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CENTER *for* A LIVABLE FUTURE

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State of Hawai‘i Department of Health and
Office of Environmental Quality Control
1250 Punchbowl St.
Honolulu, Hawai‘i 96813

Disclaimer: The opinions expressed herein are our own and do not necessarily reflect the views of The Johns Hopkins University.

Re: The Ulupono Initiative’s Proposal for Hawai‘i Dairy Farms on the Island of Kaua‘i

Dear Dr. Pressler and Mr. Glenn,

We are researchers at The Johns Hopkins Center for a Livable Future based at the Bloomberg School of Public Health in the Department of Environmental Health and Engineering. The Center engages in research, policy analysis, education, and other activities guided by an ecologic perspective that diet, food production, the environment, and public health are interwoven elements of a complex system. We recognize the prominent role that food animal production plays regarding a wide range of public health issues surrounding that system.

We have been contacted by Ms. Bridget Hammerquist, the president of Friends of Maha‘ulepu, about the proposal by The Ulupono Initiative to establish a dairy operation, Hawai‘i Dairy Farms (HDF), on the island of Kaua‘i. In response to concerns conveyed by island residents, we have reviewed the Final Environmental Impact Statement (FEIS). While we recognize that the proposed operation described in the FEIS includes many elements that are consistent with pasture-based, sustainable production, we have concerns regarding the feed and waste management plans should HDF expand to the contemplated herd size. Although The Ulupono Initiative acknowledges that additional regulatory review, permitting and public input would be required to expand the herd, some of the infrastructure required for an expansion is included in the current proposal and FEIS. Expansion to the contemplated herd size would likely involve implementation of some practices associated with industrial dairy operations. Should this occur, multiple public health implications would need to be considered, many of which are described below. In an effort to serve as a scientific resource, we have compiled and summarized research articles related to environmental health risks associated with industrial food animal production (IFAP), with particular emphasis on large-scale dairy operations. An annotated bibliography is provided on pages 6-16, and Appendix A contains the abstracts from research articles focused on large-scale dairies (pages 17-23).

Summary of Public Health Concerns Associated with IFAP

The primary human health concerns related to IFAP include: risk of infections resulting from transmission of harmful microorganisms from animal operations to nearby residents, respiratory effects from increased exposure to air pollution from animal operations, and multiple negative health impacts due to exposure to ground and/or surface waters that can be contaminated by manure from animal operations. These concerns are described in more detail below.

Disease Transmission

Conditions in IFAP operations typically include crowding. This characteristic presents opportunities for disease transmission among animals, and between animals and humans.[1,2] Nearby residents, especially those living in close proximity to multiple operations, may have an increased risk of infection from the transmission of harmful microorganisms from IFAP operations via flies or contaminated air and water.[3-7]

Of additional concern is exposure to pathogens that are resistant to antibiotics used in human medicine. It is common for IFAP operations to administer antibiotics to animals at levels too low to treat disease (non-therapeutic use), and this practice fosters the proliferation of antibiotic-resistant pathogens. A growing body of evidence provides support that antibiotic-resistant pathogens are found on animal operations that administer antibiotics for non-therapeutic purposes[10-12] and are also found in the environment in and around production facilities,[10] specifically in manure.[11,12] Workers and community members can be exposed to these resistant pathogens, and resistant infections in humans are more difficult and expensive to treat[2,8] and more often fatal[9] than infections with non-resistant strains. It is our understanding that antibiotics may not be used for non-therapeutic purposes on the proposed dairy operation.[13] While this may reduce the risk of infection with antibiotic resistant-bacteria to community members and workers compared to other large dairies, pathogens can still spread from animal production operations to the surrounding communities.[14]

Manure runoff from IFAP operations can introduce harmful microorganisms into nearby water sources.[11] Land application of manure presents an opportunity for pathogens contained in the manure to leach into the ground or run off into recreational water and drinking water sources, potentially causing a waterborne disease outbreak.[11] This is of particular concern for the approximately 8% of Kaua‘i County residents who rely on private wells for drinking water and household use[15]; private wells are not monitored by government agencies to ensure safe levels of pathogens.

Air Pollution

Community members living near IFAP operations can also be exposed to air pollution from these operations, which can cause or exacerbate respiratory conditions including asthma, bronchitis and allergic reactions.[16,17] Air emissions include particulates, volatile organic compounds, and gases such as nitrous oxide, hydrogen sulfide, and ammonia.[16,18] Odors associated with air pollutants from IFAP operations have been shown to interfere with daily activities, quality of life, social gatherings, and community cohesion.[19] Furthermore, IFAP air emissions pose a risk to susceptible populations residing beyond the immediate vicinity of these facilities, including children and the elderly.[16]

Contaminated Ground and Surface Water

The increase in geographic concentration of livestock and transition to large, high-density, confined animal feeding operations over the last several decades has resulted in the concentration of animal waste over small geographic areas.[11] Although animal manure is a useful fertilizer, the vast quanitities of waste produced by IFAP operations represent a public health and ecological hazard due to degradation of surface and ground water resources.[11]

Manure from IFAP operations have contaminated ground and surface waters with nitrates, drug residues, and other hazards,[4,20-22] and studies have demonstrated that humans can be exposed to waterborne contaminants from livestock operations through the recreational use of contaminated surface water and the ingestion of contaminated drinking water.[21-23] Exposure to elevated levels of nitrates in drinking water is associated with adverse health effects, including cancer,[24-27] birth defects and other reproductive problems,[28,29] thyroid problems,[23,24] and methemoglobinemia (i.e., blue baby syndrome).[23,30]

Nutrient runoff (including nitrogen and phosphorus) has also been implicated in the growth of harmful algal blooms,[11,31] which pose health risks for people who swim or fish in recreational waters, or who consume contaminated fish and shellfish. Exposure to algal toxins has been linked to neurological impairments, liver damage, gastrointestinal illness, severe dermatitis, and other adverse health effects.[32,33]

Concerns Regarding Hawai‘i Dairy Farms

In 2013, The Ulupono Initiative proposed to build a large dairy operation, Hawai‘i Dairy Farms (HDF), on the island of Kaua‘i. The public health concerns summarized above are associated with many types of IFAP operations, including large-scale dairies, and could be relevant concerns for the operation proposed by HDF (for specific research regarding large-scale dairy operations, please refer to Appendix A). HDF has proposed an initial herd size of 699 mature dairy cows,[13] which is one head under the number requiring a concentrated animal feeding operation (CAFO) permit by the State Department of Health.[34] HDF has indicated, however, that they may expand the herd to 2,000 cows once the initial herd is established.[13] The concentration of a large number of animals on a typical IFAP operation can present waste management challenges. Based on manure production data from the American Society of Agricultural Engineers, a herd of 2,000 mature dairy cows would produce an estimated 300,000 pounds of waste per day (150 lbs. per cow per day),[35] more than the total daily human waste generated by the entire population of Kaua‘i, which amounts to just under 250,000 pounds for the 67,091 residents of the island (3.72 lbs. per person per day).[15,36] As described above, manure can contaminate ground and surface waters, posing health risks for people exposed to these waters.[11, 21-23]

