Scoping Per- and Polyfluoroalkly Substances Releases from the Recycling of Paper and Textiles and their Implications for the Great Lakes-St Lawrence River Ecosystem:
Identifying Opportunities to Address Toxicity of Products in a Circular Economy

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Original: March 31, 2019
Final: September 5, 2019

Acknowledgement:
The Canadian Environmental Law Association would like to thank Beverley Thorpe, John Jackson, Olga Speranskaya, Cassandra Carr Kaljo, Richard Lindgren, Theresa McClenaghan, Michael Murray and Fe de Leon for their thoughtful input throughout the research, writing and production of this report.

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ISBN: 978-1-77189-997-0
CELA Publication Number: 1291

Executive Summary

The circular economy is seen as a useful framework to promote waste reduction and conserve resources. As calls grow for waste diversion of carpets and textiles along with increased composting and paper recycling, the chemical hazard of these products needs to be assessed throughout their lifecycle to avoid ongoing contamination in circular materials management. A comprehensive integration of toxicity concerns is of priority importance for products that contain per- and polyfluoroalkyl substances (PFAS). PFAS have been used to add stain resistance properties to carpets, textiles, furniture, paper and food contact material for over fifty years with over 4,000 different PFAS now on the market. They have also been used in non-stick coating for cookware, fire-fighting foam, cosmetics, and other industrial applications. The most studied perfluorinated substances, perfluorooctane sulfonate (PFOS); and perfluorooctanoic acid (PFOA), are shown to be ubiquitous in the global environment and present in all Canadian populations sampled.[1]

In the Great Lakes region PFOS and PFOA have been designated chemicals of mutual concern under the Great Lakes Water Quality Agreement (GLWQA), and the United States Environmental Protection Agency (USEPA), Health Canada and two Great Lakes states have recently established drinking water guidelines for these PFAS. The Government of Canada is considering additional restrictions to the existing regulations for PFOS, PFOA and long-chain perfluorinated carboxylic acids (PFCAs). However, the vast majority of PFAS on the market are unregulated, with little to no data on their use, toxicity and chemical structure. All PFAS, regardless of their molecular structure, are highly persistent in the environment and will remain a source of exposure for hundreds if not thousands of years. Technologies to treat PFAS exist, however they are very expensive and not widely used at this time.

The use of short-chain PFAS, commonly used as replacements for PFOS and PFOA and long-chain PFCAs in consumer products and manufacturing facilities, are known to be just as persistent in the environment as long-chain PFAS but with higher mobility, presenting a wide-scale exposure risk to drinking water and groundwater. PFAS are also found in biosolids, compost and paper mill sludge, which poses a risk to agricultural and/or non-agricultural land application. As awareness grows of the seemingly intractable and expensive problem of PFAS control and remediation, some US state regulators are drafting product – chemical policies to comprehensively address the entire chemical class of PFAS. Company leaders in the carpet, textile and food packaging arena are adopting PFAS-free alternatives to better mitigate their business, financial and reputational risk.

This review investigates the publicly available extent of PFAS releases from carpets, textile and food packaging products at end of life and recommends a precautionary product life cycle approach to address the challenges of PFAS releases into the Great Lakes-St Lawrence River Ecosystem. Recommendations include the need to integrate PFAS avoidance in current initiatives that promote the increased recycling rate of carpets, textiles and increased composting of paper food packaging within a circular economy framework. A series of actions that could be taken by the Government of Canada, the provinces of Ontario and Quebec and other stakeholders are outlined. This includes publicly disseminated monitoring results to ascertain the extent of all PFAS releases from landfills, WWTP effluents, and to identify PFAS in groundwater, drinking

water and soils in the Great Lakes-St Lawrence River Ecosystem. An underlying goal to advance informed substitution of current uses of PFAS with innovation into transparently safer fluorine-free chemicals, materials and manufacturing processes should be an overarching priority if we are to advance a chemically safer circular economy.

Contents

1. Overview of Per- and Polyfluoroalkyl Substances: toxicity, uses and data gaps

Per- and polyfluoroalkyl substances (PFAS) are a growing focus of concern among scientists, regulators, companies and the general public due to their presence in the global environment, health impacts to humans and wildlife and widespread use of these synthetic fluorochemicals in consumer products. PFAS are not found in nature and exhibit extreme stability and persistence in the environment due to the strength of the carbon-fluorine molecular bonds. Biomonitoring studies find that most people in industrialised countries have one or more PFAS in their blood. Though some PFAS may partially degrade under environmental conditions, they will all eventually transform into highly stable end products that will remain in the environment for hundreds or thousands of years such that human and environmental exposure will continue long into the future.[2] There are over 4,700 different CAS numbers for perfluorinated compounds that have been manufactured and used on the market since the late 1940s.[3] Other compounds may also be under production, but their identities are protected for confidential business reasons making data collection on their chemical hazards difficult. For most PFAS there is little to no understanding on how much has been, and will be, released and transformed in the environment over time. Biomonitoring of selected PFAS can provide some useful information regarding ongoing exposure but these generally overlook the large number of other PFAS which can cause substantial underestimation of total PFAS exposure. In addition mixture toxicity is not adequately understood or considered in current individual chemical based paradigms.[4]
Although some PFAS have been manufactured for more than 60 years, PFAS were not widely documented in environmental samples until the early 2000s. Early detection at low reporting limits was hindered due to analytical capability challenges.[5] This has led to calls for chemical manufacturers to make data on PFAS publicly available, including chemical structures, properties and toxicology and to provide scientists with standard samples of PFAS, including precursors and degradation products, to enable environmental monitoring of PFAS.[6]
PFAS are used in a wide range of consumer products due to their ability to impart oil and water repellency, temperature resistance, and friction reduction. For example, PFAS, have been used in coatings for textiles, paper products, and cookware and to formulate aqueous film forming foams (AFFF) used in fire-fighting applications. They also have a range of applications in the aerospace, photographic imaging, semiconductor, automotive, construction, electronics, and aviation industries.[7]

The PFAS family can be broken down into groups. Perfluoroalkyl substances are fully fluorinated molecules and within this group the perfluoroalkyl acids (PFAAs) are some of the most basic PFAS molecules. They are essentially non-degradable and currently are the class of PFAS most commonly tested for in the environment. The most studied and increasingly regulated of these PFAAs are perfluorooctane sulfonate (PFOS); perfluorooctanoic acid (PFOA), and long-chain perfluorinated carboxylic acids (PFCAs). These PFAS have 8 or more carbon bonds (C8). Long-chain (C9-C20) PFCAs, their salts and precursors are ubiquitous in the environment with their precursors degrading to long-chain PFCAs.[8]

