DEPARTMENT OF AGRICULTURE

PFAS in Pesticides

Interim Report to the Legislature

02/01/2024

Legislative Charge

Sec. 138. REPORTS REQUIRED; PFAS IN PESTICIDES.

The commissioner of agriculture must conduct a review of existing published literature and other available information on the presence of PFAS in pesticides used in Minnesota. The review must consider the presence of intentionally added PFAS in pesticide active and inert ingredients; the potential for PFAS that are not intentionally added in pesticides; an assessment of the use and necessity of pesticides containing PFAS in Minnesota; potential alternative products; and other considerations necessary to determine the risks of, and need for, PFAS in pesticide products used in Minnesota. The commissioner must submit an interim report to the chairs and ranking minority members of the legislative committees with jurisdiction over agriculture no later than February 1, 2024, and a final report no later than February 1, 2025.

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Executive Summary

In 2023, new laws regulating perfluoroalkyl and polyfluoroalkyl substances (PFAS) in consumer products were passed. The laws outline the process for gathering information on and prohibiting the sale and distribution of products, including pesticide products, containing intentionally added PFAS. Additionally, SF 1955 Sec. 138 directs the Minnesota Department of Agriculture (MDA) to prepare two legislative reports on PFAS in pesticides. This interim report provides an overview of what is currently known about PFAS in relation to pesticides; it will be followed by a final report provided to the Legislature in 2025.

PFAS, commonly known as "forever chemicals," are a large and diverse group of manufactured chemicals with a wide array of industrial and consumer product uses. There have been a variety of definitions of PFAS published, many of which are based on chemical structures. One characteristic that all PFAS share is the presence of a carbon-fluorine bond. The carbon-fluorine bond, which is very strong and difficult to break, imparts many of the properties (e.g., high stability and persistence) that PFAS are known for. PFAS can be found in a long list of products including non-stick cookware, waterproof outdoor gear, lubricants, and greases.

Pesticides are substances used to manage pests such as insects, weeds, and pathogens. They are important tools for growing food, fuel, and fiber, preventing disease, controlling invasive species, and managing nuisance pests. Pesticides are regulated by the Environmental Protection Agency (EPA) at the federal level and by the MDA at the state level. Prior to use in the United States (U.S.), all pesticides must go through a rigorous scientific review as part of the EPA's registration process which involves evaluating potential risks to human health and the environment. The MDA registers pesticides for use in Minnesota and may conduct additional reviews.

PFAS can be present in pesticide products as either active or inert ingredients. The MDA screened pesticide active ingredients registered for use in Minnesota and identified 95 chemicals that meet the Minnesota Law (Minn. Stat. 18B.01 subd. 15(c)) definition of PFAS, based on their chemical structure. Pesticide products containing active ingredients considered to be PFAS made up approximately 15% (2,163 products) of all the pesticide products registered in Minnesota in 2022 and accounted for approximately 2% of statewide sales (active ingredient by weight) in that year. Inert ingredients, or chemicals that are used to improve pesticide product efficacy, are not disclosed to the MDA during registration and may be considered proprietary information. It is not known how many additional pesticide products may contain intentionally added PFAS as inert ingredients at this time; however, the MDA plans to review the EPA's list of approved inert ingredients and request pesticide registrants provide information about intentionally added PFAS in their products by the applicable statutory deadlines. Additionally, pesticide products may be contaminated with PFAS from various sources including fluorinated high-density polyethylene (HDPE) containers. While analytical testing methods for PFAS in environmental matrices such as water are becoming increasingly available, validated analytical methods for testing for PFAS in pesticide products remain limited. Thus, testing for PFAS in pesticides for the purposes of enforcement will be challenging.

PFAS have been detected in air, soil, water, wildlife, and humans worldwide including in Minnesota-specific monitoring programs; however, pesticides' relative contribution to PFAS in the environment is unclear. In agricultural lands, for example, there are multiple known sources of PFAS aside from pesticides including the application of biosolids (a wastewater treatment byproduct) as fertilizer and the use of PFAS-contaminated water for irrigation, among others. With many different PFAS chemicals being widely used for a variety of purposes, it can be challenging to identify specific sources of PFAS contamination. Furthermore, PFAS monitoring has primarily focused on only a small fraction of the numerous chemicals in this class, such as perfluorooctonoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS).

A great deal of variability exists among chemicals classified as PFAS with respect to the potential risks they pose to humans and the environment. For example, the toxicity of PFAS to humans can drastically differ, as shown through comparisons of human health-based water guidance values developed by the Minnesota Department of Health. The health-based values for PFOA and PFOS are set at 0.0000079 (cancer) and 0.0023 (chronic) parts per billion (ppb), respectively, while the value for the pesticide active ingredient fomesafen (a PFAS under the Minnesota definition) is orders of magnitude higher (20 ppb, chronic). While select PFAS chemicals have been well-studied, limited information exists on the potential exposure to and toxicity of many others. The EPA has proposed six National Primary Drinking Water Regulations for select well-studied PFAS in drinking water, including PFOA and PFOS. The proposed maximum contaminant levels, set at 0.004 ppb for both PFOA and PFOS, are expected to be promulgated in 2024.

In contrast to most PFAS, data are readily available on the toxicological effects and fate of pesticides in the environment. As part of the EPA's pesticide registration process, registrants are required to submit extensive data on physical and chemical properties of pesticide active ingredients and their degradation products. Toxicity data for pesticide active ingredients to plants, animals, and humans are also submitted to the EPA as part of the federal registration process and published in publicly available documents. With respect to human health, data are typically available on short-term (acute) and long-term (chronic) pesticide toxicity from various exposure routes (e.g., oral, inhalation, dermal), in addition to data on developmental toxicity, reproductive effects, and mutagenicity. Information about potential exposure to pesticides is largely obtained through modeling and monitoring. The MDA monitors more than 180 pesticide-related chemicals in Minnesota's groundwater and surface waters, some of which would be classified as PFAS under Minnesota Law (Minn. Stat. 18B.01 subd. 15(c)).

When regulating PFAS as a class, how PFAS are defined will impact which chemicals are subject to regulations. The definition of PFAS in Minnesota Law (Minn. Stat. 18B.01 subd. 15(c)) is the broadest definition in regulatory use. It categorizes more chemicals as PFAS than the definitions used by EPA, the European Chemicals Agency, and the Organization for Economic Co-operation and Development. The MDA identified 95 pesticide active ingredients registered in Minnesota (as of June 2023) that would be considered PFAS under the Minnesota definition. By comparison, approximately six active ingredients registered in Minnesota would be PFAS under the EPA Office of Pollution Prevention and Toxics (OPPT) definition. To date, Maine is the only other state regulating intentionally added PFAS in pesticides and they are using the same definition of PFAS as Minnesota. The European Union (EU) and European Economic Area is proposing to prohibit the use of a broad suite of PFAS in products; however, a proposal from five countries recommends excluding pesticides from the proposed prohibitions due to the extensive evaluations and approval processes that are already in place for pesticides.

According to new regulations under the Minnesota Pesticide Control Law (Minn. Stat. Chapter 18B), the commissioner of agriculture may not register a pesticide product that contains intentionally added PFAS beginning January 1, 2032; and beginning January 1, 2026, the commissioner may not register a cleaning product if the product contains intentionally added PFAS. However, the Pesticide Control Law (Minn. Stat. Chapter 18B.26) provides an exemption for "currently unavoidable use" (CUU) of PFAS in pesticide products. Factors such as the need to prevent or minimize potential pest resistance and the potential human health and environmental impacts of alternative products will be considered in CUU exemption decisions. Pesticide registrants with products containing intentionally added PFAS may request a CUU exemption review that could allow the product to be registered and sold in Minnesota beyond the prohibition deadlines.

The full impacts of Minnesota laws regulating intentionally added PFAS in pesticides are uncertain. It is anticipated that the pesticide products available for sale in Minnesota will change because of the PFAS laws. Determining how the loss of pesticide products could impact agriculture and other industries would require extensive data and study. Revenue losses from a reduction in pesticide product annual registration fees and gross sales fees would likely occur. There are also pesticide-related products that may contain intentionally added PFAS such as pesticide treated seed, personal protective equipment, and fluorinated pesticide storage containers that would be regulated by the Minnesota Pollution Control Agency. The MDA is committed to ensuring that pesticide use in Minnesota will not endanger humans, damage agricultural products, food, livestock, fish, or wildlife, or cause unreasonable adverse effects on the environment.

Scientific understanding of PFAS is growing, but many uncertainties remain. This interim report summarizes regulation of pesticides, regulation of PFAS, what is known about PFAS in pesticides, monitoring and detections of PFAS in the environment, analytical methods for PFAS in pesticides, the MDA's implementation of new PFAS in pesticides laws, and key considerations and challenges when implementing PFAS regulation in pesticides laws. The full legislative report on PFAS in pesticides will further explore the science and regulation of PFAS in pesticides, areas of uncertainty, and considerations for decision-making. The full report may also include recommendations for actions.

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Introduction

Perfluoroalkyl and polyfluoroalkyl substances (PFAS), commonly known as “forever chemicals,” are a large and diverse group of manufactured chemicals with a wide array of industrial and consumer product uses. PFAS can be resistant to extreme temperatures and repel water and oil, which leads manufacturers to use them for applications such as non-stick cookware and waterproof outdoor apparel. Lubricants and greases, gaskets, electronics, textiles, ammunition, paper and packaging, musical instruments, leather, pharmaceuticals, and pesticides are just some of the many products that may contain PFAS (Glüge et al., 2020). While PFAS have been widely used since the 1940s, there has been growing interest in the potential health and environmental risks associated with these chemicals in recent years.

PFAS are often discussed and are now being regulated as a class due in part to structural similarities and shared properties. As a class, PFAS encompass over 10,000 unique chemicals and potentially many more depending on the definition used (Gaines et al., 2023). For example, the 2021 Organization for Economic Co-operation and Development (OECD) definition of PFAS encompasses over 7 million chemicals in the PubChem database (Schymanski et. al., 2023). Because there is not one universal definition of PFAS, chemicals classified as PFAS can vary greatly. One key characteristic, however, is that all PFAS share the presence of a carbon-fluorine bond. The carbon-fluorine bond is extremely strong and difficult to break; therefore, PFAS are often very stable and persistent (i.e., slow to break down). While this stability is often favorable in commercial and industrial applications, it has also led to PFAS becoming ubiquitous in the environment and in humans.

PFAS are being detected in air, soil, water, wildlife, and humans worldwide. Given the large number of chemicals and wide range of uses for PFAS, there are many potential sources of environmental contamination. Detections of PFAS at high concentrations have typically been associated with industrial sites, facilities where aqueous film forming foam (AFFF) has been used in firefighting and training activities (e.g., military complexes and airports), landfills, and sites where biosolids/municipal wastewater treatment sludge have been applied (Brunn et al., 2023; Ghisi et al., 2019). In agricultural lands, biosolids applied as fertilizer have been linked to PFAS contamination (Sepulvado et al., 2011; Washington et al., 2010), while potential contributions from other sources, including pesticides, have not been well characterized. Furthermore, testing thus far has focused on only a small fraction of chemicals that are classified as PFAS; therefore, the full extent of PFAS pollution is largely unknown.

PFAS exposure can lead to adverse effects on human health and the environment, and addressing the issue can be extremely expensive, complicated, and disruptive. For example, high concentrations of certain PFAS chemicals found in agricultural soils and groundwater in Maine, Michigan, and New Mexico have led to farms temporarily or permanently shutting down. However, the potential risks associated with PFAS vary depending on the chemical. Exposure to some PFAS may cause certain cancers, high cholesterol, and lower birth weight and size (ATSDR, 2022). Yet, other chemicals that may also be classified as PFAS are used as pharmaceuticals with beneficial health effects (e.g., Prozac and Lipitor) (Hammel et al., 2022). Scientists at the state and federal levels have been working to determine acceptable PFAS exposure levels. For instance, the U.S. Environmental Protection Agency (EPA) proposed National Primary Drinking Water Regulation for six highly fluorinated PFAS, and the Minnesota Department of Health (MDH) developed health-based guidance values for six highly fluorinated PFAS chemicals in drinking water, all of which are set at very low levels (i.e., parts per trillion) (MDH, 2022). However, for many chemicals in the PFAS class, the potential risks are simply unknown. In contrast, a substantial amount of information is available about pesticides and their risks to human health and the environment because of rigorous EPA registration requirements.

