Findings and Recommendations for a PFAS Study Plan Supporting L.D. 558

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MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

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I. Summary

The presence of perfluoroalkyl and polyfluoroalkyl (PFAS) contamination in Maine has identified the need for robust, ongoing research into the fate, transport, impacts, remediation, and mitigation of these chemicals in our environment. Although Maine State agencies, agricultural service providers, and academic researchers are already undertaking some initial research efforts to facilitate short-term decision-making necessary for impacted farms, far more is necessary to advance the state of PFAS science in Maine and nationally. There is great potential for critical PFAS research to be conducted in Maine as it relates to agriculture, particularly through strategic partnerships between the Department of Agriculture, Conservation and Forestry (DACF) and the University of Maine.

The 130th Maine Legislature passed L.D. 558 (Attachment 1), which directed DACF to develop a comprehensive research study plan to identify and aid farmers who are or may be affected by PFAS contamination. The intent of L.D. 558 was to have DACF, the University of Maine, and Cooperative Extension, along with representatives of the Department of Environmental Protection (DEP) and the Maine Centers for Disease Control and Prevention (Maine CDC), identify research projects that support long-term farm viability, despite the threat of PFAS. As explained by the bill's sponsor, Representative Bill Pluecker, "[we] need to determine how we can utilize our land in a way that still returns an income from our land despite contamination."

The study plan must identify research topic areas that may include, but are not limited to, alternative agricultural business planning, energy production, and alternative cropping systems. The study must outline study needs possible roles of state agencies and research collaborators to conduct the work, proposed time frames, a proposed budget, and target sources of funding for implementing the plan.

As a result of L.D. 558, DACF worked directly with the University of Maine over the latter half of 2021 to compile a list of potential collaborative research projects presented in this report. This report also recommends the creation of a new research advisory panel that will issue calls for proposal, receive and review study proposals, and advise the DACF and other state agencies on awarding research funding.

Understanding that PFAS research can be wide-ranging and have broad and lasting implications, the proposed research looks at near-term priorities to assist farmer viability and on-farm decision-making. It also identifies longer-term ideas and concepts that develop and builds Maine infrastructure for PFAS research.

II. Current PFAS Research in Maine

Soil and Crop Research

In 2016, the discovery of elevated PFAS in water from a municipal water system well located close to a well serving a dairy farm led to the testing of the dairy milk by DACF. High levels of the PFAS called PFOS (perfluorooctane sulfonic acid) were detected in the milk, but the

discovery could not be explained by PFOS levels in the dairy cow's drinking water. Follow-up testing of soil and hay by DEP found PFOS levels in hay that could explain the observed milk levels, yet surprisingly the soil PFOS levels were below the DEP's existing health-based soil screening levels. Thus began a multi-year effort to develop a model that could be used to predict when soil PFOS levels could result in dairy milk levels of concern and provide additional soil screening levels to be used by DEP and DACF when testing farmland amended with biosolids and other waste residuals.

This model was utilized in 2020 with the discovery of two additional farms with PFOS contaminated milk and a need to inform decision-making about which fields could be used for grazing and which fields could be used to grow hay or corn. As it became clear that model predictions were limited by the lack of scientific studies on the uptake of PFOS by hay and corn, a multi-agency effort was launched to undertake field studies to generate new scientific findings. This work was supported in part by MOFGA's ability to obtain funding from the Broad Reach Fund through the Maine Community Foundation to establish study plots on contaminated hay fields, field sampling of corn crops, and laboratory analyses of PFAS in soil and plant samples.

An interdisciplinary team from MECDC, DEP, DACF, University of Maine Cooperative Extension, and MOFGA assembled to design and undertake these initial field studies of the uptake of PFOS and other PFAS by hay and corn. From these studies, we have learned that there is considerably less uptake of PFOS by corn than hay and considerably less uptake in corn kernels and corn ears compared to the rest of the plant. It also appears that there is considerable variation in the uptake of PFOS by either corn or hay at the field level, and more study will be needed to understand the field conditions responsible for the observed variation. The results obtained from these studies have already guided decisions on one farm to convert hay fields to corn and to harvest the corn as corn ears only (snaplage) to allow for the full use of existing fields despite soil levels in excess of 100 parts per billion (ppb) of PFOS. Milk levels on this farm have dropped from a high of 800 parts per trillion (ppt) to now under 50 ppt.