In addition, we have concerns regarding some inconsistencies in the feed and waste management plans described in the FEIS. HDF proposes to establish and operate their pastoral rotational-grazing dairy farm with a herd size of 699 to 2,000 dairy cows on 469.9 acres of land.[13] Herd size sustainability is dependent on pasture productivity, and the kikuyu grass trials at HDF produced yields of 16.3 tons of grass per acre.[13] Based on United States Department of Agriculture (USDA) data and the kikuyu grass trials, a herd of 699 mature dairy cows requires 431 acres of grazing land; however, the required acreage increases to 1,232 acres with a herd size of 2,000 cows.[35,37] At current grass yields, HDF’s proposed 469.9 acres of pasture could support a maximum of 763 cows.[35,37] Even with the anticipated future yields of 20 tons of

grass per acre, a pasture of this size can only support 936 cows, which implies more than 50% of the 2,000 cows in the contemplated herd would require feed imported from the mainland.[35,37] In the FEIS, HDF states that one of the main advantages of their proposed operation compared to conventional feedlot dairy operations is that the pasture-based design greatly reduces reliance on imported feed.[13] While it is not uncommon for pasture-based operations to supplement animal diets with outside feed, HDF's reliance on imported feed would increase greatly if expanded to the contemplated herd size due to the inability of the proposed pasture acreage to support this larger herd. Furthermore, by consuming more food than the land provides, the herd will inevitably produce amounts of waste in excess of what the land is capable of absorbing.

While some manure will be deposited directly on the pasture during grazing, the FEIS also outlines plans for effluent storage ponds, or lagoons, characteristic of traditional IFAP operations.[13] The FEIS states that these lagoons will be utilized to collect the effluent from the milking parlors and will allow dairy management to control the timing and application of manure to forage fields. [13] While lagoons designed to hold waste from the milking parlor may be necessary, HDF's infrastructure plans describe the construction and utilization of an effluent storage system large enough to contain all wastewater, manure, clean water, solids, rainfall and runoff for the entire operation for a 30-day period.[13] The extent and capacity of HDF's proposed lagoons present a system which utilizes waste management practices similar to a conventional large-scale dairy, not a pasture-based operation. This discrepancy between the capacity of the proposed lagoons and the lagoon requirements of a pasture-based dairy operation should be clarified. Lagoons can be susceptible to leaks and flooding, and the dispersion of lagoon effluent on an oversaturated pasture can result in many of the public health and environmental risks described above.[11]

Several of the environmental impacts associated with IFAP outlined above have occurred on the nearby island of Hawai‘i, underlying the importance of using precaution in reviewing permitting applications for animal operations. The town of O‘okala experienced contamination of its water supply by animal waste discharged from Big Island Dairy, a dairy CAFO with about 2,000 cows.[38] The Hawai‘i Department of Health fined the CAFO $25,000 for discharging animal wastewater, biosolids, and dirt into state waters and ordered corrective action to prevent further pollution.[39] The Center for Food Safety and the community group Kupale O‘okala, Inc. have filed a lawsuit, Kupale O‘okala v. Big Island Dairy, to halt Big Island Dairy's wastewater discharge.[38] Although the operation and management practices are potentially different between HDF and Big Island Dairy, this situation is an example of the environmental impacts and resulting public health risks that can result from large-scale dairy operations.

We hope that this description of public health concerns associated with IFAP is helpful. Through our research, we know that state and local agencies can face many barriers in addressing issues surrounding IFAP due to narrow regulations and limited resources,[40,41] and we would be happy to consider a request for technical assistance if needed. In addition to relevant studies included in Appendix A, we are also attaching a copy of a local ordinance that establishes health, safety, and welfare regulations for large-scale animal production as an example of measures that have been taken by other local governments. Please do not hesitate to contact us if you have any questions.

Sincerely,

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References

1. Rostagno MH. Can stress in farm animals increase food safety risk? *Foodborne pathogens and disease*. 2009;6(7):767-776.
Link: http://online.liebertpub.com/doi/pdf/10.1089/fpd.2009.0315

This study reviewed current knowledge to assess the potential impact of stress—such as that from inadequate nutrition, deprivation of water and/or feed, heat, cold, overcrowding, handling and transport—in farm animals on food safety risk. The review focused on stress mechanisms influencing the colonization and shedding of enteric pathogens in food animals due to the potential for their dissemination into the human food chain, a serious public health and economic concern. The review concluded that there is a growing body of evidence that demonstrates the negative impact of stress on food safety through a variety of potential mechanisms, and recommends additional research to optimize animal welfare and minimize production loses and food safety risks.

2. Venter H, Henningson ML, Begg, SL. Antimicrobial resistance in healthcare, agriculture and the environment: the biochemistry behind the headlines. *Portland Press: Essays in Biochemistry.* 2017;61:1-10.
Link: http://essays.biochemistry.org/content/61/1/1

This review examined antimicrobial resistance (AMR), with a focus on three areas related to AMR, including hospital-acquired infections, the spread of resistance through animals and/or the environment, and the role of antimicrobial soaps and other products containing disinfectants. The authors note evidence of a direct relationship between the use of antimicrobials in all of these areas and the development of resistance, and argue for increased stewardship in clinical and agricultural settings.

3. Rule AM, Evans SL, Silbergeld EK. Food animal transport: A potential source of community exposures to health hazards from industrial farming (CAFOs). *Journal of Infection and Public Health*. 2008;1(1):33-39.
Link: https://www.ncbi.nlm.nih.gov/pubmed/20701843

The results of this study support the hypothesis that current methods of food animal transport from farm to slaughterhouse result in the transfer of bacteria, including antibiotic-resistant bacteria, to the vehicles travelling the same road. Bacteria were isolated from air and surface samples from vehicles following open poultry trucks, suggesting a new route of exposure to pathogens and the further dissemination of these pathogens to the general environment.

4. Spencer JL, Guan J. Public health implications related to spread of pathogens in manure from livestock and poultry operations. *Public Health Microbiology: Methods and Protocols*. 2004:503-515.
Link: https://www.ncbi.nlm.nih.gov/pubmed/15156064

Objectionable odors, flies, excessive levels of nitrogen and phosphorus and the potential spread of human pathogens are among the public concerns with the disposal of animal manure and the spread of dust and manure blown from powerful building fans. The study also finds that importance of animal manure in the spread of infectious pathogens is often underestimated despite the linkages between livestock operations and gastroenteritis in humans.