PFAS can be found in pesticide products both as intentionally added ingredients and as contaminants. Chemicals that are classified as PFAS can be used as active ingredients (i.e., ingredients that control pests) in pesticide products as well as inert ingredients (i.e., ingredients added to improve the performance of usability of the product). Active ingredients in pesticide products are disclosed on the product label; therefore, the names and amounts of these intentionally added PFAS are readily available. While information about inert ingredients in products is not publicly available, it is disclosed to the EPA and the Minnesota Department of Agriculture MDA could request the information from the pesticide registrants. PFAS can also be present in pesticide products due to contamination from a variety of sources, including fluorinated containers (USEPA, 2021). While PFAS in pesticide products can enter the air, soil, or water through pesticide use, more work is needed to understand the extent to which PFAS are present in pesticides and the relative contributions of pesticides to the total PFAS, as well as specific PFAS (e.g., Perfluorooctanesulfonic acid [PFOS]), in the environment.

Minnesota's strategic approach to address PFAS is outlined in Minnesota's PFAS Blueprint (MPCA, 2021). The PFAS Blueprint was published in February 2021 as a multi-agency approach to prevent, manage, and cleanup PFAS. One way to prevent PFAS pollution that was identified as an "opportunity for action" in the Blueprint is to restrict the use of PFAS to only essential uses.

In 2023, new laws regulating perfluoroalkyl and polyfluoroalkyl substances (PFAS) in consumer products were passed. These laws outline the process for gathering information on the intentional addition of PFAS in consumer products and prohibiting the sale and distribution of products containing intentionally added PFAS, including pesticide products (See Appendix A). Additionally, SF 1955 Sec. 138 directs the MDA to prepare two legislative reports on PFAS in pesticides.

This interim legislative report on PFAS in pesticides summarizes the science and regulation of pesticides, PFAS, PFAS in pesticides, and outlines areas of uncertainty, key considerations and challenges, and areas of future examination for the 2025 final legislative report on PFAS in pesticides.

Pesticide Regulation and Risk

According to U.S. federal law, a pesticide is a substance or mixture of substances intended to prevent, destroy, repel, or mitigate a pest. Substances or mixtures of substances used as a plant growth regulator, defoliant, or desiccant, or as a nitrogen stabilizer are also considered pesticides (U.S. Code Title 7, Chapter 6, Subchapter II, § 136 (u)). Pesticides can be chemical substances or biological agents and have many uses. For example, pesticides can be used to control weeds (herbicides), insects (insecticides), and plant diseases (fungicides). Pesticides can also be used to sanitize surfaces (e.g., antimicrobial sprays) and treat wood, among other uses. Certain substances, such as cleaning agents and fabric treatments, may be considered pesticides if pesticidal claims are made.

Pesticide Components

Pesticide products are made up of active and inert ingredients. Active ingredients are the chemicals that control pests while inert ingredients are included in the pesticide formulation but do not act directly to control the pest (40 CFR 158.300). Inert ingredients are added to pesticide products to improve the product performance and usability; for instance, inert ingredients may extend a product's shelf-life or help the pesticide penetrate leaf surfaces. Examples of inert ingredients include solvents, carriers, emulsifiers, and dyes. All active and inert ingredients must be approved by EPA before they can be included in a pesticide product. Federal law requires that all active ingredients must be listed by name and percentage on the pesticide product label; however, for inert ingredients, only the total percentage of inert ingredient is required on the label.

Adjuvants are chemicals that are used to improve pesticide product efficacy. For example, adjuvants can control the acidity and reduce foam in tank mixes, help pesticides adhere to surfaces or penetrate a target, and reduce spray drift. Adjuvants can be included in pesticide products as inert ingredients or sold separately to mix with a pesticide in a spray tank before application. When a pesticide product label directs the user to add a particular adjuvant before use, the EPA treats that adjuvant as if it were an inert ingredient.

Registration of Pesticides

Sale, distribution, and use of pesticides at the federal level is governed by the Federal Insecticide Fungicide and Rodenticide Act (FIFRA). FIFRA requires that the EPA register most pesticides sold or distributed in the United States. Under the Food Quality Protection Act (FQPA), the EPA must review each pesticide registration at least once every 15 years. When the EPA registers a pesticide, it receives an EPA registration number that must appear on all pesticide product labels.

The MDA is the lead state agency for the regulation of pesticides in Minnesota (Minn. Stat. 18B.03, Subd. 1). The MDA is responsible for regulating the registration of pesticides for distribution and use in Minnesota (Minn. Stat. 18B.26, subd. 1), as well the application of pesticides and enforcement of pesticide label requirements (Minn. Stat. 18B.03, subd. 1). With the exception of minimum risk pesticides, all pesticide products must be registered by the MDA to be legally sold, distributed, and used in the state, and registrations must be renewed annually (Minn. Stat. 18B.26, subd. 1).

Minimum risk 25(b) pesticides are pesticides that the EPA has determined pose little to no risk to human health or the environment. Pesticides in this category are exempt from federal registration under FIFRA (40 CFR 152.25(f)). The EPA maintains a list of active and inert ingredients that can be used in minimum risk pesticide products. The MDA does not currently register minimum risk pesticides at the state level; however, the MDA does regulate these pesticides to ensure that all conditions of minimum risk exemptions are met, and they are used according to label directions.

Adjuvants sold as a standalone product, that are not part of a pesticide product's formulation, are not regulated by the MDA under FIFRA or Minnesota Law (Minn. Stat. 18B).

Pesticide Risk Assessments and Review

Risk is the chance of harmful effects resulting from exposure to an environmental stressor. Risk assessments characterize the nature and magnitude of risks to human health and the environment including plants, birds, other wildlife, and aquatic life. The EPA conducts registration reviews and risk assessments for pesticides at the federal level. The MDA also conducts special registration reviews at the state level for newly registered active ingredients and for pesticides with significant new use. Reviews may also be conducted to better understand Minnesota-specific pesticide issues. Pesticide registration reviews and risk assessments are generally carried out on a chemical-by-chemical basis, though similar chemicals may be combined and reviewed as a class in some instances.

EPA

Before registration, the EPA is required to conduct an independent, rigorous scientific assessment to ensure a pesticide product will not cause unreasonable risk to humans or the environment. As part of the registration process, the EPA evaluates the product ingredients (both active and inert), the target site or crop; the amount, frequency, and timing of use, and storage and disposal practices. For products containing a new active ingredient, the extensive review process can take years to complete. Once registered, pesticides must undergo a reregistration review at least once every 15 years to ensure that new information and data are considered in the EPA's registration decision and to determine if any new risk assessments are needed.

The EPA reviews data provided by companies and develops risk assessments to evaluate the potential health and ecological effects of a pesticide product. When applying for EPA registration, companies are required to submit a suite of data on product chemistry, efficacy, how the pesticide moves and breaks down in the environment, and its toxicity to humans and other non-target organisms (40 CFR Part 158). The EPA uses the submitted data along with a variety of other risk assessment tools (e.g., databases, models) to evaluate how humans, wildlife, fish, and plants may be exposed to the pesticide and the risk of adverse effects. For example, human health risk assessments consider pesticide exposure from various sources (e.g., food, drinking water, contact/inhalation during application) and potential short-term and long-term health effects (e.g., acute toxicity, carcinogenicity, developmental effects). Ecological risk assessments are designed to evaluate risk to various taxa, including birds, mammals, fish, terrestrial and aquatic invertebrates, and plants, and assess the potential contamination of surface water and groundwater. Degradates, or breakdown products, of the pesticide are also evaluated as part of the risk assessment. Based on data review and risk assessment outcomes, the EPA makes a registration decision and may require modifications to the product or labeling to mitigate identified risks and ensure its use does not result in unreasonable adverse effects.

To mitigate risks associated with dietary exposure, the EPA establishes tolerance for active and inert ingredients in pesticide products that are labeled for use on food or feed crops. Tolerances, also known as maximum pesticide residue limits, are set for each food and feed commodity on which a pesticide is labeled for use. The EPA develops tolerances based on risk assessments that consider aggregate exposure and the potential increased susceptibility of sensitive subpopulations (e.g., infants and children), among other factors. While labeled uses of pesticides are unlikely to result in tolerance exceedances, commodities intended for sale in the U.S. are regularly tested by the Food and Drug Administration to ensure tolerances are not exceeded.

The EPA maintains a list of the inert ingredients approved for use in pesticide products, Pesticide Product Inert Ingredients. Pesticide registrants do not need to submit specific required data as with active ingredients in 40 CFR Part 158. However, the EPA "must have sufficient data to make a safety determination regarding human dietary risk under the Federal Food, Drug, and Cosmetic Act in connection with the establishment of a tolerance or tolerance exemption and to determine that the ingredient will not present unreasonable adverse effects to the environment in connection with the EPA's approval under FIFRA of pesticide products containing the ingredient."

MDA

At the state level, the MDA tracks and reviews the EPA's regulatory decisions and risk documents for potential state-specific impacts. For new active ingredients, significant new uses of existing active ingredients, and major pesticide label changes, the MDA may conduct brief registration reviews to assess the potential impacts in Minnesota. Larger, more in-depth reviews may also be conducted at the commissioner's request.

The MDA works closely with other state agencies to evaluate the risks of pesticides in Minnesota. For example, the MDA often requests human health-based guidance values from the MDH that are used to evaluate the risk of pesticides in potential drinking water sources. Similarly, the MDA often requests state-specific standards for pesticides from the Minnesota Pollution Control Agency (MPCA) to evaluate the potential risk of pesticides in rivers and streams. The MDA uses the reference values provided by the MDH and the MPCA to evaluate concentrations of pesticides detected in water through its water quality monitoring program. The MDA does not independently develop any standards or guidance for pesticides. Where such state-specific standards are not available, the MDA uses EPA developed guidance values (e.g., human health benchmarks for pesticides and aquatic life benchmarks).

PFAS Regulations and Actions

Regulations are being passed at the state and federal level, and internationally, to limit PFAS use. While select PFAS are being regulated as individual chemicals (e.g., PFOA), a growing number of jurisdictions, including the U.S., Canada, and the European Union (EU), are regulating or proposing regulations to address PFAS as a class. This section provides an overview of regulations that limit the manufacture, import, sale, use, and disposal of PFAS as it may relate to pesticides.

Federal and International Regulations and Actions

The Stockholm Convention on Persistent Organic Pollutants is an international treaty seeking to protect human health and the environment from persistent organic pollutants which remain intact in the environment for long periods, are geographically widely distributed, and accumulate in the fatty tissue of humans and wildlife. The Stockholm Convention includes regulation to eliminate use of the PFAS chemicals PFOS and its derivatives; PFOA, its salts, and PFOA-related compounds; and Perfluorohexanesulfonic acid (PFHxS), its salts, and related compounds. Currently, long-chain perfluorocarboxylic acids (LC-PFCAs) (C9-21) are being considered for inclusion in the Stockholm Convention. Notably, the U.S. signed the Stockholm Convention in 2001 but has yet to ratify the treaty.

European Union

The European Chemicals Agency (ECHA) uses Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) to protect human health and the environment from risks posed by chemicals including PFAS. From February 2023 onwards, REACH restricted PFCAs (C9-14), along with their salts and precursors, in the EU and European Economic Area (EEA) following a decision by the European Commission. ECHA continues to assess the potential risk to human health and the environment from the manufacturing or use of additional PFAS.