Polyfluoroalkly substances are distinguished from perfluoroalkyl substances by not being fully fluorinated. Within this group fluorotelomers are used to make polymers that impart soil, stain, grease, and water resistance to coated articles. Some fluorotelomer based products are also used as high performance surfactants in products where an even flow is essential, such as paints, coatings, cleaning products, and fire-fighting foams for use on liquid fuel fires. Fluorotelomer-based products can be applied to articles both at the factory and by consumers and commercial applicators in after-market uses such as carpet treatments and water repellent sprays for apparel and footwear.[9]

Biotic and abiotic degradation of many polyfluoroalkyl substances can result in the formation of PFAAs such as PFOS and PFOA.[10] During wastewater treatment, polyfluoroalkyl compounds (often called precursors) can degrade into perfluoroalkyls with the result that effluent from municipal and industrial waste water treatment plants (WWTPs) can have increased concentrations of PFAS. WWTPs are considered to be a major point source of PFAS in aquatic environments.[11]

All groupings in the PFAS family have very high persistence but some PFAS with shorter carbon chains (6 carbons or less) are considered less bioaccumulative and therefore less toxic. Researchers caution however that it is important not to make generalizations about PFAS behavior based only on chain length since other factors besides chain length may affect bioaccumulation potential of PFAS.[12] Shorter chain fluorinated alternatives are still as environmentally persistent as long-chain substances or have persistent degradation products. In addition, because some of the shorter chain PFAS are less effective, larger quantities may be needed to provide the same performance.[13] Short-chain PFAS have a high mobility in soil and water which results in quick distribution to water resources, and consequently, also to contamination of drinking water resources.[14] As the production of short-chain alternatives increase, "there is a general lack of publicly available information about their fate/transport, exposure and toxicological effects although current evidence suggests a cause for concern."[15]
In 1999 due to community health and environmental concerns of DuPont's PFOA production facility in Parkersburg, West Virginia DuPont and other manufacturers including 3M, were pressured to cease production of long-chain PFAS.[16] In 2006, DuPont and seven other manufacturers and users of PFOA partnered with USEPA to reduce and then eliminate PFOA from manufacturing processes with a phase out achieved by 2015.[17] 3M stopped production of PFOS in 2002. These facilities now produce other fluorinated alternatives to PFOA and PFOS.

Regulation in many countries has caused concentration levels of PFOS and PFOA in human samples to decline, but other PFAS remain unchanged or continue to increase.[18] This may be due to ongoing releases of PFAS from legacy waste sites and the constant exposure from consumer goods, drinking water and food that have measurable levels of legacy and new PFAS.

The health impacts of many perfluoroalkyl substances were summarized by the US Department of Health and Human Services in a June 2018 report[19] which concluded that based on a number of factors, including the consistency of findings across studies, the available epidemiology studies – also referenced by Health Canada in the recently released in December 2018 Guidelines for Drinking Water Quality for PFOS and PFOA - suggest associations between perfluoroalkyl exposure and

- Pregnancy-induced hypertension/pre-eclampsia (PFOA, PFOS);
- Liver damage (PFOA, PFOS, PFHxS);

- Increases in serum lipids, particularly total cholesterol and low-density lipoprotein (LDL) cholesterol (PFOA, PFOS, PFNA, PFDA);
- Increased risk of thyroid disease (PFOA, PFOS);
- Decreased antibody response to vaccines (PFOA, PFOS, PFHxS, PFDA);
- Increased risk of asthma diagnosis (PFOA);
- Increased risk of decreased fertility (PFOA, PFOS);
- Decreases in birth weight (PFOA, PFOS).

Unlike other persistent organic pollutants, PFAS accumulate in protein-rich organs and tissues notably the liver and blood, rather than in fat,[20] which necessitates new ways of measuring health impacts. Children are most at risk from PFAS exposure in consumer goods. According to Health Canada, main routes of exposure to PFAS for adults in the general population are linked to ingestion of food, drinking water, and house dust whereas oral hand-to-mouth contact with consumer products, such as carpets, clothing, and upholstery, is a significant contributor for infants, toddlers, and children[21] Health Canada notes that although no definitive links have been established, a large-scale report of PFAS on children suggests associations between serum PFAS and thyroid effects.[22]

The most studied perfluorinated substances, PFOS and PFOA, are found in serum, plasma, kidneys, and the liver and have also been detected in breast milk and cord blood. In 2017, the International Agency for Research on Cancer concluded that PFOA is possibly carcinogenic to humans (Group 2B); and the USEPA concluded that there was suggestive evidence of the carcinogenic potential of PFOA and PFOS in humans while increases in testicular and kidney cancer have been observed in highly exposed humans.[23] The half-life or time it takes to eliminate half of the substance from the human body, for those long-chain PFAS that have been studied, range from 2.8 to 8.5 years.[24]

PFOS and PFOA are shown to be ubiquitous in the global environment and present in all Canadian populations sampled. In 2002, serum samples from 56 individuals in Ottawa, Ontario, and Gatineau, Quebec, were analyzed for PFOS and PFOA and both substances were detected in every person sampled. In 2004, PFOS was detected in all plasma samples from 883 Nunavik Inuit living in the Canadian Arctic and subsequent testing for PFAS in 155 Inuit infants found PFOS and PFOA in all plasma samples.[25] Preliminary information from Health Canada on biomonitoring results for urinary fluoride, PFOS and PFOA found higher levels in Ontario samples compared to the rest of Canada.[26]

In 2006, Health Canada concluded that PFOS was not a concern for human health at current levels of exposure. However, Environment Canada determined that PFOS and its salts were declared toxic to the environment and its biological diversity, and PFOS was added to Schedule 1 of the Canadian Environmental Protection Act, 1999 (CEPA). In 2009, PFOS and its salts were added to the Virtual Elimination List under CEPA.

In 2012, Environment Canada and Health Canada published screening assessments of PFOA concluded that the substances are an ecological concern, but PFOA and its salts and precursors are not a concern for human life or health. In addition, Environment Canada produced an assessment of long-chain PFCAs in 2012 and based on the assessments both PFOA and long-chain PFCA and their salts and precursors were added to the List of Toxic Substances in Schedule 1 of CEPA and designated as CEPA Toxic.[27] PFOA was not added to the Virtual Elimination List under CEPA.