5. Graham JP, Leibler JH, Price LB, et al. The animal-human interface and infectious disease in industrial food animal production: Rethinking biosecurity and biocontainment. *Public Health Rep*. 2008:282-299.
Link: https://www.ncbi.nlm.nih.gov/pubmed/19006971

The transition of food animal production from small-scale methods to industrial-scale operations has been accompanied by substantial evidence of the transfer of pathogens between and among industrial food animal facilities, the environment, and exposure to farm workers. This challenges the notion that modern animal production is more biosecure than smaller operations in regards to the introduction and release of pathogens. The study concludes that industrialized food animal production risk factors must be included in strategies to mitigate or prevent the emergence of pandemic avian influenza.
Refer to page 19 of this document for the complete article abstract.

6. Jahne MA, Rogers SW, Holsen TM, Grimberg SJ, Ramler IP. Emission and dispersion of bioaerosols from dairy manure application sites: Human health risk assessment. *Environ Sci Technol*. 2015;49(16):9842-9849.
Link: https://www.ncbi.nlm.nih.gov/pubmed/26158489

The risk of human gastrointestinal infection associated with exposure to airborne pathogens following the land application of dairy manure was explored in this study. It was concluded that bioaerosol emissions from manure application sites may present significant public health risks to downwind receptors, and improved manure management practices that include better controls for bioaerosols were recommended to reduce the risk of disease transmission.
Refer to page 19 of this document for the complete article abstract.

7. Casey JA, Curriero FC, Cosgrove SE, Nachman KE, Schwartz BS. High-density livestock operations, crop field application of manure, and risk of community-associated methicillin-resistant *Staphylococcus aureus* infection in Pennsylvania. *JAMA Internal Medicine*. 2013;173(21):1980-1990.
Link: https://www.ncbi.nlm.nih.gov/pubmed/24043228

This study assessed the association between exposure to swine and dairy/veal industrial agriculture and the risk of methicillin-resistant *Staphylococcus aureus* (MRSA) infection. The study found that proximity to livestock operations and crop fields treated with swine manure were each associated with MRSA, skin and soft-tissue infection.
Refer to page 17 of this document for the complete article abstract.

8. Roberts RR, Hota B, Ahmad I, et al. Hospital and societal costs of antimicrobial-resistant infections in a Chicago teaching hospital: Implications for antibiotic stewardship. *Clin Infect Dis*. 2009;49(8):1175-1184.
Link: https://academic.oup.com/cid/article/49/8/1175/425330/Hospital-and-Societal-Costs-of-Antimicrobial

> Medical and societal costs attributable to antimicrobial-resistant infections are considerable, and important factors in understanding the potential benefits of prevention programs. Medical costs attributable to antimicrobial-resistant infections range from $18,588 to $29,069 per patient, hospital stay durations from 6.4-12.7 days, and mortality of 6.5%. Societal costs were estimated at $10.7-$15 million.

9. Filice GA, Nyman JA, Lexau C, et al. Excess costs and utilization associated with methicillin resistance for patients with *Staphylococcus aureus* infection. *Infection Control & Hospital Epidemiology*. 2010;31(04):365-373.
Link: https://www.ncbi.nlm.nih.gov/pubmed/20184420

> Healthcare costs of methicillin-resistant *S. aureus* (MRSA) infections and methicillin-susceptible *S. aureus* (MSSA) were compared in this study. MRSA infections were found to be independently associated with higher costs, more comorbidities, and higher likelihood of death than MSSA infections.

10. Burgos J, Ellington B, Varela M. Presence of multidrug-resistant enteric bacteria in dairy farm topsoil. *J Dairy Sci*. 2005;88(4):1391-1398.
Link: https://www.ncbi.nlm.nih.gov/pubmed/15778307

> This study was conducted to better understand how widespread antibiotic-resistant bacteria are in agricultural settings, particularly in dairy farm environments. The study concluded that dairy farm topsoil contains multidrug resistant enteric bacteria and antibiotic-resistant plasmids, and suggests that dairy topsoils serve as a reservoir for the development of bacterial resistance to antibiotics relevant in clinical medicine.
> *Refer to page 17 of this document for the complete article abstract.*

11. United States Environmental Protection Agency. Literature review of contaminants in livestock and poultry manure and implications for water quality. July 2013:1-137.
Link: http://ow.ly/mTDw308qwbZ

> This EPA report on the environmental occurrence and potential effects of livestock and poultry manure related contaminants on water quality found that 60-70% of manure nitrogen and phosphorus may not be assimilated by the farmland where it was generated due to the increasing concentration of industrial animal production. The report also notes the variety of pathogens contained in livestock and poultry manure, as well as the potential for their spread to humans when surface and groundwater and food crops come into contact with manure through runoff, spills, and land-application of manure. It also refers to research indicating that antimicrobial use

in livestock and poultry production has contributed to the occurrence of anti-microbial resistant pathogens in animal operations and nearby environments. The report also presents that manure discharge to surface waters can occur by various means and have deleterious effects on aquatic life and contribute to toxic algal blooms harmful to animals, and to humans when exposed via contact with contaminated drinking water or recreational use of contaminated water.

12. Wichmann F, Udikovic-Kolic N, Andrew S, Handelsman J. Diverse antibiotic resistance genes in dairy cow manure. *MBio*. 2014;5(2):e01017-13.
Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3993861/

This study was conducted to better understand the cow microbiome and the role of the land application of cow manure in the spread of antibiotic resistance. The study reports the discovery of new and diverse antibiotic resistant genes in the cow microbiome, and provides evidence that it is a significant reservoir of antibiotic resistant genes.
Refer to page 21 of this document for the complete article abstract.

13. Group 70 International on behalf of Hawai'i Dairy Farms. Final Environmental Impact Statement. Hawai'i Dairy Farms Maha'ulepu, Kaua'i; January 2017.
Link:www.hawaiidairyfarms.com/media/W1siZiIsIjIwMTcvMDEvMTgvMDJfMjZfMjJfMTdfRkVJU19IREZfVm9sXzEucGRmIl1d/FEIS_HDF_Vol 1.pdf

This document outlines the purpose and objectives of the proposed Hawai'i Dairy Farms operation. It provides descriptions of the dairy site requirements, buildings and support facilities, utilities, and agricultural infrastructure as well as proposals for activities, such as herd management, pasture management, irrigation and nutrient balance, offsite milk processing, offsite herd management and the contemplated herd size.

14. Casey JA, Kim BF, Larsen J, Price LB, Nachman KE. Industrial food animal production and community health. *Current environmental health reports*. 2015;2(3):259-271.