In January 2023, five European authorities (Denmark, Germany, the Netherlands, Norway, and Sweden) submitted a proposal to ECHA to limit the use of PFAS in the EU. The proposal seeks restrictions on both the use and production of around 10,000 PFAS to reduce negative effects on humans and the environment.

Notably, "plant protection products" and "biocidal products," (i.e., pesticide products), are recommended to be excluded from restrictions in the proposal. The authors acknowledge that pesticide ingredients are sometimes PFAS but that they are "already regulated in the EU with extensive evaluations and approval processes by designated bodies with specific expertise and experience." The authors also note that limiting the number of available pesticides generally aggravates resistance management. Thus, they proposed that pesticide active ingredients be exempt from restrictions under this proposal, but still recommend pesticides be required to report on the PFAS chemicals to the European Commission. As of January 2024, the proposal is under review with the ECHA's Risk Assessment (RAC) and Socio-Economic Analysis (SEAC) scientific committees.

Canada

In Canada, the manufacture, use, sale, offer for sale or import of PFOS, PFOA, LC-PFCAs, and products that contain them have been prohibited since 2016. Recognizing that the PFAS used to replace PFOS, PFOA, and LC-PFCAs may also be associated with environmental and/or human health effects, the Government of Canada published a notice of intent to address concerns related to PFAS in April 2021. The Government of Canada published a draft state of PFAS report and a Risk Management Scope for PFAS for public comment, in May 2023. The reports and proposed conclusion are intended to inform decision-making on PFAS as a class in Canada. However, the draft reports do not categorize agricultural chemicals or pesticides as a separate subgroup.

Australia

The Australian government has taken a precautionary approach to managing existing PFAS contamination, working to prevent or reduce environmental and human PFAS exposure wherever possible. Efforts have mainly been directed at contamination created by historical use of PFAS. Investigations are conducted across Australia to establish a greater understanding of the contamination extent and likely impacts on surrounding communities and, when necessary, developing management strategies tailored to the unique site conditions.

U.S.

At the federal level, the EPA has taken a range of regulatory actions to address PFAS in manufacturing and consumer products, including regulations under the Toxic Substances Control Act (TSCA) regarding PFAS recordkeeping and reporting, and regulations under the Safe Drinking Water Act (SDWA), Clean Water Act (CWA), and the Emergency Planning and Community Right-to-Know Act (EPCRA).

On September 28, 2023, the EPA finalized a rule under TSCA section 8(a)(7) that requires manufacturers of PFAS to submit information to EPA regarding PFAS uses, production volumes, byproducts, disposal, exposures, and environmental or health effects (EPA-HQ-OPPT-2020-0549-0001). All entities that have manufactured (including imported) PFAS in any year since January 1, 2011, will have 18 months following the effective date of this rule to report PFAS data to EPA. The rule is limited to PFAS that are considered a "chemical substance" under TSCA section 3(2) and notably does not include pesticides, which are excluded from the definition of "chemical substance."

While manufacturers of pesticides that are PFAS are not required to report to EPA under the new TSCA section 8(a)(7) rule, the contents of pesticide products must be disclosed as part of the EPA registration process. Under FIFRA Section 6(a)(2), pesticide registrants are required to inform the EPA about any unreasonable adverse effects of their product, including metabolites, degradates and impurities, such as PFAS. According to the EPA's website, "EPA considers any level of PFAS to be potentially toxicologically significant" and may trigger reporting under 40 C.F.R. 159.179(b).

In December 2023, the EPA issued orders to Inhance Technologies LLC, a major producer of fluorinated HDPE containers, directing them not to produce PFAS, chemicals that are created in the production of its fluorinated containers. Concerns over PFAS contamination from fluorinated containers began in 2020 after PFAS were first detected in a mosquito control product (see "Other Sources of PFAS in Pesticides" section for more information). The EPA conducted an investigation into fluorinated HDPE containers used to store and distribute pesticide products as a source of PFAS in pesticide products and released data in March 2021 showing the potential for PFAS to leach from fluorinated containers. In March 2022, the EPA issued an open letter to raise awareness about the potential PFAS contamination from packaging and remind industry of the TSCA requirements related to PFAS. In September 2022, the EPA released its results from an additional study on PFAS leaching from HDPE containers that tested the impact of storage time and the type of liquid being stored.

In addition to the regulatory actions, there have been several non-regulatory actions by the EPA related to PFAS and pesticides that are also important to note.

Planning actions

- In April 2021, the EPA established an EPA Council on PFAS to understand and address the risks associated with PFAS.
- In October 2021, the EPA announced its PFAS Strategic Roadmap—laying out a whole-of-agency approach to addressing PFAS, which sets timelines by which the EPA plans to take specific actions from 2021 to 2024.

Pesticide ingredients

- Previously, the EPA Office of Pesticide Programs (OPP) had determined there were no pesticide active or inert ingredients with structures like prominent PFAS such as PFOS, PFOA, and GenX.
- In 2021, the EPA OPP began applying the following working definition of PFAS to evaluate the structures of pesticide active and inert ingredients: "A structure that contains the unit R-CF2-CF(R')(R''), where R, R', and R'' do not equal "H" and the carbon-carbon bond is saturated (note: branching, heteroatoms, and cyclic structures are included)."
- The EPA is in the process of evaluating all pesticide active ingredients to determine if any meet their working definition of PFAS; however, EPA has not yet shared the results of their evaluation.
- In December 2022, the EPA issued a notice announcing the removal of 12 chemicals identified as PFAS from the current list of inert ingredients approved for use in nonfood pesticide products.

Testing pesticide products

- In September 2021, the EPA released an internally validated method for the detection of 28 PFAS compounds in oily matrices, such as pesticide products formulated in oil, petroleum distillates, or mineral oils (see "Testing for PFAS in Pesticides" section for more information).
- In May 2023, the EPA released results from its internal analysis of ten pesticide products reported by Lasee et al. (2022) to contain PFAS. The EPA did not detect any PFAS in the tested products.
- In May 2023, the EPA also released a new method for the analysis of select PFAS in pesticide formulations containing non-ionic surfactants and non-volatile oils.

State-level Regulations and Actions

In recent years, many states including California, Colorado, Connecticut, Hawaii, Illinois, Indiana, Maryland, Michigan, New Hampshire, New York, Oregon, Rhode Island, Vermont, Washington, and Wisconsin have passed laws prohibiting PFAS use in non-pesticidal product categories such as food packaging, firefighting foam, ski wax, and rugs and carpets. Three states besides Minnesota have enacted major laws related to PFAS and pesticides. They are Maine, Maryland, and Massachusetts. The California Legislature passed a bill in 2022 requiring registration of all products containing intentionally added PFAS by 2026, but it was vetoed.

In 2021, Maine passed the first extensive ban and information collection requirement (Public Law 2021, c. 477) for PFAS in all products and product components, which includes pesticide products. According to the Maine Department of Environmental Protection, "The law requires manufacturers of products with intentionally added PFAS to report the intentionally added presence of PFAS in those products to the Department now beginning January 1, 2025. The law also prohibits the sale of carpets or rugs, as well as the sale of fabric treatments, that contain intentionally added PFAS beginning on January 1, 2023. Effective January 1, 2030, any product containing intentionally added PFAS may not be sold in Maine unless the use of PFAS in the product is specifically designated as a currently unavoidable use by the Department." In 2023, an amendment extending the statutory deadline to provide information to the Maine Department of Environmental Protection beginning January 1, 2023 was extended to January 1, 2025.

Maryland passed the "Pesticides – PFAS Testing – Study" law in 2023 (SB 158/HB 319), requiring the Maryland Department of Agriculture, in consultation with the Departments of Environment and Health and the EPA, to study the use of PFAS in pesticides in the state, including: assessing human and environmental risks of PFAS in pesticides, identifying methods to test for PFAS in pesticides, and summarizing federal efforts to test for or regulate and ban PFAS in pesticides. This report was presented to the governor of Maryland in October 2023.

The Mosquito Control for the Twenty-First Century Task Force (MCTF) was created in 2020 (Chapter 120 of the Acts of 2020). One of the topics the task force was directed to review and make recommendations on was "promoting the use of the safest or minimum risk pesticides feasible and employing methods, including product disclosures or implementation of testing protocols and procedures, to avoid the use of pesticides containing per- and polyfluoroalkyl substances." In April 2022, the MCTF submitted its recommendations to avoid the use of pesticides containing PFAS and other contaminants which included:

- Using available analytical methods to ensure pesticides registered in Massachusetts are not contaminated with PFAS or emerging contaminants of concern;
- Identifying pesticides that might have unintended properties possibly through bioassay screening; Preventing the sale or use of mosquito pesticides contaminated with PFAS or emerging contaminants of concern;
- Defining or categorizing "persistence," as it relates to pesticides; and
- Making appropriate registration decisions based on new information from the EPA, including evaluating whether substances should be added to the Groundwater Protection List.

Defining PFAS for Regulation

To regulate PFAS as a class, this large and complex group of chemicals must be clearly defined. PFAS are typically defined and grouped based on their chemical structures; however, there is not a single, universal definition of PFAS (Gaines et al., 2023). Various agencies, organizations, and groups have adopted differing definitions of PFAS (see **Table 1** for examples), and many of these definitions continue to evolve over time.

Table 1. Definitions of PFAS by select organizations.

Organization	Definition of PFAS	Notes
Minnesota (2023)	"…means a class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom."	• Defined in Minn. Stat. 18B.01 subd. 15(c) and Minn. Stat. 116.943 subd. 1(p) • Also used in Minn. Stat. §325F.075 (food packaging) and §325F.072 (firefighting foam)
Maine (2021)	"…means substances that include any member of the class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom."	• Defined in Public Law 2021, c. 477
EPA – Office of Pollution Prevention and Toxics (OPPT) (2023)	"PFAS is defined as including at least one of these three structures: • R-(CF2)-CF(R')R'', where both the CF2 and CF moieties are saturated carbons; • R-CF2OCF2-R', where R and R' can either be F, O, or saturated carbons; and • CF3C(CF3)R'R'', where R' and R'' can either be F or saturated carbons."	• Defined in TSCA Section 8(a)(7) reporting and recordkeeping requirements for PFAS final rule • Modifications were made to the PFAS definition in the proposed rule following public comment

Organization	Definition of PFAS	Notes
European Chemicals Agency (ECHA) (2023)	"Any substance that contains at least one fully fluorinated methyl (CF3-) or methylene (-CF2-) carbon atom (without any H/Cl/Br/I attached to it). A substance that only contains the following structural elements is excluded from the scope of the proposed restriction: CF3-X or X-CF2-X', where X = -OR or -NRR' and X' = methyl (-CH3), methylene (-CH2-), an aromatic group, a carbonyl group (-C(O)-), -OR'', -SR'' or –NR''R''', and where R/R'/R''/R''' is a hydrogen (-H), methyl (-CH3), methylene (-CH2-), an aromatic group or a carbonyl group (-C(O)-)."	• Defined in ECHA proposed restriction of PFAS • Plant protection products and biocides are exempt from the proposed restriction
Organization for Economic Co-operation and Development (OECD) (2021)	"… fluorinated substances that contain at least one fully fluorinated methyl or methylene carbon atom (without any H/Cl/Br/I atom attached to it), i.e., with a few noted exceptions, any chemical with at least a perfluorinated methyl group (–CF3) or a perfluorinated methylene group (–CF2–) is a PFAS."	• Defined in OECD 2021 report: Reconciling Terminology of the Universe of Per- and Polyfluoroalkyl Substances: Recommendations and Practical Guidance

When regulating PFAS as a class, how PFAS are defined will impact which chemicals are subject to regulations. Therefore, the words or specific structural elements chosen to define PFAS can have important regulatory implications. Seemingly subtle differences among definitions can represent an increase or decrease in the number of regulated chemicals by orders of magnitude. For example, Hammel et al. (2022) explored the implications of PFAS definitions with respect to fluorinated pharmaceuticals and found that depending on the definition of PFAS used, between 1% and 100% of the 360 pharmaceuticals screened would be included. Furthermore, while PFAS are often described as a class of over 10,000 chemicals, Schymanski et al. (2023) found that as many as 7 million chemicals in the PubChem database would be considered PFAS under the OECD 2021 definition.