Recommendations for Section 1:

The Government of Canada should:

- ***Incorporate a consideration of mixtures when assessing toxicity of PFAS for future proposed regulations.***

- ***Require manufacturers to provide comprehensive toxicity data for all PFAS on the market with a prioritization on data gathering for short-chain PFAS and consider integrating mobility as key criteria when assessing environmental fate of short-chain PFAS.***

2. PFAS in Products and Associated Waste Management Challenges in the Great Lakes-St. Lawrence River Ecosystem

The Great Lakes Basin contains 20% of the world's fresh surface water and is home to 40 million people, including 98% of Ontarians and 40% of Canadians. As reported in Ontario's Great Lakes Strategy more than 80% of Ontarians get their drinking water from the Great Lakes basin and over 95% of Ontario's agricultural land is in Great Lakes watersheds. In 2011 Ontario's commercial Great Lakes fishing industry contributed about $234 million to Ontario's economy while Great Lakes recreational anglers contribute more than $600 million to Ontario's economy each year in consumable goods and equipment.[28] The protection of drinking water safety and a healthy ecosystem for wildlife are priorities for this region.

In the Great Lakes Basin, PFOS, PFOA, long-chain PFCAs and their salts and precursors have been designated Chemicals of Mutual Concern under Annex 3 of the Great Lakes Water Quality Agreement of 2012. The Identification Task Team (ITT), an expert committee created under the Great Lakes Water Quality Agreement to review and provide advice on candidate chemicals of mutual concern, concluded in 2015 that PFOS, PFOA and long-chain PFCAs have been identified to pose a threat to the environment and to human health in the basin.[29]

The ITT summarized the monitoring results for specific PFAS in the Great Lakes Basin and noted that PFOS concentrations in air are highest near populated areas with the highest concentrations of PFCAs in air in Toronto. PFAS are found in sediment samples from across the Great Lakes Basin with greater concentrations near population centers with sediment core samples from Lake Ontario showing increased PFAS concentrations over time. PFAS are detected in the tributaries and open water sediments across the Great Lakes Basin with the highest levels of PFAS generally found in areas of Lake Ontario, the western end of Lake Erie and the Detroit River corridor. PFOA and PFOS are found in wastewater plant effluent and PFOS has been detected at drinking water plant treatment facilities in source and treated waters.

Concentrations of PFOS are found in fish from the Great Lakes at concentrations which exceed the Canadian federal environmental quality guidelines[30] established for the protection of avian and mammalian predators, but below fish tissue guidelines established for the protection of fish themselves. Human biomonitoring studies found high frequency of detection of PFOS, PFOA and PFHxS in blood plasma of sampled people in the Great Lakes basin with slightly higher concentrations of perfluoroalkyl acids in First Nations communities in the Great Lakes compared to the national average. In addition, PFAS are listed as contaminants in the Guide to eating Ontario Fish (2017-2018). This guide makes a point to focus on sensitive populations including women of child bearing years and children younger than the age of 15 years old, and provides a consumption advisory table. It aims to focus on consuming the least contaminated fish.[31]

The ITT identified gaps in risk management, research or monitoring for PFOS, PFOA and long-chain PFCAs noting in particular the need to target releases from the waste sector (landfills, recycling plants) and conduct further research of the dynamics and environmental fate of degradation and transformation of PFAS precursors in wastewater treatment plants and landfills.

The ITT recommendations are timely because increasing evidence points to the importance of WWTPs, biosolids, and landfill leachate as significant point sources of PFAS into the environment. This necessitates a product life cycle approach, with a focus on end of life products to understand why waste management facilities have become a focus for PFAS monitoring. The use of PFAS in carpets, textiles, wire and cable, paints, food contact material and a wide range of consumer goods that have been landfilled over the years are creating PFAS releases into landfill leachate. The presence of PFAS in consumer products that generate PFAS discharge to sewer systems include cosmetics, carpet cleaning fluids, stain repellents on clothing released through washing, floor waxes and detergents and even air deposition of PFAS on windows – all of which eventually enter water systems. The waste management problem created by PFAS use in products is reflected in compilations of remediation technologies to address the problem of PFAS contamination in groundwater, soil, and water.[32]

Recognizing that wastewater treatment plants are among the important pathways by which chemicals of emerging concern enter the Great Lakes, the International Joint Commission assessed, between 2009-2011, the effectiveness of wastewater treatments for chemicals of emerging concern. Results from 3 years of performance data from 25 facilities demonstrated low removal efficiency for PFOS and PFOA.[33]

Environment and Climate Change Canada examined the potential for the WWTPs and landfills to emit PFOS to the atmosphere. Air sampling at one Ontario WWTP and two landfill sites were monitored for PFOS and volatile PFOS precursor compounds between June and September 2009. For the WWTP, concentrations of PFOS and the PFOS precursor compounds were seven and four times higher, respectively, compared with upwind and downwind background locations. Similarly, for the landfills, the concentrations of PFOS and PFOS precursor compounds were approximately three and two times greater, respectively, than the upwind sites.[34]

Mass balance studies of PFAAs at WWTPs commonly report similar or higher PFOA concentrations in effluents in comparison to raw influent, suggesting that the degradation of other fluorinated organic compounds (i.e., fluoropolymers) into PFOA may take place during wastewater treatment and that conventional WWTPs are not effective in removing PFAAs. In a 2012 study by Environment Canada and Health Canada, PFOA was detected in effluent wastewater treatment facilities at concentrations ranging from 0.007 to 0.055 μg/L in Canada.[35]

The ability of WWTPs to generate higher concentration levels of PFAS in effluent compared to influent was observed in a 2014 study investigating the fate of 21 perfluoroalkyl acids across 20 Canadian WWTPs. Researchers found that the effects of various treatment processes impacted the amount and formation of perfluoroalkyls in the effluent. The highest formation of perfluoroalkyls in effluent occurred in WWTPs with advanced biological treatment with nutrient removal, followed by slightly lower formation in WWTPs with aerated lagoon systems and then secondary biological treatment.[36] These findings are important considerations as municipalities fund the upgrading of WWTPs since enhanced waste water treatment has been shown to increase the amount of PFAS in effluent.