This study reviewed recent literature to assess the association between the elevated risk of health outcomes and living near industrial food animal production (IFAP) operations and manure-applied crop fields. The study found that respiratory outcomes, methicillin-resistant *Staphylococcus aureus* (MRSA), Q fever and stress/mood were all consistently and positively associated with living near IFAP operations. The study also found moderate evidence of an association with quality of life, and limited evidence of an association with cognitive impairment, *Clostridium difficile*, *Enterococcus*, birth outcomes, and hypertension.

15. United States Geological Survey (USGS). USGS water use data for the nation. http://waterdata.usgs.gov/nwis/wu. Updated June 8, 2016. Accessed October 3, 2017.

This United States Geological Survey website provides national water use data by area type (aquifer, watershed, county, state), source (rivers or groundwater), and category, such as irrigation or public supply.

16. Heederik D, Sigsgaard T, Thorne PS, et al. Health effects of airborne exposures from concentrated animal feeding operations. *Environ Health Perspect*. 2007:298-302.
Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1817709/

This report from a Conference on Environmental Health Impacts of Concentrated Animal Feeding Operations: Anticipating Hazards—Searching for Solutions working group states that toxic gases, vapors and particles are emitted from CAFOs into the general environment, and that while these agents are known to be harmful to human health, there are few studies that explore the health risks of exposure to these agents for the people living near CAFOs. While there is evidence that psychophysiologic changes may result from exposure to malodors and that microbial exposures are related to deleterious respiratory health effects, the working group concluded that there is great need to study and evaluate the health effects of community exposure to these CAFO related air pollutants to better understand the impact of CAFOs on the health of community members and farm workers.

17. Cambra-López M, Aarnink AJ, Zhao Y, Calvet S, Torres AG. Airborne particulate matter from livestock production systems: A review of an air pollution problem. *Environmental Pollution*. 2010;158(1):1-17.
Link: https://www.ncbi.nlm.nih.gov/pubmed/19656601

This paper reviews research on particulate matter inside and emitted from livestock production system and reports that livestock housing is an important source of particulate matter emissions. The paper recommends additional research to characterize and control particulate matter in livestock houses, as high concentrations such as those found in livestock houses can threaten the environment and the health and welfare of humans and animals.

18. Hribar C, Schultz M. Understanding concentrated animal feeding operations and their impact on communities. *Bowling Green, OH: National Association of Local Boards of Health.* 2010.
Link: https://www.cdc.gov/nceh/ehs/docs/understanding_cafos_nalboh.pdf

The National Association of Local Boards of Health produced this report with the support of the Centers for Disease Control and Prevention and the National Center for Environmental Health to assist local board of health members better understand their role in mitigating potential issues with CAFOs. The report concludes that large-scale industrial food animal production can cause numerous public health and environmental problems and should thus be monitored to prevent harm to surrounding communities. Suggested actions include passing ordinances and regulations, and increasing water and air quality monitoring and testing. The report also concludes that local boards of health, in collaboration with state and local agencies, are an appropriate body for instituting these actions due to the local nature of CAFO concerns and risks.

19. Donham KJ, Wing S, Osterberg D, et al. Community health and socioeconomic issues surrounding concentrated animal feeding operations. *Environ Health Perspect*. 2007:317-320.
Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1817697/

The Workgroup on Community and Socioeconomic Issues examined the impacts of CAFOs on the health of rural communities, using the World Health Organization's definition of health, "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." The workgroup recommended more stringent CAFO permitting, limiting animal density per watershed, improving local control, mandating environmental impact statements and considering bonding for manure storage basins.
Refer to page 18 of this document for the complete article abstract.

20. Graham JP, Nachman KE. Managing waste from confined animal feeding operations in the United States: The need for sanitary reform. *Journal of Water and Health*. 2010;8(4):646-670.
Link: https://www.ncbi.nlm.nih.gov/pubmed/20705978

Trends affecting food animal waste production, risks associated with food-animal wastes, and differences between food-animal waste and human biosolid management practices were examined in this study. The study found that no standards exist for the 335 million tons of food animal waste applied to land in the US, while human biosolids, which make up just 1% of all land-applied wastes, are subject to standards. Hormones, arsenicals, high nutrient loads, antibiotics, and pathogens, including antibiotic-resistant pathogens, are often present in animal waste. The authors made recommendations for improving management of food-animal waste through existing and new policies.

21. Showers WJ, Genna B, McDade T, Bolich R, Fountain JC. Nitrate contamination in groundwater on an urbanized dairy farm. *Environ Sci Technol*. 2008;42(13):4683-4688.
Link: https://www.ncbi.nlm.nih.gov/pubmed/18677991

This study sought to identify sources of drinking water well nitrate contamination in a housing development built on a dairy farm site using isotopic compositions of nitrate, ammonia, groundwater and chemical ratios. The results indicate that the elevated nitrate levels were due to the leaching of animal waste from pastures into groundwater during the 35 years of dairy operations. The study suggests enacting statutes requiring well water tests prior to the sale of homes built on urbanized farmland to protect the health of homeowners.
Refer to page 20 of this document for the complete article abstract.

22. Relation between nitrates in water wells and potential sources in the lower Yakima Valley, Washington state. U.S. Environmental Protection Agency, Washington, D.C., 2012. Link: Https://Www3.epa.gov/region10/pdf/sites/yakimagw/nitrate_in_water_wells_study_9-27-2012.pdf.

This study examined the effectiveness of various techniques to identify specific sources of high nitrate levels in residential drinking water well. Dairy waste was concluded to be a likely source of nitrate contamination in the wells due to isotopic data and contextual evidence such as the historical and current volumes of dairy waste in the area, lack of other potential sources of nitrogen in the area, and soil indicators.
For more detail on this report, refer to page 22 of this document.

23. Burkholder J, Libra B, Weyer P, et al. Impacts of waste from concentrated animal feeding operations on water quality. *Environ Health Perspect*. 2007:308-312.
Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1817674/

This work-group, part of the Conference on Environmental Health Impacts of Concentrated Animal Feeding Operations: Anticipating Hazards—Searching for Solutions, found that current and generally accepted livestock waste management practices do not protect water resources from the pathogens, pharmaceuticals and excessive nutrients found in animal waste. As concern about the potential human and environmental health impact of long-term exposure to contaminated water grows, there is greater need for rigorous monitoring of CAFOs, improved understanding of the major toxicants affecting human and environmental health, and a system to enforce these practices.

24. Ward MH. Too much of a good thing? Nitrate from nitrogen fertilizers and cancer. *Rev Environ Health*. 2009;24(4):357-363.
Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3068045/

Nitrate, the breakdown product of nitrogen fertilizers, accumulates in groundwater under agricultural land and can spread through waterways due to agricultural field runoff. Nitrates are associated with a range of adverse health effects, including methemoglobinemia, various cancers, negative reproductive outcomes, diabetes, and thyroid conditions. Additional research is needed to further evaluate the health effects of nitrate exposure, especially as environmental exposure to nitrates has increased over the last 50 years and 90% of rural Americans depend on groundwater for drinking water, many relying on private wells, which are not regulated by the Safe Drinking Water Act.