Minnesota Law (Minn. Stat. 18B.01 subd. 15(c)) defines PFAS as "a class of fluorinated chemicals containing at least one fully fluorinated carbon atom." While the language in the Minnesota Law definition largely parallels that of the OECD 2021 definition (see **Table 1**), the Minnesota definition notably does not specify that the fully fluorinated carbon atom must be a methyl (-CH3) or methylene (-CH2-) carbon. Similarly, while the term "per/poly-fluoroalkyl substances" itself has scientific meaning with respect to chemical structure, the Minnesota definition does not explicitly state that the chemical be an alkyl substance or contain a minimum number of fluorine atoms. The MDA looked to 15 U.S.C. § 8931(2)(B) to define "fully fluorinated carbon," which offered the following: “The term ‘fully fluorinated carbon atom’ means a carbon atom on which all the hydrogen substituents have been replaced by fluorine.” As noted by Hammel et al. (2022), the U.S. Code definition does not specify that the fully fluorinated carbon must be saturated (contains only single bonds) or part of an alkyl chain. Therefore, as written, the Minnesota Law definition of PFAS allows for the inclusion of chemicals such as beta-cyfluthrin, which contains a single fluorine atom on a benzene ring (**Figure 1**).

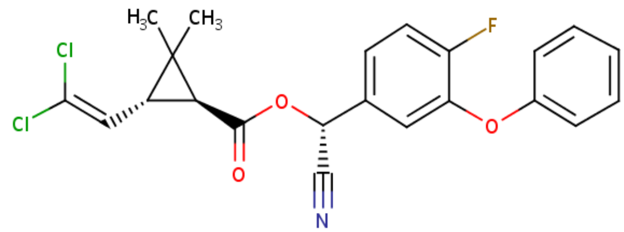

Figure 1. Chemical structure for the pesticide active ingredient beta-cyfluthrin (source: EPA Comptox Chemicals Dashboard).

The definition of PFAS adopted by the state of Minnesota (Minn. Stat. 18B.01 subd. 15(c)) is broader than the EPA Office of Pollution Prevention and Toxics (OPPT), ECHA, and OECD definitions. As a result, chemicals that would not be considered PFAS by EPA OPPT, ECHA, or OECD may be classified and regulated as PFAS in Minnesota (e.g., beta-cyfluthrin, **Figure 1**). The MDA conducted a preliminary screening of pesticide active ingredients registered in Minnesota and identified 95 active ingredients that are classified as PFAS under the Minnesota Law definition (Minn. Stat. 18B.01 subd. 15(c)). By comparison, approximately 65 of the active ingredients screened would be classified as PFAS under the OECD 2021 definition, and approximately six would be PFAS under the EPA OPPT definition. The number of active ingredients that would be considered PFAS under different definitions is provided strictly for comparison to demonstrate the variability among definitions. The MDA is bound to the definition of PFAS in Minnesota Law (Minn. Stat. 18B.01 subd. 15(c)) and is working closely with the MPCA to ensure a clear and consistent interpretation across agencies.

PFAS in Pesticides

PFAS can be present in pesticide products as both an intentionally added ingredient as well as a contaminant. The MDA has been carefully tracking the presence of PFAS in pesticides for many years and is continuing to gather information to carry out new PFAS laws in Minnesota. This section reviews the known uses of PFAS in pesticides, the MDA’s previous and future information gathering efforts, and potential sources of PFAS contamination in pesticide products.

PFAS as Pesticide Active Ingredients

Many pesticide active ingredients contain fluorine, which can favorably alter the properties of a chemical and improve its efficacy as a pesticide. For example, fluorine can be used to provide additional selectivity, specificity, and improved stability of pesticides in the field (Alexandrino et al., 2022). The manufacturing and use of fluorinated pesticides have increased worldwide over the last 30 years (Burriss et al., 2018). Between 2016 and 2020, 28 out of 42, or two-thirds of, newly registered active ingredients with the International Organization for Standardization assigned common names were fluorinated molecules (Ogawa et al., 2020). Not all pesticide active ingredients that contain fluorine are PFAS; however, many are categorized as PFAS under the Minnesota Law definition (Minn. Stat. 18B.01 subd. 15(c)), which includes all organic chemicals containing at least one fully fluorinated carbon atom.

The MDA completed a preliminary screening of all pesticide active ingredients registered in Minnesota in June 2023 and identified 95 active ingredients that are considered PFAS under Minnesota Law (Minn. Stat. 18B.01 subd. 15(c)) (see **Table 2**). In its review, the MDA applied the 15 U.S.C. § 8931(2)(B) definition of "fully fluorinated carbon" (a carbon atom on which all the hydrogen substituents have been replaced by fluorine). Because the definition does not specify whether the fully fluorinated carbon must be saturated, chemicals containing a single fluorine atom attached to a benzene ring, a common structural element among fluorinated pesticides (e.g., flumetsulam), were considered PFAS. This approach is consistent with Hammel et al. (2022). Most of the active ingredients in **Table 2** do not meet the EPA's current OPPT definition of PFAS. **Table 2** also provides sales data from the MDA Pesticide Sales Database expressed as pounds of active ingredient (lbs a.i.) sold. Sales data do not necessarily correlate with pesticide use in the state on an annual basis.

Table 2. Preliminary list of pesticide active ingredients in Minnesota (as of June 2023) that meet the Minnesota Law (Minn. Stat. 18B.01 subd. 15(c)) definition of PFAS (i.e., contain at least one fully fluorinated carbon atom) with links to chemical structures from EPA's CompTox Chemicals Dashboard.

EPA PC Code	CAS Number	Chemical Name	Pesticide Type	Chemical Structure	2021 Sales in MN (lbs a.i.)
084301	1861-40-1	Benfluralin	Herbicide	Benfluarlin	204
118831	1820573-27-0	beta-Cyfluthrin	Insecticide	beta-Cyfluthrin	2,837
018986	352010-68-5	Bicyclopyrone	Herbicide	Bicyclopyrone	13,984
128825	82657-04-3	Bifenthrin	Insecticide	Bifenthrin	166,551
128825	83322-02-5	Bifenthrin, trans	Insecticide	Bifenthrin, trans	(see bifenthrin)
128400	581809-46-3	Bixafen	Fungicide	Bixafen	3,358
283200	1207727-04-5	Broflanilide	Insecticide	Broflanilide	55

EPA PC Code	CAS Number	Chemical Name	Pesticide Type	Chemical Structure	2021 Sales in MN (lbs a.i.)
112802	63333-35-7	Bromethalin	Rodenticide	Bromethalin	11
128712	128639-02-1	Carfentrazone-ethyl	Herbicide	Carfentrazone-ethyl	1,126
129093	122453-73-0	Chlorfenapyr	Insecticide	Chlorfenapyr	151
125203	105512-06-9 105511-96-4	Clodinafop-propargyl	Herbicide	Chlodinafop-propargyl	0
129116	147150-35-4	Cloransulam-methyl	Herbicide	Chloransulam-methyl	35,201
555550	180409-60-3	Cyflufenamid	Fungicide	Cyflufenamid	<1
138831	400882-07-7	Cyflumetofen	Miticide/ Insecticide	Cyflumetofen	11
128831	68359-37-5	Cyfluthrin	Insecticide	Cyfluthrin	989
108201	35367-38-5	Diflubenzuron	Insecticide	Diflubenzuron	2,845
005107	109293-98-3	Diflufenzopyr-sodium	Herbicide	Diflufenzopyr-sodium	17,169
128994	97886-45-8	Dithiopyr	Herbicide	Dithiopyr	18,465
113101	55283-68-6	Ethalfluralin	Herbicide	Ethalfluralin	107,573
107091	153233-91-1	Etoxazole	Insecticide	Etoxazole	32
129121	120068-37-3	Fipronil	Insecticide	Fipronil	802
128016	158062-67-0	Flonicamid	Insecticide	Flonicamid	118
129108	145701-23-1	Florasulam	Herbicide	Florasulam	194
030093	1390661-72-9	Florpyrauxifen-benzyl	Herbicide	Florpyrauxifen-benzyl	86

EPA PC Code	CAS Number	Chemical Name	Pesticide Type	Chemical Structure	2021 Sales in MN (lbs a.i.)
122809	79241-46-6	Fluazifop-P-butyl	Herbicide	Fluazifop-P-butyl	147,881
129098	79622-59-6	Fluazinam	Fungicide	Fluazinam	12,388
114009	181274-17-9	Flucarbazone-sodium	Herbicide	Flucarbazone-sodium	4,277
071503	131341-86-1	Fludioxonil	Fungicide	Fludioxonil	1,806
050410	318290-98-1	Fluensulfone	Nematicide	Fluensulfone	0
121903	142459-58-3	Flufenacet	Herbicide	Flufenacet	0
138008	1383809-87-7	Fluindapyr	Fungicide	Fluindapyr	no data
036007	69770-45-2	Flumethrin	Insecticide	Flumethrin	605
123001	62924-70-3	Flumetralin	Plant Growth Regulator	Flumetralin	0
129016	98967-40-9	Flumetsulam	Herbicide	Flumetsulam	78,443
128724	87546-18-7	Flumiclorac	Herbicide	Flumiclorac	84
129034	103361-09-7	Flumioxazin	Herbicide	Flumioxazin	43,617
027412	239110-15-7	Fluopicolide	Fungicide	Fluopicolide	5
080302	658066-35-4	Fluopyram	Fungicide	Fluopyram	19,286
028869	361377-29-9	Fluoxastrobin	Fungicide	Fluoxastrobin	9,336
112900	59756-60-4	Fluridone	Herbicide	Fluridone	507
128959	69377-81-7	Fluroxypyr	Herbicide	Fluroxypyr	45,164
128968	81406-37-3	Fluroxypyr-meptyl	Herbicide	LFluroxypyr-meptyl	272

EPA PC Code	CAS Number	Chemical Name	Pesticide Type	Chemical Structure	2021 Sales in MN (lbs a.i.)
125701	56425-91-3	Flurprimidol	Plant Growth Regulator	Flurprimidol	164
108803	117337-19-6	Fluthiacet-methyl	Herbicide	Fluthiacet-methyl	376
014018	958647-10-4	Flutianil	Fungicide	Flutianil	0
128975	66332-96-5	Flutolanil	Fungicide	Flutolanil	398
128940	76674-21-0	Flutriafol	Fungicide	Flutriafol	33,434
109302	69409-94-5	Fluvalinate	Insecticide	Fluvalinate	4
138009	907204-31-3	Fluxapyroxad	Fungicide	Fluxapyroxad	19,970
123803	72178-02-0	Fomesafen	Herbicide	Fomesafen	232,191
123802	108731-70-0	Fomesafen, sodium	Herbicide	Fomesafen, sodium	(see fomesafen)
128807	76703-62-3	gamma-Cyhalothrin	Insecticide	gamma-Cyhalothrin	555
117501	943831-98-9	Halauxifen-methyl	Herbicide	Halauxifen-methyl	185
118202	86479-06-3	Hexaflumuron	Insecticide	Hexaflumuron	0
118401	67485-29-4	Hydramethylnon	Insecticide	Hydramethylnon	8.4
067710	173584-44-6	Indoxacarb	Insecticide	Indoxacarb	258
123000	141112-29-0	Isoxaflutole	Herbicide	Isoxaflutole	5,281
128888	77501-63-4	Lactofen	Herbicide	Lactofen	10,717
128897	91465-08-6	lambda-Cyhalothrin	Insecticide	lambda-Cyhalothrin	77,673
122000	1417782-03-6	Mefentrifluconazole	Fungicide	Mefentrifluconazole	48,852

