSIBLE EVIDENTIARY FOUNDATION FOR ENFORCING ENVIRONMENTAL LAWS IN THE CAFO CONTEXT

The source tracking methods described above will have to pass the *Daubert* test in order to support a successful case, and, for the most part, they can and should pass the test. Microbial source tracking has gained widespread acceptance as a scientific approach to identifying sources of pollution.[98] Microbial source tracking using PCR, specifically, has also gained widespread acceptance. This is evident in, among other things, the *Tyson* court's decision to admit the evidence in that case.[99] Where the *Tyson* court likely erred was in its factual conclusion that the evidence was not reliable enough to support a preliminary injunction because it "ha[d] not been peer-reviewed or published,"[100] a judgment that refers directly to one of the four *Daubert* factors. At the time of the decision, there had in fact already been twenty-seven peer-reviewed publications referring

96. United States v. McCluskey, No. CR 10–2734 JCH, 2013 WL 3766686, at *17, *21 (D. N.M. 2013).

97. *Id.* at *24.

98. *See, e.g.*, MICROBIAL SOURCE TRACKING: METHODS, APPLICATIONS, AND CASE STUDIES (Charles Hagedorn et al. eds., 2011) (including a chapter on microbial source tracking); SHANE ROGERS & JOHN HAINES, EPA, DETECTING AND MITIGATING THE ENVIRONMENTAL IMPACT OF FECAL PATHOGENS ORIGINATING FROM CONFINED ANIMAL FEEDING OPERATIONS: REVIEW (Sept. 2005) (also including a chapter on microbial source tracking); TETRA TECH, INC. AND HERRERA ENVTL. CONSULTANTS, *supra* note 65.

99. *Tyson Foods*, 565 F.3d at 780.

100. Oklahoma ex rel. Edmondson v. Tyson Foods, Inc., No. 05-CV-329-GKF-SAJ, 2008 WL 4453098, at *4 (N.D. Okla. Sept. 29, 2008), *aff'd sub nom.* Attorney Gen. of Okla. v. Tyson Foods, Inc., 565 F.3d 769 (10th Cir. 2009).

to the use of PCR for microbial source tracking.[101] Since then, over seventy more peer-reviewed papers have been published,[102] including higher-order studies such as an international comparison of human- and ruminant-specific assays.[103] At this point, many or most forms of microbial source tracking using PCR should be seen as having undergone sufficient peer review to be admissible under *Daubert*.

Microbial source tracking methods, both genotypic and phenotypic, have also developed to the point that they should pass the "rate of error" *Daubert* analysis. Pre- and post-*Daubert* cases provide some limited and rough insight into what degree of uncertainty is consistent with reliability. Pre-*Daubert*, tests reliable at 90-99% have been admissible. One case, for example, involved gas chromatograph methods used to identify the source of hazardous oils illegally dumped into public sewers.[104] Under the *Frye* standard, the court found the methods to be sufficiently reliable to conclude that they were "generally accepted":

> Dr. Bentz testified that tests performed on the [flame ionization detector] found it to be reliable in excess of 90%. Similar tests performed on the FPD found it also to be reliable in excess of 90%. Because the results obtained from each detector are independently reliable, when the results of both detectors agree, they are reliable in excess of 99%.[105]

On the other hand, a comparative bullet lead analysis method with an error rate of 25-33% was not admissible.[106]

Post-*Daubert*, in a case involving a potentially toxic feed additive, and an expert method for detecting the additive in

101. Medline/Pubmed search for articles including the search terms "microbial source tracking" and PCR in the title or abstract, published before Sept. 29, 2008 (search performed by authors, Aug. 27, 2013).

102. Medline/Pubmed search for articles including the search terms "microbial source tracking" and PCR in the title or abstract, published since Sept. 29, 2008 (search performed by authors, Aug. 27, 2013).

103. Georg H. Reischer et al., *Performance Characteristics of PCR Assays Targeting Human- and Ruminant-Associated Bacteroidetes for Microbial Source Tracking across Sixteen Countries on Six Continents*, 47 ENVTL. SCI. & TECH. 8548 (2013).