25. Chiu H, Tsai S, Yang C. Nitrate in drinking water and risk of death from bladder cancer: An ecological case-control study in Taiwan. *Journal of Toxicology and Environmental Health, Part A*. 2007;70(12):1000-1004.
Link: https://www.ncbi.nlm.nih.gov/pubmed/17497410

The association between bladder cancer mortality and nitrate exposure from Taiwan drinking water was investigated in this study. The results showed a significant positive relationship between the levels of nitrates in the drinking water and the risk of death from bladder cancer, indicating that environmental exposure to nitrates plays a role in the development of bladder cancer.

26. Ward MH, Kilfoy BA, Weyer PJ, Anderson KE, Folsom AR, Cerhan JR. Nitrate intake and the risk of thyroid cancer and thyroid disease. *Epidemiology*. 2010;21(3):389-395.
Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2879161/

This study examined the association between nitrate intake through public water and diet with the risk of thyroid cancer and hypo- and hyperthyroidism. The study found an increased risk of thyroid cancer with high water nitrate levels and with longer consumption of water containing

nitrates. The increased intake of dietary nitrate was associated with an increased risk of thyroid cancer, and with the prevalence of hypothyroidism.

27. Gulis G, Czompolyova M, Cerhan JR. An ecologic study of nitrate in municipal drinking water and cancer incidence in Trnava district, Slovakia. *Environ Res*. 2002;88(3):182-187.
Link: https://www.ncbi.nlm.nih.gov/pubmed/12051796

This ecologic study was conducted to assess the association between nitrate levels in drinking water with non-Hodgkin lymphoma and cancers of the digestive and urinary tracts in an agricultural district. The study found is that a higher incidence of some cancers was associated with higher levels of nitrate in drinking water. The trend was found in women for overall cancer cases, stomach cancer, colorectal cancer and non-Hodgkin lymphoma, and in men for non-Hodgkin lymphoma and colorectal cancer.

28. Manassaram DM, Backer LC, Moll DM. A review of nitrates in drinking water: Maternal exposure and adverse reproductive and developmental outcomes. *Environmental Health Perspectives*. 2006.
Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1392223/

The relationship between maternal exposure to nitrates through drinking water and adverse reproductive and developmental outcomes was reviewed in this study. Animal studies support the association between nitrate exposure and adverse reproductive effects, and some studies report an association between nitrates in drinking water and spontaneous abortion, intrauterine growth restriction and various birth defects, though a direct exposure-response relationship remains unclear and there is insufficient evidence to establish a causal relationship.

29. Brender JD, Weyer PJ, Romitti PA, et al. Prenatal nitrate intake from drinking water and selected birth defects in offspring of participants in the national birth defects prevention study. *Environ Health Perspect*. 2013;121(9):1083-1089.
Link: https://www.ncbi.nlm.nih.gov/pubmed/23771435

The relationship between prenatal exposure to nitrates in drinking water and birth defects was examined in this study. The study concluded that higher maternal water nitrate consumption was associated with birth defects, including spina bifida, limb deficiency, cleft palate, and cleft lip.

30. Knobeloch L, Salna B, Hogan A, Postle J, Anderson H. Blue babies and nitrate-contaminated well water. *Environ Health Perspect*. 2000;108(7):675-678.
Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1638204/

Two cases of infant methemoglobinemia associated with nitrate contaminated private well water were described in this paper. The case studies underscore the danger that this contaminated water poses to infants during the first six months of life, as well as the risks of long-term exposure, which include cancer, thyroid disease and diabetes. Steps to reduce nitrate inputs in groundwater and routine well water testing are recommended to protect health.

31. Heisler J, Glibert PM, Burkholder JM, et al. Eutrophication and harmful algal blooms: A scientific consensus. *Harmful Algae*. 2008;8(1):3-13.
Link: http://www.sciencedirect.com/science/article/pii/S1568988308001066

The US EPA held a roundtable discussion to develop consensus among academic, federal and state agency representatives on the relationship between eutrophication and harmful algal blooms. Seven statements were adopted during the session, which include acknowledgement of the important role of nutrient pollution and degraded water quality in the development and persistence of many harmful algal blooms.

32. Carmichael WW. Health effects of toxin-producing cyanobacteria: "The CyanoHABs". *Human and Ecological Risk Assessment: An International Journal*. 2001;7(5):1393-1407.
Link: http://www.tandfonline.com/doi/abs/10.1080/20018091095087

Current understandings of cyanobacteria toxin poisonings (CTPs) and their risk to human health were reviewed in this paper. CTPs occur in fresh and brackish waters throughout the world as a result of eutrophication and climate change. Cyanobacteria toxins are responsible for acute lethal, acute, chronic and sub-chronic poisonings of wild and domestic animals and humans. These poisonings result in respiratory and allergic reactions, gastrointestinal disturbances, acute hepatotoxicosis and peracute neurotoxicosis.

33. Paerl HW, Fulton RS,3rd, Moisander PH, Dyble J. Harmful freshwater algal blooms, with an emphasis on cyanobacteria. *Scientific World Journal*. 2001;1:76-113.
Link: https://www.ncbi.nlm.nih.gov/pubmed/12805693

This paper reviews the effects of harmful freshwater algal blooms, resulting from nutrient oversupply and eutrophication, on water quality. Algal blooms contribute to water quality degradation, including malodor and foul taste, fish kills, toxicity, and food web alterations, while algal bloom toxins can adversely affect human and animal health through exposure to contaminated recreational and drinking water. The control and management of blooms, and their negative outcomes, must include nutrient input constraints, particularly on nitrogen and phosphorus.

34. United States Environmental Protection Agency. National Pollutant Discharge Elimination System (NPDES) Permit Writers' Manual for Concentrated Animal Feeding Operations. February 2012.
Link: www.epa.gov/sites/production/files/2015-10/documents/cafo_permitmanual_entire.pdf

The NPDES Permit Writers' Manual outlines current NPDES regulations and effluent limitations guidelines applicable to CAFOs under the Clean Water Act. It provides information to CAFO applicants, inspectors, facility operators, and the general public on CAFO permitting requirements to manage wastewater and manure discharge from these facilities.

35. American Society of Agricultural Engineers. Manure Production and Characteristics. ASAE Standards 2005.

Link: http://www.agronext.iastate.edu/immag/pubs/manure-prod-char-d384-2.pdf

The American Society of Agricultural Engineers (ASAE) is an international organization dedicated to agricultural, food, and biological systems engineering advancement. The ASAE Standards provide a guideline for standardization in regards to agricultural field equipment, farmstead equipment, structures, soil and water resource management, turf and landscape equipment, forest engineering, food and process engineering, electric power applications, plant and animal environment, and waste management. This standard provides information for estimating characteristics of livestock and poultry manure.