EPA PC Code	CAS Number	Chemical Name	Pesticide Type	Chemical Structure	2021 Sales in MN (lbs a.i.)
090088	403640-27-7	Methiozolin	Herbicide	Methiozolin	12
109709	240494-70-6	Metofluthrin	Insecticide	Metofluthrin	5,791
016331	609346-29-4	Momfluorothrin	Insecticide	Momfluorothrin	0
105801	27314-13-2	Norflurazon	Herbicide	Norflurazon	0
124002	116714-46-6	Novaluron	Insecticide	Novaluron	1,745
118204	121451-02-3	Noviflumuron	Insecticide	Noviflumuron	0
128111	1003318-67-9	Oxathiapiprolin	Fungicide	Oxathiapiprolin	7
111601	42874-03-3	Oxyfluorfen	Herbicide	Oxifluorfen	207
100249	494793-67-8	Penflufen	Fungicide	Penflufen	348
119031	219714-96-2	Penoxsulam	Herbicide	Penoxsulam	5
090112	183675-82-3	Penthiopyrad	Fungicide	Penthiopyrad	15,318
129200	117428-22-5	Picoxystrobin	Fungicide	Picoxystrobin	22,426
110201	29091-21-2	Prodiamine	Herbicide	Prodiamine	70,199
129031	94125-34-5	Prosulfuron	Herbicide	Prosulfuron	0
030090	129630-19-9	Pyraflufen-ethyl	Herbicide	Pyraflufen-ethyl	2
000692	365400-11-9	Pyrasulfotole Technical	Herbicide	Pyrasulfotole Technical	18,184
295149	179101-81-6	Pyridalyl	Insecticide	Pyridalyl	no data
555555	337458-27-2	Pyrifluquinazon	Insecticide	Pyrifluquinazon	6

EPA PC Code	CAS Number	Chemical Name	Pesticide Type	Chemical Structure	2021 Sales in MN (lbs a.i.)
090099	447399-55-5	Pyroxasulfone	Herbicide	Pyroxasulfone	93,590
108702	422556-08-9	Pyroxsulam	Herbicide	Pyroxsulamink	129
055459	124495-18-7	Quinoxyfen	Fungicide	Quinoxyfen	<1
118203	372137-35-4	Saflufenacil	Herbicide	Saflufenacil	43,832
114402	62476-59-9	Sodium acifluorfen	Herbicide	Sodium acifluorfen	14,055
005210	946578-00-3	Sulfoxaflor	Insecticide	Sulfoxaflor	478
128912	79538-32-2	Tefluthrin	Insecticide	Tefluthrin	10,942
012801	335104-84-2	Tembotrione	Herbicide	Tembotrione	118,623
120603	112281-77-3	Tetraconazole	Fungicide	Tetraconazole	9,967
090097	1229654-66-3	Tetraniliprole	Insecticide	Tetraniliprole	0
036201	88-30-2	TFM	Piscicide	TFM	0
012311	1220411-29-9	Tiafenacil	Herbicide	Tiafenacil	0
119093	122454-29-9	Tralopyril	Antimicrobial	Tralopyril	55
129112	141517-21-7	Trifloxystrobin	Fungicide	Trifloxystrobin	47,798
128879	68694-11-1	Triflumizole	Fungicide	Triflumizole	36
036101	1582-09-8	Trifluralin	Herbicide	Trifluralin	122,909
129002	126535-15-7	Triflusulfuron-methyl	Herbicide	Triflusulfuron-methyl	287

PFAS as Pesticide Inert Ingredients and Adjuvants

Compared to pesticide active ingredients, little information is available about inert ingredients at the state level. Inert ingredients are considered trade secrets or confidential business information under the Uniform Trade Secrets Act (UTSA), and pesticide registrants are not required to disclose inert ingredients in pesticide products by name or percentage to the product label or to the MDA as a part of the registration process. There is, however, a list of all approved inert ingredients maintained by the EPA on its website. Currently, there are more than 5,000 inert ingredients on this list that may be present in pesticide products. The list can be accessed through the EPA's InertFinder database. The MDA is currently reviewing inert ingredients present in the EPA's InertFinder database to determine which would be considered PFAS under the Minnesota Law (Minn. Stat. 18B.01 subd. 15(c)) definition. As of January 2024, the MDA has identified at least six inert ingredients that would be considered PFAS in Minnesota.

The EPA OPP conducted a review of chemical substances approved for use as inert ingredients in pesticide products to determine whether any of these ingredients are PFAS. The EPA identified 12 ingredients as PFAS and removed them from the list of inert ingredients approved for use in pesticides in December 2022. It is important to note that the EPA's review would have been conducted using the EPA OPPT 2021 working definition of PFAS (i.e., "a structure that contains the unit R-CF2-CF(R')(R''), where R, R', and R'' do not equal "H" and the carbon-carbon bond is saturated"), which is narrower than Minnesota's definition; therefore, the MDA may identify additional ingredients on the EPA's inert list that may be considered PFAS under the Minnesota definition.

The MDA and MPCA are collaboratively discussing the relevant PFAS statute language that applies to both agencies. Adjuvants included in pesticide products as inert ingredients will be screened under the umbrella of inert ingredients, as regulated under Minnesota Law (Minn. Stat. Chapter 18B). Since adjuvants sold as standalone products are not registered under the Pesticide Control Law (Minn. Stat. Chapter 18B), they will be regulated by the MPCA under Minnesota Law (Minn. Stat. Chapter 116). The MDA does not have a list of standalone adjuvants that are sold, distributed, or used in Minnesota.

PFAS in Minimum Risk Pesticides

The MDA reviewed all active ingredients and inert ingredients permitted for use in minimum risk 25(b) pesticide products by the EPA in June 2023 (40 CFR 152.25(f)). No ingredients on either the active or inert 25(b) lists were identified as PFAS based on Minnesota's definition.

Other Sources of PFAS in Pesticides

While PFAS may be directly added to a pesticide product as either an active or inert ingredient, there is also potential for PFAS to be present in products from other sources. For example, PFAS may appear in the product as a byproduct or impurity. Recently, it was discovered that fluorinated HDPE containers can act as an unintentional source of PFAS in pesticide products.

Fluorinated HDPE containers are commonly used in the manufacturing, transport, storage, and packaging of pesticides. Fluorination creates a barrier on plastic containers that can improve the containers' stability and make them less chemically reactive and permeable. The EPA began investigating fluorinated HDPE containers as a potential source of PFAS in pesticides in 2020 after PFAS were detected in the mosquito control product Anvil 10+10 (PEER, 2020). Through its investigation, the EPA found that fluorinated HDPE containers have certain PFAS on/in their walls that can leach into the liquid pesticide stored inside. In its 2021 study, "Rinses from Selected Fluorinated and Non-Fluorinated HDPE Containers," the EPA detected eight different PFAS leached from the tested fluorinated HDPE containers at levels ranging from 20 to 50 parts per billion (ppb) (USEPA, 2021). Further studies by the EPA demonstrated the ability of PFAS from containers to leach into both water and organic solvent-based products and found that the total amount of PFAS leached into the products can gradually increase over storage time (USEPA, 2022). The EPA also noted variability in PFAS leaching from different fluorinated containers tested and suggested this may be due to different degrees of fluorination and the technology used. A study by Vitale et al., (2022) similarly found that the manufacturing and fluorination technologies used to produce fluorinated HDPE containers resulted in differences in PFAS leaching.

Another potential route of PFAS contamination in pesticide products is by contaminated ingredients. The widespread use of PFAS in industry and their ubiquity in the environment provides opportunities for contamination of ingredients. For example, various plant-derived ingredients are included on the EPA's listed of registered inert ingredients, and studies have shown that plants can take up PFAS from contaminated water and soil (Weiping et. al., 2021). Inclusion of ingredients such as these could lead to the unintentional inclusion of PFAS in the final pesticide products.

Under FIFRA Section 6(a)(2), pesticide registrants are required to inform the EPA about any unreasonable adverse effects of their product, including metabolites, degradates and impurities, such as PFAS. According to the EPA's website, "EPA considers any level of PFAS to be potentially toxicologically significant" and may trigger reporting under 40 C.F.R. 159.179(b) (PFAS here refers to chemicals meeting the EPA OPPT definition [see Table 1]). Therefore, PFAS in pesticides from fluorinated containers or other sources may need to be reported to the EPA.

The new Minnesota PFAS laws apply only to intentionally added PFAS in products. Minnesota's PFAS laws defines "intentionally added PFAS" as PFAS deliberately added during the manufacture of a product where the continued presence of PFAS is desired in the final product or one of the product's components to perform a specific function. Given that PFAS appearing in pesticide products from fluorination of containers are not intentionally added, they do not fall under the purview of the Pesticide Control Law (Minn. Stat. Chapter 18B). Fluorinated HPDE containers may be regulated under Minnesota Law (Minn. Stat. Chapter 116).

MDA's Previous and Ongoing Work on PFAS in Pesticides

The MDA recognized potential concerns with select PFAS in pesticides over 15 years ago and has since been working to track and understand their presence in pesticide products used in Minnesota. The MDA carefully tracks EPA actions, scientific literature, and other published literature related to pesticides and PFAS and is committed to ensuring that the use of pesticides in Minnesota will not endanger humans, damage agricultural products, food, livestock, fish, or wildlife, or cause unreasonable adverse effects on the environment.

The MDA first examined pesticide active and inert ingredients as a potential source of PFAS in the environment in 2007. Through its review, the MDA identified one active ingredient (sulfluramid) and one inert ingredient (Fluowet PL-80) that may contribute to PFAS in the environment. The MDA determined that neither ingredient was likely a significant source of PFAS at the time. Fluowet PL-80 has since been cancelled, and sulfluramid has not been registered for use by the EPA for over a decade. It is important to note that the MDA did not have a set structural definition of PFAS to apply at the time, and instead reviewed ingredients for structures that resembled well-known PFAS like PFOS and PFOA.

More recently, the MDA reviewed the mosquito control product Anvil 10+10 as a potential source of PFAS in the environment after the EPA announced that PFAS had been detected in the product. In 2020, the EPA began investigating the potential source of PFAS in Anvil 10+10 and determined that the detected PFAS had leached from the product packaging (see the "Other Sources of PFAS in Pesticides" section for more information). Based on Minnesota sales data for the active ingredient in Anvil 10+10 (phenothrin), the MDA concluded this product was not likely a significant source of PFAS in the state. However, it is unclear at this time if PFAS leaching from pesticide containers into pesticide products is a widespread issue and could be a significant source of PFAS in the environment. The MDA plans to further research PFAS from packing and other potential sources of PFAS contamination in pesticides (contamination during manufacturing and storage, impurities, etc.) and report on this in the final PFAS in Pesticides legislative report.

The MDA is continuing to track changes to the PFAS definitions being used by the EPA. In 2021, the EPA OPP began applying the EPA OPPT's 2021 "working definition" of PFAS to identify pesticide active or inert ingredients that would be considered PFAS. The EPA OPPT's 2021 working definition defined PFAS as "a structure that contains the unit R-CF2-CF(R')(R''), where R, R', and R'' do not equal "H" and the carbon-carbon bond is saturated." This definition included branching, heteroatoms, and cyclic structures (EPA website). Previously, EPA had determined that there were no pesticide active or inert ingredients with structures similar to prominent PFAS (e.g., PFOS, PFOA, GenX). EPA is in the process of evaluating all pesticide active ingredients to determine which would be considered PFAS; however, EPA has not yet published the results of their evaluation. The EPA also conducted a review of chemical substances approved for use as inert ingredients based on the EPA OPPT 2021 working definition. In December 2022, the EPA removed 12 PFAS inert ingredients from its list of approved inert ingredients, none of which were being used in registered pesticide products at that time (EPA-HQ-OPP-2022-0542). The MDA independently conducted a preliminary review of pesticide active ingredient structures based on the EPA OPPT's 2021 working definition and identified at least two active ingredients (broflanilide and pyrifluquinzon) that meet the structural criteria to be PFAS. Based on the EPA OPPT's updated 2023 definition of PFAS (see Table 1), the MDA has identified approximately six active ingredients that would be considered PFAS. The MDA has not yet independently reviewed EPA's inert ingredient list to determine which are considered PFAS.