A fraction of PFAS will partition with sewage sludge during wastewater treatment. Overall, anaerobic and aerobic digestion of mixed secondary and primary sludge has been shown to increase the concentration of perfluoroalkyls, compared to untreated sludge. The disposal of biosolids on land can act as source of PFAS to surface water, groundwater and the food chain. Preferential leaching of short chain PFAS were observed in biosolids indicating the potential for contamination of groundwater resulting from application of typical municipal biosolids to agricultural fields.[37]

Another important source of PFAS release is landfill leachate. Over the years, the deposition to landfill of carpets, textiles, paper and other household and industrial waste that contain PFAS is now generating releases of these chemicals to the environment. Landfill leachate contains greater concentrations of PFAS than most other environmental media with the exception of firefighting training and manufacturing impacted sites.[38]

A UNEP Stockholm Convention Persistent Organic Review Committee (POPRC) Report from its 14th session in October 2018[39] notes that PFAS are routinely detected in landfill leachate with short-chain PFAS being most abundant, possibly an indication of their greater mobility and higher water solubility, and reflecting the shift toward usage of short-chain substances in the market. Following disposal, PFAS are released from the waste through both biological and abiotic leaching either from precursor degradation (biological or abiotic) or from direct use of PFAS.

When leachate is collected and sent to WWTPs, biological or chemical degradation of precursors during secondary treatment can increase the presence of long-chain PFCAs in WWTP effluent.

Since PFAS are inherently very stable they pose a unique challenge in remediation of contaminated water. Current standard industry practice for treating PFAS-contaminated water is via filtration through granular activated carbon (GAC). While GAC is effective at removing long-chain PFAS compounds, the short-chain compounds are not removed as efficiently which can lead to costly GAC replacement and unsatisfactory remediation outcomes for short-chain PFAS. Other treatment technologies such as synthetic resins to bind long-and short-chain compounds show promise but are very expensive relative to GAC and performance is yet to be verified. More traditional processes such as reverse osmosis and ozone fractionation have been successfully used to remove PFAS from water but require significant capital outlay and operating costs and still generate a PFAS residue that requires disposal.[40]

The Priority of a Product Lifecycle approach – an upstream focus on the use of PFAS in consumer products

Attempting to deal with PFAS in waste streams is costly and technically challenging. A 2012 review summarized the challenges in remediation of soil and groundwater due to the extreme variables in physiochemical properties within the PFAS class making the viability of treatment for some PFAS not viable for others. Other challenges are the high mobility and degradation products of many PFAS and the maturity, scale and cost of available technologies.[41] This necessitates a more proactive and upstream consideration of the use of PFAS in consumer products and industrial manufacturing facilities. WWTPs cannot be expected to adequately address these chemicals and in fact WWTPs with secondary or tertiary treatment are shown to increase the problem of PFAS release into the environment. Considering the longevity of the legacy waste problem, it is important to assess all waste treatment options extensively as well as monitor and publicly list the location of contaminated sites. However, going forward it would be prudent to prioritize the prevention of new PFAS releases to landfills, WWTPs and sewer systems. Even if organics are removed from landfills and advanced technologies become more feasible and cost-effective, a precautionary course of action would be to consider the whole life cycle of PFAS and the impact to a Circular Economy. Promoting market uptake of transparently safer PFAS-free products and manufacturing processes that will not create long term waste problems offers a prudent way forward.

A product life cycle approach would expand the current Canadian government regulatory initiatives for PFOS, PFOA and long-chain PFCAs. It would require identifying the use of all PFAS in products and manufacturing, determining the necessity of the PFAS function, the fate and degradation products of PFAS at end of life, and the availability of transparently safer PFAS-free alternatives.

A product - chemical approach has been taken by the California Department of Toxic Substances Control (DTSC) which in February 2018 issued a Discussion Draft that would list carpets and rugs containing PFAS as a Priority Product.[42] The DTSC nominated the entire chemical class as hazardous chemicals in these designated products. Under the Safer Consumers Products (SCP) Regulations hazardous chemicals are evaluated in priority products along with possible alternatives.[43] This product-chemical combination meets the identification and prioritization factors outlined in the state's SCP Regulations, namely that: (1) there is potential for human and other organism exposure to PFAS in carpets and rugs; and (2) the exposure has the potential to contribute to or cause significant and widespread adverse impacts. All PFAS are Candidate Chemicals because the California Environmental Contaminant Biomonitoring Program lists the entire class as Priority Chemicals for measuring in the blood or urine of Californians. Figure 1 outlines the key routes of PFAS exposure from treated carpets and rugs.

In 2017 the House of Commons Standing Committee on Environment and Sustainable Development made recommendations to support the need for alternatives assessment for chemicals of high concern.[44] Among the recommendations (specifically 57-60) the Committee recommended that CEPA be amended to add a mandatory duty to assess alternatives as part of all screening assessments of existing substances; ensure that decisions about how to regulate toxic substances are based in part on information about substitutes with a goal of replacing toxic substances with safer alternatives; and that the Minister prepare national safer alternatives action plans for substances for which reports on safer alternatives have been prepared. This is a timely opportunity as current market trends to PFAS-free materials continues to escalate, notably in food contact materials, carpet and textile manufacturing, and fire-fighting foams.

Recommendations for Section 2:

The Government of Canada should:

- ***Address the gaps identified by the ITT. In addition both Canadian and US government strategic plans to implement the ITT recommendations should be incorporated into the Lakewide Action and Management Plans (LAMP). The LAMPs could then assess the effectiveness of actions to reduce the levels of these chemicals of mutual concern in the Great Lakes Basin.***

- ***Create an inventory of all PFAS use in the Great Lakes to help fill in the current lack of data.***

- ***Implement the recommendations of the House of Common Standing Committee on Environment and Sustainable Development to amend CEPA to require mandatory alternatives assessment, with a focus on PFAS in products sold and manufactured in the wider Great Lakes-St Lawrence River Ecosystem. Product sectors and manufacturing facilities using PFAS in the Great Lakes-St Lawrence River Ecosystem should be a priority for a comprehensive alternatives assessment process with a focus on identifying the availability of PFAS-free substitutes. A Taskforce should be convened with a focus on downstream users (brands and retailers) who have adopted PFAS-free materials for carpets, textiles and food contact materials in order to inform other stakeholders in the supply chain about the availability of PFAS-free innovations. In addition the taskforce should include effective and transparent public engagement.***