36. United States Government Accountability Office (GAO). Concentrated Animal Feeding Operations: EPA Needs More Information and a Clearly Defined Strategy to Protect Air and Water Quality from Pollutants of Concern. September 2008.
Link: https://www.gao.gov/new.items/d08944.pdf

This GAO report discusses the trends in CAFOs over the past 30 years, including: amounts of waste they generate, findings of key research on CAFOs' health and environmental impacts, EPA's progress in developing CAFO air emissions protocols, and effects of recent court decisions on EPA's regulation of CAFO water pollutants. The GAO recommends that the EPA complete its inventory of permitted CAFOs, reassess the current nationwide air emissions monitoring study, and establish a strategy and timetable for developing a process-based model for measuring CAFO air emissions, in order to more effectively regulate CAFOs.

37. United States Department of Agriculture: Natural Resources Conservation Service. Balancing your Animals with your Forage: Small Scale Solutions for your Farm. 2009.
Link: www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1097070.pdf

This document serves as a guide for balancing between herd size and forage requirements in order to promote good grazing management systems. It provides methods for calculating the maximum number of animals for a specific pasture size and the minimum amount of land required for a specific number of grazing animals.

38. The Center for Food Safety. Community groups sue Idaho-based Big Island Dairy for polluting Hawaii waters with animal waste. June 2017.
Link: www.centerforfoodsafety.org/press-releases/4995/community-groups-sue-idaho-based-big-island-dairy-for-polluting-hawaii-waters-with-animal-waste

This press release outlines the public concerns and legal action taken against Big Island Dairy for their continued contamination of state waters and the Pacific Ocean through the discharge of animal waste and pollutants from their CAFO.

39. Big Island Now. Big Island Dairy fined for water pollution violations. May 2017.
Link: bigislandnow.com/2017/05/05/big-island-dairy-fined-for-water-pollution-violations

This article reports the charges filed against Big Island Dairy for the unlawful discharge of wastewater from the dairy's field irrigation practices, the financial penalty incurred, and the corrective actions required to prevent future contamination and maintain compliance with the federal regulations of the Clean Water Act and state water pollution laws.

40. Fry JP, Laestadius LI, Grechis C, Nachman KE, Neff RA. Investigating the role of state and local health departments in addressing public health concerns related to industrial food animal production sites. *PloS one*. 2013;8(1):e54720.
Link: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0054720

The role of local and state health departments in responding to and preventing community concerns with industrial food animal production are explored in this study through qualitative interviews with state and county health department staff and community members in eight states. Political barriers, lack of jurisdiction, and limited resources, expertise and staff all limit health departments' ability to respond to IFAP concerns, while impacted community members reported difficulty engaging health departments. These limitations and difficulties contribute to limited health department engagement on these issues.

41. Fry JP, Laestadius LI, Grechis C, Nachman KE, Neff RA. Investigating the role of state permitting and agriculture agencies in addressing public health concerns related to industrial food animal production. *PloS one*. 2014;9(2):e89870.
Link: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0089870

This study explored how state permitting and agriculture agencies respond to environmental public health concerns regarding industrial food animal production through qualitative interviews with state agency staff in seven states. The study found that the agencies were unable to adequately address these environmental public health concerns due to narrow regulations, limited resources and a lack of public health expertise. When these constraints are considered alongside those faced by health departments, it is clear that significant regulatory gaps exist that impact the ability to respond to and prevent public health concerns and issues.

Appendix A: Research Articles Related to Dairy Production and Environmental and/or Public Health Risks

We have underlined sections of the abstracts in the appendix to highlight main points.

Burgos, J. M., B. A. Ellington, and M. F. Varela. "Presence of multidrug-resistant enteric bacteria in dairy farm topsoil." *Journal of Dairy Science* 88.4 (2005): 1391-1398.
Link: https://www.ncbi.nlm.nih.gov/pubmed/15778307

> In addition to human and veterinary medicine, antibiotics are extensively used in agricultural settings, such as for treatment of infections, growth enhancement, and prophylaxis in food animals, leading to selection of drug and multidrug-resistant bacteria. To help circumvent the problem of bacterial antibiotic resistance, it is first necessary to understand the scope of the problem. However, it is not fully understood how widespread antibiotic-resistant bacteria are in agricultural settings. The lack of such surveillance data is especially evident in dairy farm environments, such as soil. It is also unknown to what extent various physiological modulators, such as salicylate, a component of aspirin and known model modulator of multiple antibiotic resistance (mar) genes, influence bacterial multi-drug resistance. We isolated and identified enteric soil bacteria from local dairy farms within Roosevelt County, NM, determined the resistance profiles to antibiotics associated with mar, such as chloramphenicol, nalidixic acid, penicillin G, and tetracycline. We then purified and characterized plasmid DNA and detected mar phenotypic activity. The minimal inhibitory concentrations (MIC) of antibiotics for the isolates ranged from 6 to >50 microg/mL for chloramphenicol, 2 to 8 microg/mL for nalidixic acid, 25 to >300 microg/mL for penicillin G, and 1 to >80 microg/mL for tetracycline. On the other hand, many of the isolates had significantly enhanced MIC for the same antibiotics in the presence of 5 mM salicylate. Plasmid DNA extracted from 12 randomly chosen isolates ranged in size from 6 to 12.5 kb and, in several cases, conferred resistance to chloramphenicol and penicillin G. <u>It is concluded that enteric bacteria from dairy farm topsoil are multidrug resistant and harbor antibiotic-resistance plasmids. A role for dairy topsoil in zoonoses is suggested, implicating this environment as a reservoir for development of bacterial resistance against clinically relevant antibiotics.</u>

Casey JA, Curriero FC, Cosgrove SE, Nachman KE, Schwartz BS. High-Density Livestock Operations, Crop Field Application of Manure, and Risk of Community-Associated Methicillin-Resistant *Staphylococcus aureus* Infection in Pennsylvania. JAMA Intern Med. 2013 Sep 16; 21205(21):1980–90.
Link: https://www.ncbi.nlm.nih.gov/pubmed/24043228