The MDA also continues to track articles related to PFAS and pesticides in scientific literature. While the number of papers published specifically on PFAS in pesticides is limited, one example of a recent article on the topic is by Lasee et al. (2022). The study by Lasee et al. (2022) reported detections of PFAS, specifically PFOS, in six out of ten pesticide products tested; however, the EPA was unable to confirm the results using their own analytical laboratory tests. In addition, the MDA is reviewing literature related to fluorinated pesticides (e.g., Ogawa et al., 2020), as many fluorinated pesticides meet the Minnesota Law (Minn. Stat. 18B.01 subd. 15(c)) definition of PFAS, along with various reports, webinars, and other sources of information shared by different states and organizations. The MDA has begun screening all registered pesticide active ingredients and allowable inert ingredients to identify those that would be categorized as PFAS under the Pesticide Control Law (Minn. Stat. 18B.01 subd. 15(c)) definition (See the "PFAS as Pesticide Active Ingredients" and "PFAS as Pesticide Inert Ingredients and Adjuvants" sections).

As part of the 2024 pesticide product renewal process, the MDA has requested that pesticide registrants voluntarily check a box on their form indicating whether their product contains intentionally added PFAS. The MDA conveyed to registrants that while the statutory deadline to provide PFAS information to the MDA is January 2026, providing it sooner would allow adequate time for the MDA to assess products in the prioritized categories (i.e., cleaning products) for currently unavoidable use if the pesticide registrants request this. To evaluate "currently unavoidable use" exemption requests, the department plans to collect additional information from the registrants (see the "Implementation of PFAS in Pesticides Laws" section). Depending upon the complexity of the information needed to evaluate for "currently unavoidable use" exemptions, it may take the MDA up to six months to evaluate a single product.

Sources of PFAS Pollution

PFAS are used globally in many consumer and industrial products. With the large number of chemicals that may be considered PFAS and their wide range of uses, it can be challenging to identify specific sources of PFAS contamination. Detections of PFAS at high concentrations have typically been associated with industrial sites, facilities where AFFF has been used (e.g., military complexes), landfills, and sites where biosolids/municipal wastewater treatment sludge have been applied (Brunn et al. 2023; Ghisi et al. 2019). PFAS in agricultural lands can originate from various sources including biosolids applied as fertilizer (Cousins et al., 2022), irrigation supplied from PFAS-contaminated surface and groundwater (Kwiatkowski et al., 2020), atmospheric deposition from fluoropolymer manufacturing and use (Prevedouros et al., 2006), and/or pesticides (Ogawa et al., 2020). More research is needed to understand other potential sources of PFAS contamination in the environment such as lubricants and polymers used on seeds, microencapsulation used for pesticides and fertilizers, and leachate from contaminated sites (e.g., manufacturing plants, landfills).

Overall, the contribution of pesticide products alone to total PFAS pollution in agricultural lands or other sites is unclear. Due to the variability in pesticide use depending on crop, intended use, and geographic region, quantifying PFAS pollution from pesticides is complicated. For example, the pesticides used in soybeans can differ significantly from those used in corn or wheat. In addition, there are thousands of products registered for use on various crops, which further complicates the contribution of pesticides to PFAS pollution. Pesticides have a relatively low application rate, generally a few pounds per acre, compared to biosolids which are applied at a rate of tons per acre. However, without data on the concentration and type of PFAS found in biosolids versus PFAS-containing pesticides, a direct comparison between the two cannot be made.

Data is available on the time it takes for pesticide active ingredients that are PFAS to degrade or break down in the environment. While PFAS are generally persistent, many pesticides degrade within a few days to months. For example, sodium acifluorfen, a pesticide active ingredient considered PFAS according to the Minnesota definition, has a half-life of approximately 100 to 200 days in soil under aerobic conditions (i.e., when oxygen is present). However, sodium acifluorfen degrades to amino acifluorfen in anaerobic conditions (i.e., when oxygen is not present), which is considered a PFAS under the Minnesota Law definition (Minn. Stat. 18B.01 subd. 15(c)).

PFAS in the environment can be an issue due to persistence, bioaccumulation in plants and animals, and known human health risks (Brunn et al., 2023; Ghisi et al., 2019). Because agricultural lands are directly linked to our food source, PFAS pollution is of great interest and concern. In response to concerns over PFAS in agriculture, several states have developed programs and guidance to help ensure agricultural products do not contain unsafe levels of PFAS.

Maine passed a law in 2021 that required the Department of Environmental Protection (DEP) to develop and implement a program to evaluate soil and groundwater for PFAS at locations licensed to apply sludge or septage to land prior to 2019. The DEP began testing farms and found some locations to have high levels of PFAS, requiring them to cease production. In 2022, Maine restricted the application of sludge and sludge-derived compost that contain levels of PFAS above the state determined safe levels (≥2.5 ppb, depending on the specific PFAS). Additionally, Maine has developed state-specific guidance on safe levels of PFAS in consumer products like meat and milk.

The Michigan Department of Environment, Great Lakes, and Energy began a statewide study in 2018 evaluating the presence of PFAS in land applied biosolids. While not considered a risk-based value, Michigan considers biosolids/sludge with PFAS concentrations above 150 ppb as "industrially impacted." Michigan implemented an Interim PFAS Strategy in 2021 focused on biosolid sampling, PFAS source identification and reduction, and landowner and farmer communication. In at least one instance the Michigan Department of Agriculture and Rural Development issued a consumption advisory for cattle that may contain PFOS.

In New Mexico, PFAS contamination of agricultural land is partly driven by U.S. Department of Defense activities. The use of fire suppressing aqueous film-forming foams at Holloman and Cannon Air Force Bases led to PFAS contamination of surrounding lands. Shared water resources have affected neighboring dairy operations resulting in unsafe levels of PFAS in milk and the loss of millions of dollars in milk production (New Mexico Petition to the USEPA). In 2023, the New Mexico Environment Department began testing private domestic wells for PFAS across the state.

As new information becomes available, the MDA plans to track and summarize applicable findings for inclusion in the full PFAS and Pesticide legislative report. Anticipated topics to be covered in more detail in the full report are listed below.

- Non-pesticidal sources of PFAS in agricultural lands.
- Residue data on food for pesticides with intentionally added PFAS.
- Human health risk of pesticides with intentionally added PFAS.

Monitoring for PFAS in Minnesota

The EPA has validated analytical methods available to support regulatory or guidance activities for PFAS in drinking water, groundwater, surface water, and wastewater. The EPA has draft methods for wastewater, soil, biosolids, sediment, landfill leachate, and fish tissue. Current analytical methods can identify a limited number of PFAS analytes; however, there are over 10,000 PFAS compounds and many more transformation products known to exist. In environmental sampling studies variation in analytical methods results in study-to-study differences in quantitative detection limits, and the number of PFAS analytes that can be detected (Brusseau et al., 2020). Minnesota has developed state-specific guidance values for PFAS and human health in several matrices, including drinking water, soil, air, and for site-specific water quality (fish consumption and surface water).

PFAS are known to be persistent, highly mobile, and found in inhabited and uninhabited areas worldwide (Rankin et al., 2016). Therefore, it is expected that some amount of PFAS will be found in all environments. The background or ambient levels of PFAS in various environments have been measured in several matrices, including soil, groundwater, surface water, air, and precipitation. The MPCA has summarized ambient PFAS detections (i.e., not directly associated with industry, commercial, or agricultural environmental inputs) related to each matrix in the document PFAS ambient background concentrations. Due to the physicochemical properties of PFAS and how they bind and move through the environment, concentrations tend to be higher in soil and groundwater than in other environmental matrices. However, Minnesota-specific studies have found PFAS in soil (Rankin et al., 2016; Scher et al., 2018), groundwater (MPCA, 2021), surface water (Simcik and Dorweiler, 2005), rain (Gewurtz et al., 2019), and air (MCPA, 2021), ranging widely in concentration depending on the specific PFAS and sampling location. For more information on PFAS monitoring in drinking water, visit the MPCA's interactive dashboard.

As noted in previous sections, a number of pesticide active ingredients are also considered to be PFAS under Minnesota Law (Minn. Stat. 18B.01 subd. 15c). The MDA monitors for over 180 pesticide-related chemicals in groundwater and surface water through its ambient water quality monitoring program. Thirty-one of the monitored analytes are, or are associated with, currently registered pesticide active ingredients that are categorized as PFAS in Minnesota (**Table 3**). Details regarding the number of detections, concentrations, and method reporting limits for the monitored analytes are available in the MDA's annual water quality monitoring reports and through the Water Quality Portal.

Table 3. MDA water monitoring detection record (2018-2022) for pesticide active ingredients categorized as PFAS under Minnesota Law (Minn. Stat. 18B.01 subd. 15c).

EPA PC Code	CAS Number	Analyte Name	Detected in Groundwater 2018-2022	Detected in Rivers/Streams 2018-2022
114402	62476-59-9	Acifluorfen	Yes	Yes
084301	1861-40-1	Benfluralin	No	No
118831	68359-37-5	Cyfluthrin	No	No
018986	352010-68-5	Bicyclopyrone	Yes	Yes

EPA PC Code	CAS Number	Analyte Name	Detected in Groundwater 2018-2022	Detected in Rivers/Streams 2018-2022
128825	82657-04-3	Bifenthrin	No	Yes
128400	581809-46-3	Bixafen	No	No
129116	147150-35-4	Cloransulam-methyl	No	Yes
128994	97886-45-8	Dithiopyr	No	No
113101	55283-68-6	Ethalfluralin	No	No
129121	120068-37-3	Fipronil	No	Yes
121903 (Flufenacet)	201668-31-7	Flufenacet OXA	No	No
129016	98967-40-9	Flumetsulam	Yes	Yes
128940	76674-21-0	Flutriafol	No	Yes
138009	907204-31-3	Fluxapyroxad	Yes	Yes
123803	72178-02-0	Fomesafen	Yes	Yes
117501	943831-98-9	Halauxifen-methyl	No	No
123000	141112-29-0	Isoxaflutole	No	Yes
128897	91465-08-6	lambda-Cyhalothrin	No	No
122000	1417782-03-6	Mefentrifluconazole	No	Yes
090088	403640-27-7	Methiozolin	No	No
016331	609346-29-4	Momfluorothrin	No	No
105801	27314-13-2	Norflurazon	No	Yes
128111	1003318-67-9	Oxathiapiprolin	No	No
129200	117428-22-5	Picoxystrobin	No	No
090099	447399-55-5	Pyroxasulfone	No	Yes
118203	372137-35-4	Saflufenacil	Yes	Yes
012801	335104-84-2	Tembotrione	Yes	Yes
120603	112281-77-3	Tetraconazole	Yes	Yes
090097	1229654-66-3	Tetraniliprole	No	No
129112	141517-21-7	Trifloxystrobin	No	No
036101	1582-09-8	Trifluralin	No	Yes

The MDA plans to continue to track and summarize additional information about levels of PFAS in Minnesota environments. As new information becomes available, data on PFAS and Pesticides in various matrices including air, soil, and water will be incorporated in the full legislative report.

Testing for PFAS in Pesticides

As new rules and regulations regarding PFAS are passed, the ability to test for PFAS in pesticides is critical. Reliable, robust analytical methods are necessary to enforce restrictions. The ability to test pesticide products for PFAS is also important for manufacturers/registrants to identify and quantify PFAS in their products, whether added intentionally or present as an impurity or byproduct.