- ***Adopt the recommendations presented in March 2018 by the National Expert Panel established by the Canadian Water Network in its Blue Print for Federal Action on contaminants in wastewater. This calls for the federal government to 'work with all stakeholders, provincial, territorial, local and indigenous rights holders' to continue to apply and further develop an effective risk management approach to deal with complexity and changing nature of chemicals mixtures in waste water and their observed effects in the environment and on human health. The precautionary***

principle approach, based on best science and indigenous knowledge, and inclusive of uncertainty and adaptive management, would be core to this work.[45]

Furthermore:

- ***To emphasis the scale of the waste management problem for PFAS at end of life product use, the Government of Canada should work with the Provinces of Ontario, Quebec, and municipalities and public/private utilities in the Great Lakes-St Lawrence River Ecosystem to disseminate their review of most effective technologies to remove PFAS in WWTPs, in landfill leachate and in drinking water treatment plants. Discussions with impacted regulatory bodies should establish who is responsible for paying these costs.[46]***

- ***Considering the high cost and technological difficulty in dealing with PFAS releases at the waste management stage, the Great Lakes Water Quality Agreement should adopt a product lifecycle approach as the most expedient course of action to mitigate waste management costs and technological challenges in the Great Lakes Basin. A product life cycle approach would shift the focus from end of life product waste management to a more proactive prevention at source, including product innovation and design to avoid toxic and/or harmful substances with a particular focus on the use of PFAS in products currently used and discarded in the region.***

3. Great Lakes-St. Lawrence River Ecosystem and Drinking Water Standards

The production of PFOS by 3M in Minnesota lead to downstream contamination and a subsequent 2011 report by the Michigan Department of Environmental Quality highlighted problems to drinking water safety in Michigan and the Great Lakes.[47, 48]

In May 2016, the USEPA established a Lifetime Health Advisory (LHA) for PFOA and PFOS in drinking water of 0.07 µg/L. This LHA is applicable to PFOA and PFOS individually, or in combination, if both chemicals are present at concentrations above the reporting limit. The LHA is advisory in nature; it is not a legally enforceable federal standard and is subject to change as new information becomes available.[49] The USEPA announced in February 2019 that it is moving forward with a Maximum Contaminant Level process for PFOA and PFOS and is also gathering and evaluating information to determine if regulation is appropriate for a broader class of PFAS.[50] In the USEPA Action Plan for PFAS, the EPA identified several industries that are likely to be discharging PFAS in their wastewater and will begin a more detailed study to evaluate the potential for PFAS presence in their wastewater discharges. As part of this study, the EPA plans to gather more detailed information for the following point-source categories: organic chemicals, plastics, synthetic fibers, pulp and paper, textiles, and airports.[51]

In 2018, the US Agency for Toxic Substances & Disease Register (ATSDR) issued a draft toxicological profile for perfluoroalkyls.[52] The draft profile suggested provisional minimal risk levels (MRLs) of 7 ng/l for PFOS and 11 ng/l for PFOA – parameters that are seven to ten times lower than the lifetime advisory levels set by USEPA.

As reported by the Interstate Technical Regulatory Council, two Great Lakes states – Minnesota and Michigan - have set drinking water and groundwater standards for PFOA and PFOS. [53] Minnesota has set Health Based Values (HBV) for PFOA in drinking water and groundwater at 0.035 µg/L and for PFOS at 0.027 µg/L. The Minnesota Rule has not been promulgated. Michigan set Generic Clean Up Criteria (GCC) for both PFOA and PFOS in drinking water and groundwater at 0.07 µg/L. The state also established a Human Non Cancer Value (HNV) for surface water at 0.42 µg/L for PFOA and 0.011 µg/L for PFOS. The Michigan rules have been legally promulgated.

Several individual US states are setting parameters for PFAS in drinking water at even more stringent levels that the USEPA LHA.

In 2017 the state of Minnesota updated their health values basing them on the vulnerability of foetuses and infants who are exposed via their mothers, rendering the values significantly lower than those set by the federal USEPA.[54] The lowering of mandatory and advisory levels for PFAS in drinking water indicate a growing awareness that exposure to PFAS even at low levels can have negative impacts on human health. In particular, studies have found impaired immunological responses to vaccines at levels of exposure as low as 1 ng/l in serum – levels that are exceeded in most humans.[55] State regulatory authorities in Michigan and Minnesota have prioritized easy online access to PFAS issues including monitoring data and location of PFAS contaminated sites.[56]

In Canada there are no provincial drinking water guidelines for PFAS in the Great Lakes-St Lawrence River Ecosystem. The one province with a water standard for PFAS in drinking water and groundwater is British Columbia which set a water standard for drinking and groundwater at 0.2 µg/L for PFOA and 0.3 µg/L for PFOS. In December 2018, Health Canada published Guidelines for Canadian Drinking Water Quality for both PFOA and PFOS, which are comparatively higher than the USEPA's Lifetime Health Advisory for PFOA and PFOS in drinking water of 0.07 µg/L.[57] The Canadian government's maximum acceptable concentration (MAC) for PFOS in drinking water is 0.6 µg/L and for PFOA at 0.2 µg/L[58]. In addition, the Guidelines state: 'As the toxicological effects of PFOS and PFOA are considered to be additive, the sum of the ratios of the detected concentrations to the corresponding MACs for PFOS and PFOA should not exceed 1.'

Health Canada notes that water utilities should characterize their source water for drinking water to assess PFOA and PFOS concentrations, particularly if source waters are impacted by firefighting training areas, military bases, airports, manufacturing sites and/or waste disposal sites. The Guidelines note that conventional treatment is not effective for PFOA or PFOS removal. Other treatment methods are promising, although full-scale studies are limited. Activated carbon adsorption can achieve treated water concentrations of PFOA and PFOS below the MAC if proper operation of the system is followed.