> Nearly 80% of antibiotics in the United States are sold for use in livestock feeds. The manure produced by these animals contains antibiotic-resistant bacteria, resistance genes, and antibiotics and is subsequently applied to crop fields, where it may put community members at risk for antibiotic-resistant infections. <u>The objective of this study was to assess the association between individual exposure</u>

to swine and dairy/veal industrial agriculture and risk of methicillin-resistant *Staphylococcus aureus* (MRSA) infection. This study was a population-based, nested case-control study of primary care patients from a single health care system in Pennsylvania from 2005 to 2010. Incident MRSA cases were identified using electronic health records, classified as community-associated MRSA or health care–associated MRSA, and frequency matched to randomly selected controls and patients with skin and soft-tissue infection. Nutrient management plans were used to create 2 exposure variables: seasonal crop field manure application and number of livestock animals at the operation. In a substudy, we collected 200 isolates from patients stratified by location of diagnosis and proximity to livestock operations. The study measured community-associated MRSA, health care–associated MRSA, and skin and soft-tissue infection status (with no history of MRSA) compared with controls. From a total population of 446,480 patients, 1,539 community-associated MRSA, 1335 health care-associated MRSA, 2895 skin and soft-tissue infection cases, and 2914 controls were included. After adjustment for MRSA risk factors, the highest quartile of swine crop field exposure was significantly associated with community-associated MRSA, health care-associated MRSA, and skin and soft-tissue infection case status (adjusted odds ratios, 1.38 [95% CI, 1.13-1.69], 1.30 [95% CI, 1.05-1.61], and 1.37 [95% CI, 1.18-1.60], respectively); and there was a trend of increasing odds across quartiles for each outcome ($P \leq .01$ for trend in all comparisons). There were similar but weaker associations of swine operations with community-associated MRSA and skin and soft-tissue infection. Molecular testing of 200 isolates identified 31 unique *spa* types, none of which corresponded to CC398 (clonal complex 398), but some have been previously found in swine. Proximity to swine manure application to crop fields and livestock operations each was associated with MRSA and skin and soft-tissue infection. These findings contribute to the growing concern about the potential public health impacts of high-density livestock production.

Donham KJ, Wing S, Osterberg D, al et, Flora JL, Hodne C, et al. Community health and socioeconomic issues surrounding concentrated animal feeding operations. Environ Health Perspect. 2007 Feb;115(2):317–20.
Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1817697/

A consensus of the Workgroup on Community and Socioeconomic Issues was that improving and sustaining healthy rural communities depends on integrating socioeconomic development and environmental protection. The workgroup agreed that the World Health Organization's definition of health, "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity," applies to rural communities. These principles are embodied in the following main points agreed upon by this workgroup. Healthy rural communities ensure a) the physical and mental health of individuals, b) financial security for individuals and the greater community, c) social well-being, d) social and environmental justice, and e) political equity and access. This workgroup

> evaluated impacts of the proliferation of concentrated animal feeding operations (CAFOs) on sustaining the health of rural communities. Recommended policy changes include a more stringent process for issuing permits for CAFOs, considering bonding for manure storage basins, limiting animal density per watershed, enhancing local control, and mandating environmental impact statements.

Jahne, Michael A., et al. "Emission and Dispersion of Bioaerosols from Dairy Manure Application Sites: Human Health Risk Assessment." *Environmental Science & Technology* 49.16 (2015): 9842-9849. Link: http://pubs.acs.org/doi/pdfplus/10.1021/acs.est.5b01981

> In this study, we report the human health risk of gastrointestinal infection associated with inhalation exposure to airborne zoonotic pathogens emitted following application of dairy cattle manure to land. Inverse dispersion modeling with the USEPA's AERMOD dispersion model was used to determine bioaerosol emission rates based on edge-of-field bioaerosol and source material samples analyzed by real-time quantitative polymerase chain reaction (qPCR). Bioaerosol emissions and transport simulated with AERMOD, previously reported viable manure pathogen contents, relevant exposure pathways, and pathogen-specific dose-response relationships were then used to estimate potential downwind risks with a quantitative microbial risk assessment (QMRA) approach. Median 8-h infection risks decreased exponentially with distance from a median of 1:2700 at edge-of-field to 1:13 000 at 100 m and 1:200 000 at 1000 m; peak risks were considerably greater (1:33, 1:170, and 1:2500, respectively). These results indicate that bioaerosols emitted from manure application sites following manure application may present significant public health risks to downwind receptors. Manure management practices should consider improved controls for bioaerosols in order to reduce the risk of disease transmission.

Schmalzried, Hans D., and L. Fleming Fallon Jr. "Proposed Mega-Dairies and Quality-of-Life Concerns: Using Public Health Practices to Engage Neighbors." *Public Health Reports* 125.5 (2010): 754. Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2925014/

> This article describes the steps taken by the Henry County Health Department (Ohio) to engage with concerned community members by collaborating in baseline data collection prior to the arrival of a large-scale dairy operation. Data collection included water quality testing of residential wells neighboring the dairy operation, a fly trapping and counting program, and a review of local property values. As a dairy with 690 cows will have average water requirements of 35,000 gallons/day, the Health Department coordinated a pumping test to assess groundwater levels and found that groundwater volumes were sufficient to supply the needs of the dairy and the surrounding residential wells. Residential wells were tested for coliform bacteria and field-tested for nitrates and hydrogen sulfide gas, and some of the wells tested unsafe for bacteria. In these cases, homeowners were given

instructions on how to disinfect their wells and advised to do follow-up testing. The narrative concludes that data obtained prior to operations can be very useful and that local health departments can work with neighbors and facility operators to ensure that appropriate preventive measures are in place before operation to protect the public.

Showers, William J., et al. "Nitrate contamination in groundwater on an urbanized dairy farm." *Environmental Science & Technology* 42.13 (2008): 4683-4688.
Link: http://pubs.acs.org/doi/full/10.1021/es071551t

Urbanization of rural farmland is a pervasive trend around the globe, and maintaining and protecting adequate water supplies in suburban areas is a growing problem. Identification of the sources of groundwater contamination in urbanized areas is problematic, but will become important in areas of rapid population growth and development. The isotopic composition of NO3(δ15NNO3 and δ18O NO3), NH4 (δ15NNH4), groundwater (δ2Hwt and δ18Owt) and chloride/bromide ratios were used to determine the source of nitrate contamination in drinking water wells in a housing development that was built on the site of a dairy farm in the North Carolina Piedmont, U.S. The δ15NNO3 and δ18O NO3 compositions imply that elevated nitrate levels at this site in drinking well water are the result of waste contamination, and that denitrification has not significantly attenuated the groundwater nitrate concentrations. δ15NNO3 and δ18ONO3compositions in groundwater could not differentiate between septic effluent and animal waste contamination. Chloride/bromide ratios in the most contaminated drinking water wells were similar to ratios found in animal waste application fields, and were higher than Cl/Br ratios observed in septic drain fields in the area. δ18Owt was depleted near the site of a buried waste lagoon without an accompanying shift in δ2Hwt suggesting water oxygen exchange with CO2. This water−CO2 exchange resulted from the reduction of buried lagoon organic matter, and oxidation of the released gases in aerobic soils. δ18Owt is not depleted in the contaminated drinking water wells, indicating that the buried dairy lagoon is not a source of waste contamination. The isotope and Cl/Br ratios indicate that nitrate contamination in these drinking wells are not from septic systems, but are the result of animal waste leached from pastures into groundwater during 35 years of dairy operations which did not violate any existing regulations. Statutes need to be enacted to protect the health of the homeowners that require well water to be tested prior to the sale of homes built on urbanized farmland.