Targeted analysis is used to test a product for a specific, pre-determined list of known chemicals. Because PFAS are a very large complex group of chemicals, no single method can be used to analyze pesticide products for all PFAS. Most targeted analytical methods focus on a small subset of PFAS, often widely used PFAS or those with known adverse human health or environmental effects (e.g., PFOS, PFOA, GenX). Currently, the EPA has validated methods to analyze for a limited number of PFAS in pesticides. In September 2021, the EPA released a method to detect 28 PFAS compounds in oily matrices that can be used for pesticide products formulated in oil, petroleum distillates, or mineral oils (USEPA, 2021). The EPA released another method in May 2023 for analysis of PFAS in pesticide formulations containing non-ionic surfactants and non-volatile oils, which can be used to detect 29 PFAS compounds (USEPA, 2023). PFAS analysis is also available through some commercial laboratories such as Eurofins Environment Testing. Many other private laboratories offer PFAS testing services; however, not all testing laboratories are accredited by the EPA.

With respect to pesticide active ingredients, analytical methods are generally widely available; therefore, a variety of methods are expected to exist for the active ingredients categorized as PFAS under the Minnesota definition. When available, the MDA can also request analytical standards and methods for active ingredients and their degradates, or breakdown products, from pesticide registrants. The MDA often does this as part of the registration process for new active ingredients in Minnesota, particularly when there is interest in environmental monitoring.

Given the quantity and diversity of PFAS compounds, interest in using non-targeted analysis (NTA) to test for PFAS is growing. Non targeted analysis is a relatively new, developing approach to identifying unknown chemicals in a sample. While NTA could provide more comprehensive screening for PFAS in pesticides compared to traditional targeted analyses, several challenges and limitations to its application exist at this stage. Work has been done at the federal and state levels exploring the application of NTA for PFAS analysis, and the EPA Office of Research and Development (ORD) is working to provide guidance on NTA workflows and data libraries for PFAS identification and has been working on projects in collaboration with state agencies in California, Maryland, and Minnesota. The MDA will continue to research the potential application of NTA, along with other analytical methods, to detect PFAS in pesticides as part of the final PFAS and Pesticides legislative report.

Implementation of PFAS in Pesticides Laws

The MDA will collect information on, implement prohibitions for, and evaluation of "currently unavoidable use" (CUU) for pesticide products regulated under Minnesota Law (Minn. Stat. Chapter 18B), which includes pesticide products with an EPA registration number. Further detail on determining CUU exemptions, assessing the necessity of pesticides containing intentionally added PFAS and the risks of alternative products, and areas of uncertainty that could affect the implementation of PFAS in pesticide laws are discussed below. For more information about the MDA's information gathering and pesticide product bans visit the MDA's Products with added PFAS website.

Currently Unavoidable Use

As per the Pesticide Control Law (Minn. Stat. Chapter 18B.26), unless the commissioner of agriculture determines that the use of PFAS is a CUU, the MDA is directed to:

- Not register a cleaning product that contains intentionally added PFAS beginning January 1, 2026; and
- Not register any pesticide product that contains intentionally added PFAS beginning January 1, 2032.

"Currently unavoidable use" (Minn. Stat. Chapter 18B.01 Subd. 6c) as it applies to pesticides, is defined as "a use of PFAS that is essential for health, safety, or the functioning of society and for which alternatives are not reasonably available. Currently unavoidable use may include consideration of the need to prevent or minimize potential pest resistance, and the potential human health and environmental impacts of alternative products."

Many factors affect when and where pesticides may be essential, including the target pest, site of application, and the presence of pesticide-resistance issues. Over 14,000 pesticide products were registered in Minnesota in 2023, and they were used to manage many pests, such as pathogens, weeds, insects, and rodents. Therefore, all pesticide CUU decisions need to be product specific. The MDA may consider the following information to make a CUU determination for a pesticide product with intentionally added PFAS.

- Whether the product is essential for the health, safety, or the functioning of society.
- Whether there are reasonably available alternative products that do not contain intentionally added PFAS.
- Whether the product is needed to prevent or minimize potential pest resistance.
- What are the potential human health and environmental impacts of alternative pesticide products.

Necessity of and Alternatives for Pesticides Products Containing PFAS

Pesticides are an important tool for safe and adequate food production, prevention of human and animal diseases, protection of structures and human dwellings, and maintenance of natural environments. Pesticides are used globally to increase crop yields, manage microorganisms and their vectors that cause disease, prevent structural and nuisance pests, and stop invasive species from spreading. Safe and judicious use of pesticides is crucial to the protection of human health, the environment, and the food supply.

The MDA is currently collecting information about pesticides containing intentionally added PFAS in Minnesota (see the Implementation of PFAS in Pesticides Laws section). However, at this time, much is still unknown about the extent to which registered pesticide products contain intentionally added PFAS under the Minnesota definition of PFAS. For the final PFAS and Pesticide legislative report due in 2025, the MDA anticipates receiving some information from registrants about pesticide products that contain intentionally added PFAS; however, the statutory deadline for submitting this information to the MDA is January 1, 2026, for pesticidal cleaning products and January 1, 2032, for all other pesticide products so a comprehensive understanding and summary is unlikely to be available in the final report.

Until the MDA has received information from pesticide registrants about intentionally added PFAS in pesticide products, it will not be possible to fully understand and assess the use and necessity of pesticides containing PFAS in Minnesota. At this time, pesticide active ingredients have been screened to determine which meet the definition of PFAS; however, it is not known how many products contain PFAS inert ingredients. It is also unknown whether registrants will reformulate products to remove PFAS ingredients. Pesticide products containing active ingredients considered to be PFAS under the Minnesota definition make up approximately 15% (2,163 products) of all the pesticide products registered in the state in 2022 and accounted for approximately 2% of pesticide active ingredient sales (by weight) in Minnesota in 2022. Likewise, determining reasonable alternatives to pesticides with intentionally added PFAS will be difficult until the MDA has received information from pesticide registrants about intentionally added PFAS in their pesticide products.

Key Considerations and Challenges in Implementing PFAS in Pesticides Laws

It is important for the state to adequately address concerns about the risks PFAS pose to human health and the environment, including those that arise from pesticides that contain PFAS. Discussed below are important considerations and challenges related to regulating PFAS in pesticides.

Definitions, Deadlines, and Data Privacy

Some aspects of the new Minnesota PFAS laws are not explicitly defined. For example, while a cleaning product "means a pesticide used primarily for domestic, commercial, or institutional cleaning purposes, including but not limited to an air care product, an automotive maintenance product, a general cleaning product, or a polish or floor maintenance product" (Minn. Stat. 18B.01 subd. 4(d)), primarily is not defined in statute. Products used for domestic, commercial, or institutional cleaning purposes that also make claims about eliminating, preventing, or mitigating pests are considered pesticides. In cases such as this, when a product is used both for cleaning purposes and pesticidal purposes, it can be challenging to identify a product's primary use.

The deadlines in law for providing the MDA with information on intentionally added PFAS in pesticidal cleaning products and for the MDA to cease registering pesticidal cleaning products with intentionally added PFAS are both January 1, 2026. It will not be possible for the MDA to process all the information about intentionally added PFAS, potentially assess CUU claims, and determine which products should not be registered all in one day. For now, pesticide registrants are being encouraged to submit their information ahead of the information submission deadline. However, on January 1, 2026, the MDA may not register pesticidal cleaning products with intentionally added PFAS for which a CUU determination has not been made.

Information about intentionally added PFAS in pesticides, particularly as inert ingredients, may be considered confidential business information. The MDA has procedures for handling such information, and in law it says that a distributor, registrant, or guarantor is not required to provide technical data to another state agency if the distributor, registrant, or guarantor has previously submitted the data to the commissioner and the data is available to the other state agencies. However, as the MDA works in collaboration with other state agencies, PFAS information-sharing may occur, and additional work may be needed to assure all data practices laws are followed.

Laboratory Capacity

The MDA has a laboratory that tests for chemicals in various materials such as groundwater and surface water. Currently, capabilities to analyze for some PFAS chemicals exist. However, there is limited capacity to test for PFAS in pesticides. Absent additional funding to cover the machines, supplies, and staff time, the number of pesticide product samples tested for PFAS for enforcement purposes would remain low.

Breadth of Chemicals Captured by the Minnesota Definition of PFAS

Compared to the structural definitions of PFAS used by the EPA, OECD, and ECHA, Minnesota's definition of PFAS under Minnesota Law (Minn. Stat. 18B.01 subd. 15(c)) is the broadest and therefore captures the largest number of chemicals. For a chemical to be classified as PFAS in Minnesota, the only structural requirement is that it contain at least one fully fluorinated carbon atom. Because the definition does not specify whether the carbon must be saturated, chemicals that contain a single fluorine atom (e.g., beta-cyfluthrin [see **Figure 1** for structure]) may be considered PFAS. Based on the MDA's preliminary screening, 95 pesticide active ingredients are categorized as PFAS under Minnesota's definition. For comparison, approximately six active ingredients were identified as meeting the EPA OPPT 2023 definition. The MDA is consulting with experts regarding interpretation of Minnesota's PFAS definition and working closely with MPCA to ensure a clear and consistent interpretation across agencies.

While pesticide active and inert ingredients that would be categorized as PFAS can be quantified, it is worth noting that Minnesota's broad definition of PFAS will encompass a very large number of chemicals in total. PFAS are often described as a class of over 10,000 chemicals; however, this number is typically based on more narrow structural definitions of PFAS. Schymanski et al. (2023) reviewed the OECD 2021 definition of PFAS (see **Table 1**) and identified more than 7 million chemicals in PubChem that would be considered PFAS. Minnesota's definition is even broader than the OECD 2021 definition; therefore, the number of chemicals considered PFAS is expected to be substantially higher in Minnesota.

As discussed in the Defining PFAS for Regulation section of this report, a universal PFAS definition does not exist, and definitions continue to evolve and differ depending on the context and purpose. For example, the EPA revised the PFAS definition used in the TSCA section 8(a)(7) reporting rule following public comment to capture certain chemicals of interest that would have been excluded based on the initial proposed definition.

Variable Risk from PFAS

The potential risk (i.e., chance of harmful effects from exposure to a chemical) from different PFAS varies greatly. For example, PFAS chemicals can drastically differ in their toxicity to humans, as seen through comparisons of human health-based water guidance values developed by the Minnesota Department of Health;

the health-based value for PFOA is set at only 0.035 parts per billion (ppb) (chronic), while the value for the pesticide active ingredient fomesafen is orders of magnitude higher (20 ppb, chronic). In addition, PFAS can vary in how they move and break down in the environment which will impact the risk of exposure.

Variable Information Available about PFAS

PFAS are often described as a group of chemicals we know little about. While there are many PFAS for which data is scant, the same cannot be said about PFAS that are used as ingredients in pesticide products. In the U.S., pesticide active and inert ingredients are regulated at the state and federal levels. Before pesticides are approved for use, and at least every 15 years after, the EPA reviews data and conducts risk assessments to characterize human health and environmental risks. Therefore, information is available on many aspects of pesticides, including basic properties (e.g., solubility), movement and breakdown in the environment (e.g., half-life in soil and water, major degradates), effects on various taxa (e.g., toxicity to fish, birds, bees, plants), and human health effects (e.g., acute and chronic toxicity, carcinogenicity). For example, we know fluindapyr, a fungicide active ingredient that is considered PFAS under the Minnesota definition, is slightly mobile, stable to hydrolysis, degrades slowly in both soil and aquatic environments, is highly toxic to fish and aquatic invertebrates, practically non-toxic to mammals, birds, and honeybees, and is considered not likely to be carcinogenetic by the EPA (MDA, 2022).

In contrast to many other products, all ingredients in pesticide products are reported. Active ingredients must be listed on the product label, and inert ingredients must be reported to the EPA. Additionally, the MDA tracks the sale of pesticides in Minnesota and assists with surveys to gauge pesticide use throughout the state. The state does not have this level of information about product distribution and use for most other types of products. Because pesticide use rates are regulated, the maximum amount of an active ingredient that can be applied to an area in any given year is known. Longstanding regulation of pesticides also exists in Europe with extensive evaluations and approval processes. While there is a proposed ban of products with PFAS in the EU and the European Economic Area, five countries have proposed that pesticides be excluded from the ban.