Because PFAS contamination of the environment is a global problem, there are researchers worldwide studying the unusual behavior of PFAS in agricultural settings, and we have greatly benefited and continue to benefit from their published findings. German and Swedish researchers have published findings on the intake of PFAS from contaminated fodder by dairy cows and its movement into milk. German researchers have also studied the transfer of PFAS from contaminated feed to sheep and chicken eggs. Several Australian research groups have published findings on the uptake and elimination of PFAS in beef cattle and chicken eggs from birds provided with contaminated water. Closer to home, USDA scientists have published results from their own controlled study of PFAS uptake and elimination of PFAS from beef cattle. This body of scientific literature has been critical to developing our models to predict the uptake of PFAS from soil to animal fodder to dairy milk or from contaminated water to chicken eggs. This literature also provides evidence that PFAS dubbed "forever chemicals" are not forever in livestock, based on reports that levels of PFAS in milk and meat from cows can drop substantially in just two months once exposure ceases. In eggs, it has been reported to take only a

few weeks after exposure has ended for chickens to produce eggs with very little PFAS, findings we have observed in our own field sampling work.

There is also a growing international body of scientific literature on the study of PFAS plant uptake. Unfortunately, much of the current literature is limited to controlled potted plant studies that appear to indicate a much higher uptake of PFAS from soil than apparent from the limited field studies. Nonetheless, it is these potted plant studies that have indicated only limited uptake of PFAS from soil into plant fruits or grains. This finding has been reported for tomatoes, peas, cucumbers, strawberries, corn, wheat, and oats. Plant storage tissues like carrots and potatoes also appear to have only limited uptake of PFAS relative to their above-ground vegetation. These studies point to possible options of crops that may still be safely grown on PFAS contaminated soil, but field studies are needed to confirm the findings from potted plant studies.

While there is much to be learned from the evolving scientific literature on the behavior of PFAS in agricultural settings, staying current on the scientific literature is in and of itself a time-consuming task.

Livestock Research:

No federal or other widely recognized, validated standards exist currently to measure PFAS levels in a biologic sample (e.g., blood, tissue, manure) from livestock and to determine if the products from that animal (e.g., meat or milk) are safe for human consumption. In light of this current scientific deficit, the DACF Animal Health team gathered published data and consulted with federal colleagues to gain funding and access to no-cost, validated testing for swine and cattle plasma, muscle tissue, and manure at one PFAS impacted farm. Our short-term goals were to: 1) connect with experts in food safety regulations and experience with these emerging contaminants, of whom there are few; 2) expand the extremely limited amount of biological data on levels of PFAS contamination in live food animals; and 3) collect multiple types of samples from the same animal at a single point in time to help further research towards creating reliable biomarkers in samples that can be collected from live animals. These biomarkers ultimately would allow us to advise farms on timelines for the depuration of animals to predict the rate at which PFAS can be safely reduced and/or eliminated from their edible parts.

When contamination levels at one Maine farm, which raised swine, dairy, and beef cattle, exceeded all hope of detoxifying livestock within a reasonable timeframe, humane euthanasia of those animals occurred. However, this unfortunate reality presented an opportunity to collect paired blood, tissue, and manure samples from a representative set of these animals. Those samples have been submitted to the federal food safety labs, and all samples submitted confirmed detectable PFAS contamination of the animals. Our hope is that the results, with the help of academic partners with research expertise and infrastructure and the potential capacity to host live animal studies focused on controlled depuration of livestock, can lead us to a live animal test for PFAS in food animals that can help reliably predict the best path forward for affected animals and aid producers in planning for the future.

University of Maine Research:

University of Maine researchers also have been engaging with PFAS research. For instance, two grants are currently funded and underway. The first is an "integrated assessment of alternative management strategies for PFAS-contaminated wastewater residuals" sponsored by the Water Research Institute. An interdisciplinary research team is examining the environmental, social, and economic consequences of a range of management options for PFAS-contaminated wastewater residuals. The project will generate a survey of the general public's perception of risks from PFAS, original data on PFAS movement in landfill liner material, and a summary document comparing management alternatives for PFAS-contaminated wastewater residuals.

The second University of Maine research project is "Developing and Deploying a Risk Framework for PFAS Management in Rural America: Connecting Predictive Models of PFAS Contamination with Risk Perceptions to Guide Management Decisions." This proposal uses an integrated risk framework to quantify and communicate the threat of PFAS contamination to the resilience and livelihoods of rural areas. The project has three objectives: 1) identify factors that predict PFAS fate and transport near biosolids agricultural application areas to develop vulnerability models for groundwater resources; 2) determine barriers to scientific information uptake and implementation of management strategies; and 3) provide a research blueprint for the replication of the approach to benefit PFAS-impacted rural communities.