104. United States v. Distler, 671 F.2d 954, 955 (6th Cir. 1981).

105. *Id.* at 962.

106. Clemons v. State, 392 Md. 339, 370-71 (2006).

animal tissue, the court concluded that a 20% rate of error "[did] not weigh in favor of admissibility."[107] Another case considered and admitted fingerprint evidence, which, according to the court, "has been admissible as reliable evidence in criminal trials in this country since at least 1911."[108] Although the rate of error was not quantitatively estimated by the government's expert, the expert did testify that it was "negligible," and the majority opinion cited testimony from another case that the error rate was "essentially zero."[109] The dissent, however, cited two tests of the method in which "less than half" and "less than sixty percent" of fingerprint examiners made accurate identifications and eliminations, and stated that "[a]n error rate that runs remarkably close to chance can hardly be viewed as acceptable under *Daubert*."[110]

Although these cases are far from exhaustive, and the other *Daubert* factors will influence any analysis, it might be suggested that methods with error rates of 0-10% are likely to be admissible, while methods with error rates of 20% or greater are likely to be excluded. Methods with error rates of 10-20%, then, can be expected to be hotly contested. Using this rough metric, microbial source tracking should be admissible. One study, mentioned above, used a bovine bacteroides PCR microbial source-tracking assay that had 100% true-positive identification and 0% false-positive identification rates.[111] Another study identified PCR microbial source tracking assays that had greater than 90% specificity for humans, ruminants, and pigs.[112] The EPA reviewed several antibiotic resistance assays, describing the "average of correct classification," or ARCC, for each.[113] ARCCs ranged from 62-88% for individual species, and from 72-97% when pooled into larger categories like "poultry," "beef," and

107. Koch v. Shell Oil Co., 49 F. Supp. 2d 1262, 1268 (D. Kan. 1999).

108. United States v. Crisp, 324 F.3d 261, 266 (4th Cir. 2003).

109. *Id.* at 269 (citing United States v. Havvard, 260 F.3d 597, 599 (7th Cir. 2001).

110. *Id.* at 275.

111. Layton et al., *supra* note 67, at 4214.

112. Michèle Gourmelon et al., *Evaluation of Two Library-Independent Microbial Source Tracking Methods to Identify Sources of Fecal Contamination in French Estuaries*, 73 APPLIED & ENVTL. MICROBIOLOGY 4857, 4861 (2007).

113. ROGERS & HAINES, *supra* note 98, at 65-66.

"human."[114] One assay, for example, achieved 92% ARCC using the categories human, livestock, and wildlife.[115]

VIII. CONCLUSION

Factory farming generates a waste stream with a unique pollution fingerprint. This industry discharges waste laden with DNA markers, and relies on a host of specific dietary additives to promote the survival and profitable growth of animals housed in extremely inhumane conditions. These additives, including antibiotics, hormones, and metals, pass through the animals and enter the substantial waste stream that the industry generates. Developing scientific methods to track these indicator pollutants have the potential to bolster citizen and agency enforcement efforts.

Some of these analytical techniques are becoming increasingly well tested, widely used, and reliable, including microbial source tracking and methods for measuring antibiotics, hormones, and metals. Other methods, such as fecal source tracking, are relatively new.[116] These are useful evidentiary tools, but should not be relied upon exclusive of more reliable methods. All of these methods of generating a CAFO "fingerprint" facilitate the enforcement of legal standards for more ubiquitous pollutants like nitrates. The science to support successful cases is advancing rapidly, and these cases are becoming increasingly viable as the law catches up with the state of the science. For example, the *Tyson* decision would likely be indefensible today. By combining conventional analyses of basic pollutants like nitrates and bacteria with more advanced source tracking methods, animal and environmental advocates have new opportunities to hold CAFO owners accountable for their inhumane and environmentally destructive practices.

114. ROGERS & HAINES, *supra* note 98, at 65-66.

115. *Id.*

116. *See, e.g.*, Schill & Mathes, *supra* note 83, at 5229 (citing "the first [study] to use [mitochondrial DNA for fecal source tracking] for the detection of human, cow, swine, and ovine fecal mtDNA sequences using real-time PCR" from 2005).