Wichmann, Fabienne, et al. "Diverse antibiotic resistance genes in dairy cow manure." *MBio* 5.2 (2014): e01017-13.
Link: http://mbio.asm.org/content/5/2/e01017-13.short

Application of manure from antibiotic-treated animals to crops facilitates the dissemination of antibiotic resistance determinants into the environment.

However, our knowledge of the identity, diversity, and patterns of distribution of these antibiotic resistance determinants remains limited. We used a new combination of methods to examine the resistome of dairy cow manure, a common soil amendment. Metagenomic libraries constructed with DNA extracted from manure were screened for resistance to beta-lactams, phenicols, aminoglycosides, and tetracyclines. Functional screening of fosmid and small-insert libraries identified 80 different antibiotic resistance genes whose deduced protein sequences were on average 50 to 60% identical to sequences deposited in GenBank. The resistance genes were frequently found in clusters and originated from a taxonomically diverse set of species, suggesting that some microorganisms in manure harbor multiple resistance genes. Furthermore, amid the great genetic diversity in manure, we discovered a novel clade of chloramphenicol acetyltransferases. Our study combined functional metagenomics with third-generation PacBio sequencing to significantly extend the roster of functional antibiotic resistance genes found in animal gut bacteria, providing a particularly broad resource for understanding the origins and dispersal of antibiotic resistance genes in agriculture and clinical settings. The increasing prevalence of antibiotic resistance among bacteria is one of the most intractable challenges in 21st-century public health. The origins of resistance are complex, and a better understanding of the impacts of antibiotics used on farms would produce a more robust platform for public policy. Microbiomes of farm animals are reservoirs of antibiotic resistance genes, which may affect distribution of antibiotic resistance genes in human pathogens. Previous studies have focused on antibiotic resistance genes in manures of animals subjected to intensive antibiotic use, such as pigs and chickens. Cow manure has received less attention, although it is commonly used in crop production. Here, we report the discovery of novel and diverse antibiotic resistance genes in the cow microbiome, demonstrating that it is a significant reservoir of antibiotic resistance genes. The genomic resource presented here lays the groundwork for understanding the dispersal of antibiotic resistance from the agroecosystem to other settings.

Williams, D'Ann L., et al. "Cow allergen (Bos d2) and endotoxin concentrations are higher in the settled dust of homes proximate to industrial-scale dairy operations." *Journal of Exposure Science and Environmental Epidemiology* 26 (2014): 42-47.
Link: https://www.nature.com/articles/jes201457

Airborne contaminants produced by industrial agricultural facilities contain chemical and biological compounds that can impact the health of residents living in close proximity. Settled dust can be a reservoir for these contaminants and can influence long-term exposures. In this study, we sampled the indoor- and outdoor-settled dust from 40 homes that varied in proximity to industrial-scale dairies (ISD; industrial-scale dairy, a term used in this paper to describe a large dairy farm and adjacent waste sprayfields, concentrated animal feeding operation or animal feeding operation, that uses industrial processes) in the Yakima Valley, Washington. We analyzed settled dust samples for cow allergen (Bos d2, a cow allergen associated with dander, hair, sweat and urine,

it is a member of the lipocalin family of allergens associated with mammals), mouse allergen (Mus m1; major mouse allergen, a mouse urinary allergen, in the lipocalin family), dust mite allergens (Der p1 (*Dermatophagoides pteronissinus* 1) and Der f1 (*Dermatophagoides farinae* 1)), and endotoxin (a component of the cell walls of gram negative bacteria, lipopolysaccharide, which can be found in air and dust and can produce a strong inflammatory response). A concentration gradient was observed for Bos d2 and endotoxin measured in outdoor-settled dust samples based on proximity to ISD. Indoor-settled dust concentrations of Bos d2 and endotoxin were also highest in proximal homes. While the associated health effects of exposure to cow allergen in settled dust is unknown, endotoxin at concentrations observed in these proximal homes (100 EU/mg) has been associated with increased negative respiratory health effects. These findings document that biological contaminants emitted from ISDs are elevated in indoor- and outdoor-settled dust samples at homes close to these facilities and extend to as much as three miles (4.8 km) away.

Relation between Nitrates in Water Wells and Potential Sources in the Lower Yakima Valley, Washington State. U.S. Environmental Protection Agency, Washington, D.C., 2012. Link: https://www3.epa.gov/region10/pdf/sites/yakimagw/nitrate_in_water_wells_study_9-27-2012.pdf

Several investigations relating to nitrate contamination in the Lower Yakima Valley in Washington State have shown nitrate levels in drinking water above the U.S. Environmental Protection Agency (EPA) maximum contaminant level (MCL) of 10 mg/L. From February through April 2010, EPA conducted sampling of drinking water wells and potential sources of nitrate contamination in the Lower Yakima Valley, in central Washington State. This report presents the results of these sampling efforts. EPA collected over 331 samples from residential drinking water wells for nitrate and bacteria, and multi-parameter sampling on 29 water wells (26 residential drinking water wells and three dairy supply wells), 12 dairy lagoons (15 samples), 11 soil samples (five at dairy application fields and six at irrigated and fertilized crop fields), five dairy manure pile samples, and three wastewater treatment plant (WWTP) influent samples. EPA's data provide some indication of the likely nitrate sources for seven of the 25 residential wells tested--animal waste was determined to be the source for six of the wells, and synthetic fertilizer the source for one of the wells. Given the historic and current volumes of wastes generated and stored by dairies, and the application of nitrogen-rich fertilizers including dairy waste in the Lower Yakima Valley, it is expected that dairies are a likely source of high nitrate levels in downgradient drinking water wells. The total nitrogen, major ions, alkalinity and barium data provide strong evidence that the dairies evaluated in this study are likely sources of the high nitrate levels in the drinking water wells downgradient of the dairies. Additional information that supports this conclusion includes: there are few potential sources of nitrogen located upgradient of the dairies; the dairy lagoons are likely leaking large quantities of nitrogen-rich liquid into the subsurface; and Washington State Department of Agriculture inspectors have reported elevated levels of nitrogen in

application fields of the dairies in the study. Evaluating actions to reduce nitrate concentrations in residential drinking water wells was beyond the scope of the EPA's report. EPA concluded that actions to reduce nitrate levels are needed, although it may take many years to reduce nitrates in residential drinking water wells to safe levels because of the extent of the nitrate contamination in the Lower Yakima Valley and the persistence of nitrate in the environment.