III. Future Research Priority Areas

The following research study areas have been organized in the following fashion:

- Short-term priorities (now through 3+ years):
    - Research that supports short-term farm management decisions
    - Research that assesses future options for viable uses of land
    - Research that develops and builds infrastructure.
- Long-term priorities (now through 10+ years)
    - Long-term monitoring

<u>Research that supports short-term farm management decisions.</u>
Timeline: immediately with a duration of 3 years
Involved Parties: University of Maine, Department of Agriculture, Conservation and Forestry
Estimated budget: $1-2M
Funding sources: State of Maine, USDA-NIFA, FFAR, other federal sources

1. Literature review and planning:
    - Determine priority matrix of information needs around crop uptake (e.g., species, management, soils).
    - Compile and assess (e.g., meta-analysis) existing literature to identify potential crops and animal products for study (e.g., synthesis research like Ghisi et al. 2019. Accumulation of perfluorinated alkyl substances (PFAS) in agricultural plants: A review. Environ. Res. 169, 326– 341, DOI: 10.1016/j.envres.2018.10.023)

2. Lab/controlled conditions experimental research:
- Investigate management options that mitigate contaminated sites (e.g., pump and treat, biochar soil amendments, phytoremediation).
- Test methods to treat manure to minimize that pathway of exposure (e.g., separation of solids).
- Determine the hyperspectral signatures indicative of PFAS uptake in various crop species under experimental conditions, testing to expand to field conditions to evaluate its potential for long-term and large land scale methods for contamination assessment.
- Determine and quantify PFAS transfer rates for:
    - Crop and animal products currently being produced or potentially produced.
    - Alternative crops that could potentially replace current crops. Research should be conducted to determine the transfer rates for alternative crops in the same soil/water conditions (e.g., tomatoes, peppers, melons, squash, sweet potatoes, fruit crops).
    - Soil characteristics (e.g., soil type, soil pH, salinity, organic matter)
    - Existing or potential production methods (e.g., irrigation, fertility)
    - Based on uptake rates, determine the risk to consumers of potential alternative crops.

3. Field experimental research:
- Transfer factor studies specific to individual fields - allow farms to determine what fields to stop using entirely (cropping and/or grazing), or what fields to rotate to alternatives such as ongoing studies of rotating corn (snaplage) from perennial pastures.
- Test rotations that can be utilized for alternative crops (e.g., switching from grasses to grains).
- Continue testing of hyperspectral signatures for PFAS crop and soil contamination.
- Studies must include comparisons between manipulative studies at the bench, greenhouse, and field-scale to determine trade-offs and applicability of controlled study results to field relevant conditions.

<u>Research that assesses future options for viable uses of land.</u>
Timeline: immediately with duration of 3 years
Involved Parties:
Estimated budget: $1M
Funding sources: State of Maine, USDA-NIFA

1. Economic evaluation:
- Investigate potential for investing in equipment/facilities/infrastructure that allow farmers to maintain profitability while they transition to new cropping systems.
- Develop enterprise budgets for alternative cropping systems and their "cost-effective" characteristics.
- Develop enterprise budgets for transitioning to alternative farm revenue streams.
- Determine the cost of soil and water remediation systems and their viability.
- Synthesize farm information for potential solar development assessment (GIS mapping, site data and location, coordination with PUC, DEP, DACF).
- Quantify the impact of PFAS on Maine agriculture and agricultural communities.

2. Decision support:
- Develop decision support systems for impacted farmers and understand the range of factors that influence their decision-making on PFAS.
- Determine viability of replacing annual with perennial crops (e.g., annual vegetable cropping vs. rhubarb, asparagus, etc.; strawberries vs. blueberries/raspberries. This assumes that the perennial plants could take up, accumulate and transfer PFAS at a higher rate than annual, or biennial cropping).

3. Extension:
- Determine best practices for informing customers about the potential of being near or on a biosolid application site.
- Develop messaging around PFAS and agricultural lands, crops, and agricultural products.
- Provide information/guidance on buying/selling ag lands that have had biosolids applied.