Recommendations for Section 3:

- ***Provinces in the Great Lakes-St Lawrence River Ecosystem i.e., Ontario and Quebec, should adopt the most stringent drinking water guidelines into their relevant provincial drinking water legislation for PFOS, PFOA and other PFAS. This should be modeled on the current most precautionary limits (for example Michigan and Minnesota).***

- ***Health Canada, provincial and municipal regulators in the Great Lakes-St. Lawrence River Ecosystem should prioritize monitoring of PFAS in surface and ground water potentially impacted by firefighting training areas, military bases, airports, manufacturing sites and/or waste disposal sites and make such monitoring results public.***

- ***Health Canada, provincial authorities and municipal utilities should make PFAS monitoring information available online to help inform communities in the Great Lakes-St. Lawrence River Ecosystem on the status of bi-national efforts to fill the data gaps identified by the ITT.***

- ***All PFAS starting with the listing of PFOA and PFOS should be added for reporting on the National Pollutants Release Inventory with a focus on WWTPs, pulp and paper mills, textile manufacturing plants and recycling facilities.***

- ***Improve compliance and enforcement mechanisms for drinking water guidelines and ensure annual data is made public accessible.***

- ***Require municipalities to monitor for PFAS in drinking water and make the data publicly accessible.***

4. An Overview of PFAS Regulatory Restrictions in Canada and the Stockholm Convention on Persistent Organic Pollutants

- **PFOS**

PFOS, its salts and its precursors, are both intentionally produced and an unintended degradation product of related perfluoroalkyl acids within the whole class of PFAS. The PFOS molecule contains eight carbon atoms in which all of the carbon-hydrogen (C-H) bonds are replaced by carbon-fluorine (C-F) bonds. PFOS is subject to long-range transport, and is ubiquitous in the environment. Owing to its chemical and physical properties, PFOS is typically found at higher concentrations in water compared with air, and can travel long distances by oceanic currents. In contrast, PFOS precursors are more volatile and can be transported through air to areas far from initial release, where they subsequently degrade to PFOS.

Although never manufactured in Canada, it is estimated that imports of PFOS and its precursors accounted for 43% (258,000 kg) of the 600,000 kg of PFASs imported into Canada between 1997–2000. The majority of all perfluorinated alkyl compounds imported into Canada were used in applications involving water, oil, soil and grease repellents for fabric, packaging, and rugs and carpets; and surfactants/detergents, emulsifiers, wetting agents, dispersants and fire-fighting foams. It is expected that PFOS and its precursors are present in many of these use applications.[59] Releases of PFOS into the environment persist from the legacy of consumer articles containing PFOS such as vacuuming and cleaning of carpets, final disposal of treated carpets to landfill through leachate, as well as groundwater or surface water contamination from AFFF use.[60]

In 2009, the Stockholm Convention on Persistent Organic Pollutants (Stockholm Convention on POPs) listed PFOS as a 'new POP' to Annex B (restriction) of the Stockholm Convention with certain exemptions in the semi-conductor, aviation, metal plating, medical devices, firefighting foam, carpets, textiles and upholstery, paper and packaging sectors.[61] At the ninth Conference of Parties (COP9) in April/May 2019, the COP will evaluate the continued need for exemptions while taking into account the recommendations of the POPRC, a technical subsidiary body of the Stockholm Convention. These recommendations include the removal of several exemptions. PFOS has been controlled since 2008 through the Perfluorooctane Sulfonate and its Salts and Certain Other Compounds Regulations and in January 2009 Canada added PFOS to the Virtual Elimination List. Since December 23, 2016, the manufacture, use, sale, offer for sale and import of PFOS, its salts and precursors as well as products that contain them have been further restricted in Canada under the *Prohibition of Certain Toxic Substances Regulations, 2012* (PCTSR) with some exemptions.

On December 20, 2018, a consultation document describing the proposed amendments to the PCTSR was published for a 60-day public comment period. The proposed amendments would further restrict the manufacture, use, sale, offer for sale and import of PFOS by removing or restricting exemptions.[62] The consultation document indicates that proposed amendments would be published in Winter 2020.

Through the consultation, ECCC requested specific information related to activities currently permitted, including their use in photoresists, photographic films, papers and printing plates, and in the use of AFFF. Information gathering includes achievable timelines for companies to complete a phase-out, cost estimates, and efficiency or suitability of alternatives. There is currently no stipulation to conduct comprehensive hazard assessment of alternatives or to prioritize information gathering on non-fluorinated alternatives.

- **PFOA**

PFOA and its salts are used as polymerization aids in the production of fluoropolymers and fluoroelastomers. The most common commercially used salt form of PFOA is the ammonium salt, referred to as APFO. APFO is used primarily as a commercial polymerization aid in the manufacture of fluoropolymers which are used in various sectors, including the automotive, electronics, construction and aerospace industries. Fluoropolymers are used in the manufacture of stain- and water-resistant coatings on textiles and carpet; hoses, cable and gaskets; non-stick coatings on cookware; and personal care consumer products. APFO can also be used as a constituent in paints, photographic film additives and in the textile finishing industry. AFFF may also contain APFO as a component. Fluorochemicals that are potential PFOA precursors are used in the treatment of food packaging materials to enhance their properties as a barrier to moisture and grease and trace amounts may be present as a contaminant or degradation product.

Although PFOA itself has never been manufactured in Canada, quantities of APFO were imported. According to industrial information obtained for the 2004 calendar year on the Canadian manufacture, import and export of PFASs, APFO was imported into Canada in wide ranging estimated quantities of between 100 – 100,000 kg.

PFOA may be found in the environment due to releases from fluoropolymer manufacturing or processing facilities, effluent releases from wastewater treatment plants, landfill leachates and due to degradation/transformation of PFOA precursors. There are no published data on direct releases to air, water or land from Canadian industrial facilities. [63]

At the Stockholm Convention's Conference of Parties (COP9) in April/May 2019 the parties to the Stockholm Convention will consider listing PFOA, its salts and PFOA-related compounds to Annex A for elimination as was recommended by the POPRC in September 2018. Ten time-limited exemptions have been proposed for specific uses such as in semiconductor manufacturing, textiles for oil and water repellency, firefighting foams and medical devices. According to some environmental stakeholders including the International POPs Elimination Network (IPEN), PFOA should be listed in Annex A with no specific exemptions. IPEN also believes that if exemptions are granted, they should be for specific products and the listing should require labeling new products that contain PFOA.

Since December 23, 2016, the manufacture, use, sale, offer for sale and import of PFOA and its precursors and products that contain them have been prohibited in Canada under the PCTSR with few exemptions. PFOA was never manufactured in Canada, however it was imported in products and may continue to be imported in AFFF used in fire-fighting applications, and in manufactured items such as textiles (rugs, carpets, clothing and outdoor equipment); paper and packaging; and electrical and electronic equipment.

On December 20, 2018, a consultation document describing proposed amendments to the PCTSR was published for a 60-day public comment period and comments and information received will be considered in the development of proposed regulations to amend the PCTSR targeted for publication in Winter 2020. The proposed amendments would further restrict the manufacture, use, sale, offer for sale and import of PFOA by removing exemptions.[64] Through the consultation, ECCC requested specific information related to activities currently permitted which include the import use, sale and offer for sale of AFFF that contains PFOA for fire-fighting; the import, use, sale and offer for sale of manufactured items containing PFOA such as surface treated paper and cardboard packaging for commercial and consumer use; textiles used in outdoor applications such as awning, outdoor furniture and camping gears; textiles for oil and water repellency; membranes intended for use in medical textiles, filtration in water treatment, and others. Information gathering will also focus on the import or use of manufactured items made outside Canada containing PFOA, whether or not they are made from recycled material.