Sources of PFAS Pollution

The large number of PFAS chemicals and their wide range of uses can make it difficult to determine specific point sources of PFAS pollution. The relative amount of PFAS loading to the landscape from pesticides compared to other PFAS sources is not known at this point. Pesticides are applied at lower rates (e.g., pounds/acre or less) compared to other potential PFAS sources such as biosolids which are applied at rates of tons/acre. However, without data on the concentration and type of PFAS found in biosolids versus PFAS-containing pesticides, a direct comparison between the two cannot be made.

Limitations of Testing for PFAS in Pesticide Products

Analytical methods for pesticide active ingredients categorized as PFAS are generally readily available; however, methods for other PFAS are quite limited. Analytical methods, including those validated by the EPA, typically only test for a small fraction of PFAS (approximately 30 chemicals). In addition, challenges related to testing for PFAS in pesticide products and the potential for errors have also been recently highlighted after the EPA was unable to validate findings by Lasee et al. (2023).

To enforce restrictions, reliable, robust analytical methods are needed to test for PFAS in pesticide products. Testing for PFAS is also necessary for manufacturers/registrants to identify and quantify PFAS in their products, whether added intentionally or present as an impurity or byproduct. Under Minnesota's new law, pesticide manufacturers are required to submit analytical methods for any intentionally added PFAS in their products. Since Minnesota's PFAS definition is broader than the EPA definition, EPA validated methods for PFAS may not target certain chemicals designated as PFAS in Minnesota.

Pesticide Degradates

Active ingredients that are classified as PFAS break down or degrade in the environment and may form other PFAS different from the parent. Breakdown of the parent PFAS may reduce the concentration of the parent PFAS in the environment, but a new PFAS may be produced. For example, many of the active ingredients classified as PFAS under Minnesota's definition contain a trifluoromethyl group and could potentially degrade to form trifluoroacetic acid (TFA). As part of the registration process, the EPA requires data on how pesticides move and breakdown in the environment. The MDA is reviewing research on potential PFAS degradates resulting from pesticides and plans to further explore this important topic as part of the full report.

Determining Currently Unavoidable Use

Assessing pesticide products for CUU determinations will not be simple. It may require a detailed assessment of the intended use and sites each pesticide product is labeled for, the pests they target, and the larger context of available pesticide products. Often, a pesticide product is approved for managing more than one type of pest. For example, products with active ingredient bifenthrin are approved for use against mosquitoes, ticks, ants, fruit and vegetable pests, crop pests, structural pests, and many more. A product may qualify for a CUU exemption because it is needed to prevent or minimize potential pest resistance in an agricultural crop but does not qualify for a CUU exemption for managing other approved pest applications. Likewise, a product may qualify for a CUU exemption because it is used for management of emerald ash borer, an invasive pest in Minnesota, but may not qualify as a CUU for other tree pests. The MDA is exploring options for scenarios where a product with intentionally added PFAS receives a CUU determination for one of its registered use sites but not others. Statute specifies the need to prevent or minimize potential pest resistance and the potential human health and environmental impacts of alternative products could be factored into CUU decisions. However, assessing potential pest resistance and human health and environmental impacts of alternative products will be challenging.

The use of broflanilide, a PFAS pesticide active ingredient for soil insect control illustrates the complexities that will need to be considered during the CUU decision-making process. The EPA states that an insecticide with a novel mode of action, such as broflanilide, is a significant benefit to growers. However, based on registrant submitted data, the EPA found that the benefits of broflanilide registration to integrated pest management and insecticide resistance management programs varied by crop. They state that benefits will be limited for field corn, but popcorn and sweetcorn may see a greater benefit. They also clarify that benefits are contingent on the proper use of action thresholds, rotation of pesticides, non-chemical controls, and crops (USEPA, 2020).

Additional challenges are expected when defining what is considered essential for health, safety, or the functioning of society; cost considerations while determining reasonably available; duration of the "currently unavoidable" use status, and the criteria to determine the safety of potential alternative products.

Consequences of the Potential Loss of Pesticide Products

Given the breadth of chemicals considered PFAS under the Minnesota definition, many pesticide products may be classified as containing intentionally added PFAS as active or inert ingredients. The consequences of not registering pesticides with intentionally added PFAS are uncertain. When pesticide registrants request a CUU exemption, the MDA is required to consider whether the product is essential for the health, safety, or the functioning of society, whether there are reasonably available alternative products that do not contain intentionally added PFAS, whether the product is needed to prevent or minimize potential pest resistance, and what the potential human health and environmental impacts of alternative pesticide products are. However, it is not known how many pesticide products contain intentionally added PFAS, how many pesticide registrants will request a CUU exemption, or how many CUU exemptions will be granted. Thus, determining the potential impact of pesticide product loss on agricultural production and other industries will be difficult.

Resources and Potential Revenue Loss

The Legislature appropriated $250,000 over two years for the MDA to work on the interim and full PFAS in Pesticide legislative reports. No money has been allocated for the MDA to gather information on the intentional addition of PFAS in pesticide products, make CUU determinations, or to prohibit the sale and distribution of pesticide products containing intentionally added PFAS.

Revenue is generated through the registration and sale of pesticide products. There is an annual registration fee and a gross sales fee for pesticide products that are registered and sold in Minnesota. To illustrate potential revenue loss, fees from all pesticide products containing a PFAS-considered active ingredient were calculated. In total, these products provided approximately $1.7 million from registration and gross sales fees in 2022 ($757,000 in registration fees and $903,000 in gross sales fees). The actual total revenue loss expected from the new PFAS in pesticides laws is uncertain because it is unknown how many additional pesticide products contain PFAS as inert ingredients, how many pesticide registrants will request and be granted CUU exemptions, or whether other pesticide products will replace those that are not registered.

Pesticide-related Products

While the following products are not under the MDA's authority to regulate for intentionally added PFAS, they are products that relate to pesticides.

Fluorinated Containers

It has been established that PFAS can leach from some fluorinated HDPE containers and enter liquid pesticide products; however, the fluorination technique used in the manufacturing of the container can impact its potential to leach PFAS along with the type of liquid stored in the container (e.g., water vs. organic solvent-based pesticides). Therefore, it is not possible to accurately predict which PFAS and how much of each may be present in pesticide products due to leaching from containers. Furthermore, the MDA does not have a record of the types of containers used to store pesticide products during manufacture, transport, and sale. In general, the use of fluorinated containers for pesticides registered in Minnesota is expected to be extensive. In 2019, the Ag Container Recycling Council estimated that "roughly 20-30% of all rigid ag chem packaging in North America sold into the crop protection market are produced with fluorinated HDPE."

Pesticide Treated Seed

Treated seeds are usually coated with biologicals, inoculants, and/or pesticides to facilitate planting, improve germination, increase seedling growth, and alleviate biotic and abiotic stresses. Pesticide treated seeds are considered “treated articles” and are exempt from FIFRA registration requirements. Since pesticide-treated seed is exempt from pesticide registration requirements, there is limited information on the sale and use of pesticide-treated seeds, the pesticide active ingredients contained in the coating coated, and any other materials in the coating (e.g., dyes, lubricants, and polymers). Pesticides used for treating seeds fall under the purview of the Pesticide Control law (Minn. Stat. 18B), but pesticide treated seed will fall under the purview of Minnesota Chapter 116. Because pesticide treated seeds are not pesticides, they have not been included in this report.

Personal Protective Equipment for Pesticide Application

Pesticide personal protective equipment (PPE) are garments or other equipment deemed necessary to ensure the safe handling and use of pesticides before, during, and after a pesticide application. PPE is used in many fields, such as medical settings, and some PPE are known to contain PFAS (e.g., anti-fog goggles, waterproof coveralls) (Cousins et al., 2019). However, PFAS use in some pesticide PPE is considered essential because it is required for human health and safety, and, in many cases, no safer alternatives exist (Bălan et al., 2023, and Cousins et al., 2019). The EPA determines what PPE is required for a specific pesticide application during the pesticide registration process, and using the PPE listed on the label is legally required. In the near term, PPE intentionally treated with PFAS for the purpose of repelling substances will not be banned under Minnesota Law (Minn. Stat. Chapter 116.943). Under that law, the MPCA will in the future determine whether PPE containing intentionally added PFAS will be exempted from the 2032 ban as a “currently unavoidable use.”

Abbreviations

ASTDR: Agency for Toxic Substances and Disease Registry
AFFF: Aqueous Film Forming Foam
CUU: Currently unavoidable use
CWA: Clean Water Act
DEP: Department of Environmental Protection
ECHA: European Chemicals Agency
EEA: European Economic Area
EPA: Environmental Protection Agency
EPCRA: Emergency Planning and Community Right-to-Know Act
EU: European Union
FIFRA: Federal Insecticide Fungicide and Rodenticide Act
FQPA: Food Quality Protection Act
GenX: Chemicals that replace perfluorooctanoic acid such as hexafluoropropylene oxide (HFPO)
HDPE: High Density Polyethylene
LC-PFCAs: Long chain perfluorocarboxylic acids
MCTF: Mosquito Control for the Twenty-First Century Task Force
MDA: Minnesota Department of Agriculture
MDH: Minnesota Department of Health
MPCA: Minnesota Pollution Control Agency
NTA: Non-Targeted Analysis
OPP: Office of Pesticide Programs
OPPT: Office of Pollution Prevention and Toxics
OECD: Organization for Economic Co-operation and Development
PFAS: Perfluoroalkyl and polyfluoroalkyl substances
PFBA: Perfluorobutanoic acid
PFHxS: Perfluorohexanesulfonic acid
PFOA: Perfluorooctanoic acid
PFOS: Perfluorooctane sulfonic acid
PPB: Parts per billion
PPM: Parts per million
PPT: Parts per trillion
PPE: Personal Protective Equipment
RAC: Risk Assessment Committee
REACH: Registration, Evaluation, Authorization and Restriction of Chemicals
SDWA: Safe Drinking Water Act
SEAC: Socio-Economic Analysis Committee
TFA: Trifluoroacetic Acid
TSCA: Toxic Substance Control Act
UTSA: Uniform Trade Secrets Act

Appendix A

Minn. Stat. Chapter 18B.03

Subd. 5. Perfluoroalkyl and polyfluoroalkyl substances. The commissioner has the sole regulatory authority over the terrestrial application of pesticides containing PFAS, including but not limited to the application of pesticides to agricultural crops, structures, and other nonaquatic environments. In order to reduce duplication, a registrant is not required to provide technical data to another state agency if the registrant previously submitted the data to the commissioner and the data is available to the other state agencies.

Minn. Stat. Chapter 18B.26 Sec. 28.

Subd. 7. Notification required; waivers and extensions. (a) Beginning January 1, 2026, a pesticide registrant must annually provide a statement that a product contains no intentionally added PFAS or, for products that contain intentionally added PFAS, a pesticide registrant must submit to the commissioner the following information:

(1) the name and purpose for which PFAS are used in the pesticide, including in any product components;

(2) the amount of each PFAS in the product, identified by its name, chemical structure, analytical methods, chemical abstracts service registry number, or other unique method approved by the commissioner; and

(3) any additional information required by the commissioner.

(b) The commissioner may waive all or part of the notification requirement under paragraph (a) if the commissioner determines that substantially equivalent information is available. The commissioner may extend the deadline for the submission of the information required under paragraph (a) if the commissioner determines that more time is needed by the registrant to comply with the submission requirement.

Minn. Stat. Chapter 18B.26 Sec. 29.

Subd. 8. PFAS prohibitions. (a) Beginning January 1, 2026, the commissioner may not register a cleaning product if the product contains intentionally added PFAS unless the commissioner determines that the use of PFAS is a currently unavoidable use.

(b) Beginning January 1, 2032, the commissioner may not register a pesticide product that contains intentionally added PFAS unless the commissioner determines that the use of PFAS is a currently unavoidable use.

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