<u>Research that develops and builds infrastructure.</u>
Timeline: immediately with duration of 3 years
Estimated budget: $3M
Funding sources: State of Maine, USDA-NIFA

1. Testing Capacity and Data Management:
- Determine testing that is needed (e.g., PFAS species, precursors, breakdown products).
- Conduct a review of sampling and handling protocols that exist or are used and their suitability for Maine farms and operations.
- Determine the costs for testing facility updates and new testing site establishment, including initial and ongoing operating costs. Current testing resources include: state laboratory in Augusta (currently undergoing renovations); University of Maine research laboratory; commercial and federal laboratory facilities outside of Maine. In-state commercial laboratory facilities are under development but not yet operational.
- Develop, implement, and support a statewide agricultural program in "PFAS" testing. A statewide program should include:
    - Considerations for cropping system, soil type, and depth
    - Capacity for repeated sampling over time
    - Related factors included in data stream (e.g., water, residuals, soil, feed).
    - Testing protocols for lands surrounding cropping areas and determining how this added data stream impacts the suitability of sampling and testing protocols
    - Determining the needs for lab accreditation for specific media and methods
    - Establishing data assurance and quality standards
    - Determining data use standards for regulatory-based decisions vs. screening-level decisions only
    - Determining tiered testing cost structure to ensure equitable access and/or sampling and testing strategies that could reduce costs (e.g., pooled testing, or an upfront infrastructure investment in a university laboratory that could then provide a certain number of free analyses for state-sponsored research or outreach projects)

    - Determining ways to reduce testing time and rapid result dissemination
- Developing a plan to integrate testing centers together to capitalize on investments made.
- Developing a data management system to make the data as widely available as possible while protecting individual confidentiality

Long-term monitoring.
Timeline: establishment of framework immediately with duration of 10 years
Estimated budget: $5-10M
Funding sources: State of Maine, USDA-NIFA

1. Planning, establishing, and maintaining a long-term monitoring network:
    - Develop a framework for a long-term monitoring program that enhances comparability among study sites for larger multi-site analyses over time.
        - Frequently horizon-scan for emergent technologies in remote sensing, field sensors, or other approaches that dramatically influence the approach and possibilities for long-term monitoring
    - Develop standard criteria.
        - Determine how long-term monitoring sites are identified and selected; establish suitable criteria (e.g. accessibility, ownership, soil characteristics)
        - Determine the criteria for a site of interest in terms of PFAS sources/types, current/past land use, landscape features, and other characteristics

2. Establish a long-term database:
    - Create a unified data repository using minimum data standards for all data sets and quality assurance and control.
        - Allows for Artificial Intelligence, modeling, and other standard and advanced statistical and analysis procedures to be utilized

3. Compliance:
    - Develop specific criteria and methods for determining non-compliance.
    - Determine the suitability for long-term monitoring on sites that are found to be out of compliance.

IV. PFAS Research Advisory Committee Proposal

Given the enormous effort needed to launch numerous multi-faceted, relevant, and technical PFAS research studies, the Department recommends that the Legislature create a PFAS Research Advisory Panel. The Panel would issue calls for proposals, carefully review them, and ultimately recommend how the state agency(ies) award research funding allocations. Although the Department, along with DEP and CDC, understands what types of research could provide practical information to residents and producers in Maine facing PFAS contamination, staff expertise and current resources do not align with an overall research project(s) needs as well as design, execution, or management. An advisory panel could provide the critical function of vetting scientific research proposal design and potential impact.

The Panel would be comprised of individuals with relevant and applicable expertise. These could include Maine-based members with relevant environmental, agricultural, public health, academic research experience, external academics, and possibly, paid technical members. We could also explore whether federal partners from USDA, FDA, or EPA would be willing to be participants (or external advisers to the Panel), as their presence would help us also with access and knowledge of what research is underway elsewhere.

The concept of an advisory panel is not new. In 2005, the Legislature established the Lead Poisoning Prevention Fund (LPPF) under 22 MRS § 1322-E-F. Maine CDC stewards this dedicated revenue source from a fee of $0.25 assessed on every gallon of paint sold in the State. Maine CDC administers the LPFF allocations with the review and advice of an advisory board. Funding has been used for designated prevention purposes, including contracts for community-based outreach and education programs, an annual targeted mailing to young families, lead dust testing initiatives, an ongoing major media campaign, and the operation of a lead-safe housing registry.

The DACF further proposes that the Legislature establish a dedicated fund similar to the LPPF to support ongoing, critical PFAS research. The Legislature will need to capitalize the fund to sustain research efforts on an annual basis for the foreseeable future. Resources need to be available now to address PFAS research and other needs head-on, with the hope that one day the State can recover PFAS related costs through litigation pursued against PFAS manufacturers.