Information gathering incudes achievable timelines for companies to complete a phase-out, cost estimates, and efficiency or suitability of alternatives. There is no stipulation to conduct comprehensive hazard assessment of alternatives or to prioritize information gathering on non-fluorinated alternatives.

- **Long-Chain (C9-C20) PFCAs their Salts and their precursors - including Four New Fluorotelomer-Based Substances**

Long-chain PFCAs are used for surfactant applications and in the production of fluoropolymers to provide oil-, grease-, water- and stain-repellent properties. While these substances were never manufactured in Canada, they were historically imported and may continue to be imported in AFFF used in fire-fighting applications, and in manufactured items such as textiles (rugs, carpets, clothing and outdoor equipment); paper and packaging; and electrical and electronic equipment.

The presence of PFCAs is ubiquitous. They have been found in typical North American homes with carpeted floors, pre-treated carpet and commercial carpet-care liquids. PFCAs as well as their precursors have been found in window films from indoor/outdoor/downtown/suburban/rural/carpet store locations in Toronto, Ontario.[65] Floor waxes and stone/tile/wood sealants that contain fluorotelomer products are potential sources of C9 to C12 PFCAs in homes and commercial buildings containing these materials. Other potential sources include treated home textile, upholstery and apparel and household carpet/fabric care liquids and foams. PFCAs have been measured in the blood of ski wax technicians which suggests that fluorinated organic compounds are added to glide waxes to prevent adhesion of snow, ice and dirt.

There are no available data on the direct release through industrial use/manufacturing of long-chain PFCAs to the Canadian environment. Commonly used precursors which are present in commercial products, such as long-chain fluorotelomers can degrade to long-chain PFCAs. Surveys done in 2000 and 2004 found between 1000 and 100 000kg of precursors to long-chain PFCAs were reported to be imported into Canada. [66] Empirical evidence on the degradation of long-chain fluorotelomer-based polymers into long-chain PFCAs in wastewater treatment (effluent and biosolids) suggests these are a source of long-chain PFCAs. In fact, WWTPs with secondary treatment increased the presence of long-chain PFCAs.[67]

The manufacture, use, sale, offer for sale and import of long-chain PFCAs, their salts and precursors, as well as products that contain them have been prohibited in Canada under the PCTSR with some exemptions similar to those for PFOA.

On December 20, 2018, a consultation document describing the proposed amendments to the PCTSR was published for a 60-day public comment period. The proposed amendments would further restrict the manufacture, use, sale, offer for sale and import of long-chain-PFCAs by removing exemptions.

In a separate but related initiative, four new fluorotelomer-based substances were identified as precursors to long-chain-PFCAs. These were never manufactured in Canada although they may have been imported and may continue to be imported within manufactured items. The decision to prohibit these substances was a precautionary and preventative measure. Because the four new fluorotelomer-based substances are precursors to long-chain-PFCAs, ECCC is proposing through the consultation to remove the separate listing for these substances in the regulations and consolidate the regulatory requirements with those for long-chain-PFCAs. ECCC requested specific information related to activities currently exempted in order to address remaining data gaps and understand any potential challenges faced by stakeholders in eliminating their use.[68] Information gathering incudes achievable timelines for companies to complete a phase-out, cost estimates, and efficiency or suitability of alternatives. There is currently no stipulation to conduct comprehensive hazard assessment of alternatives or to prioritize information gathering on non-fluorinated alternatives.

Recommendation for Section 4:

- ***To avoid regrettable substitution, or the replacement of a hazardous chemical with one that has equal or more hazards, the federal government should ensure alternatives assessments are conducted for all uses of PFOS, PFOA and long-chain PFCA with a priority for information gathering on non-fluorinated alternatives.***

5. Non Regulated and Short-chain PFAS are a Growing Focus of Concern

As stated above, an estimated 600,000 kg of PFAS were imported into Canada between 1997–2000. Beyond this timeframe, it is unknown how much PFAS was imported into Canada in consumer articles or industrial applications before and after this period. Although PFOS and PFOA and long- chain PFCAs are regulated in Canada, other PFAS continue to be used in carpets, textiles and paper and packaging, outdoor apparel, footwear and sporting equipment, ski and snowboard waxes, non-stick cookware, paints, varnishes, dyes, and inks, adhesives and long-chain aqueous film firefighting foam (AFFF). This is because producers of PFAS have replaced PFAS with similar or shorter chain PFAS (typically with six or fewer perfluoroalkyl carbons) as alternatives. One of the criteria used by 3M Company to screen and select its replacement to PFOA in the production process of fluoropolymers was that the alternative “fulfills all requirements for the polymerization process with minor process adjustments”.[69]

A meta-analysis performed on consumer products found children’s textiles and carpets can be highly loaded with diffuse mixes of PFAS and may contribute to the exposure of children and toddlers particularly via textile-mouth or hand-mouth contact. The replacement of PFOS and PFOA with shorter chain fluorinated compounds is a concern. Thirty consumer products from the Norwegian markets were analyzed with shorter chained PFAS found to be a major contributor to the total PFAS load of consumer products especially in non-stick ware and water proofing agents. In other studies, the dominance of short-chain PFAS was particularly high in leather and carpets and in paper based food contact material (FCM).[70]

This trend to use fluorinated alternatives is occurring within a wide-scale lack of data. In a 2017 article by Wang, et al the authors point out that among the thousands of PFAS still being produced and used, there are many overlooked ones that have been produced since the 1970s or earlier, are structurally similar to PFOS, PFOA, or their precursors, and are produced in high volumes (e.g., >10 tonnes/year). Furthermore, for most of these overlooked PFAS, there is little to no information about their fate/transport, exposure, and toxicological effects in the public domain, or even awareness to study them.[71] Although long-chain PFAS are generally thought to present greater toxicity in humans than shorter chain PFAS, short-chain PFAS are as persistent in the environment as their longer chain analogues and are highly mobile in soil and water. Due to increasing global production and use, environmental and human exposure to short-chain PFAS is expected to increase over time.[72]

Moreover, very short chain PFAS are also volatile and can be distributed to remote regions far from their initial point source of direct exposure. Short-chain PFAS are known to accumulate in edible plants with the impact of accumulation in food chains relatively unknown. Due to their persistence and mobility, and inability for water treatment systems to prevent their spread in the environment, some researchers are calling for short-chain PFAS to be considered of equivalent concern to Persistent, Bioaccumulative and Toxic (PBT) substances. [73]

Other policy makers are beginning to shift the focus toward mobility as a key chemical parameter of concern so that persistent mobile toxic (PMT) criteria are considered as important as PBT criteria. Germany's Federal Environment Agency (UBA) developed the PMT concept and suggested that PMTs could be identified as substances of very high concern (SVHCs) under European Union (EU) Registration, Evaluation and Authorization of Chemicals (REACH). In December 2018, the EU's Scientific Committee on Health, Environmental and Emerging Risks (Scheer) identified PMTs as one of 14 emerging issues.[74] A report commissioned by the EU has proposed new screening criteria to identify potential persistent organic pollutants (POPs) on the basis of their mobility in the environment and this was circulated at the meeting of the Competent Authorities for REACH for discussion on 19-20 March, 2019.[75] Proponents highlight that mobility "M" may cause environmental and health concerns that even exceed those of the "B" criterion.[76]

The 2019 USEPA Action Plan on PFAS summarizes the overarching challenges for PFAS management noting that:

> *Unknown and undiscovered PFAS likely exist within the environment as impurities or byproducts of chemical production or as a result of environmental degradation and transformation processes. Health and occurrence data and validated analytical methods are available for certain PFAS (e.g., PFOA and PFOS). However, for most PFAS there is limited or no toxicity information. While validated EPA drinking water measurement methods are available for 18 PFAS today, including PFOA and PFOS, and more are in development, we lack validated analytical methods for national environmental measurements and assessment of exposure for hundreds of other PFAS. Additional challenges to remediation and cleanup include PFAS occurrence as mixtures with other contaminants.*[77]

Recommendation for Section 5:

- ***The Government of Canada should adopt criteria on mobility in addition to persistence, bioaccumulation and toxicity when identifying chemicals of mutual concern in the Great Lakes-St Lawrence River Ecosystem including a goal to establish PFAS as a chemical class for nomination under the GLWQA and the Canada-Ontario Agreement.***

6. The Rationale for Regulating PFAS as a Chemical Class

Researchers are increasingly highlighting the need for a class based approach to PFAS regulations.[78] The sheer amount of PFAS on the market make chemical by chemical regulations effectively impossible to meet the goal of protecting Canadians and wildlife from exposure to harmful chemicals. There is little to no information on the production and use history for most PFAS on the market and general unknown identities of most PFAS on the market highlight current regulatory controls as ineffective. Recent monitoring studies confirm that humans and the environment are being exposed to a wide range of organofluorine compounds, with increasing ratios of unidentified ones.

The current absence of regulations or controls for the vast majority of PFAS allows industry to replace one PFAS with other structurally similar PFAS. PFAS are an intractable, potentially never-ending chemicals management issue. The very high persistent of PFAS leads to poorly reversible exposure in all environments including groundwater. The high solubility and protein binding characteristic of many PFAAs challenge the conventional assessment of bioaccumulation potential that is traditionally assessed through either bioconcentration factor in aquatic species, or models based on octanol-water partitions coefficients. Children and the developing fetus are most at risk. The current lack of an adequate mechanistic understanding of all adverse effects across species and their life stages associated with exposure to individual PFAS may introduce substantial uncertainties and difficulties in the selection and testing of the most sensitive toxicological end points such as developmental immunotoxicity and types of endocrine disruption.

We currently face a lack of effective control measures to eliminate, prevent, reduce or mitigate the risks of PFAS. Available data on PFAS in consumer products are scarce to date making quantification of PFAS in waste streams difficult. Most remediation technology for contaminated sites is in research development stage and will be costly. Technologies currently being proposed to treat PFAS containing wastewater and landfill leachates to reduce or eliminate the amounts of PFAS to be released will still require high-temperature incineration of highly contaminated concentrates or sorbent materials.

Future innovation should focus on the development of alternative substances that are truly ‘benign by design’ by following the 12 principles of Green Chemistry and by making these innovations in PFAS-free publicly available on dedicated web portals. The OECD has compiled comprehensive Alternatives Assessment frameworks to help companies and regulatory authorities navigate the roadmap to transparently safer substitute chemicals and materials.[79]

Positioning chemical hazard as a priority consideration within the mix of technical feasibility and cost considerations can prevent regrettable substitution.

As signatories of the Madrid Statement on Poly- and Perfluoroalkyl Substances point out: 'Global action through the Montreal Protocol (United Nations Environment Programme 2012) successfully reduced the use of the highly persistent ozone-depleting chlorofluorocarbons thus allowing for the recovery of the ozone layer. However, many of the organofluorine replacements for CFCs are still of concern due to their high global warming potential. It is essential to learn from such past efforts and take measures at the international level to reduce the use of PFAS in products and prevent their replacement with fluorinated alternatives in order to avoid long-term harm to human health and the environment.'[80]

In a 2019 report, The Cost of Inaction -A socioeconomic analysis of environmental and health impacts linked to exposure to PFAS, the Nordic Council of Minister note that because of the extreme persistence of PFAS in the environment that will remain on the planet for hundreds if not thousands of years, human and environmental exposure will continue far into the future and efforts to mitigate this exposure will lead to significant socioeconomic costs – costs largely shouldered by governments and taxpayers. Costs were based on exposure scenarios ranging from high (workers in manufacturing plants); medium (communities near chemical plants or in areas impacted by PFAS in drinking water; to low (adults in general population exposed via consumer products and background levels). The range of estimated annual health-related costs due to PFAS exposure is EUR 2.8–4.6 billion for the five Nordic countries and EUR 52–84 billion for all EEA countries. The authors note that the actual costs are likely to be higher, since these calculations are for only a few of the health impacts linked to exposure to PFAS.[81]

Recommendations for Section 6:

The Government of Canada should:

- ***Require data collection, toxicity, and use amounts from chemical producers and make this information publicly accessible as per the recommendation in the Madrid Statement on PFAS. The government has taken steps to require more information in the PCTSR Consultation document for PFOS, PFOA and long-chain PFCAs and could expand this request for all PFAS on the Canadian market.***

- ***Require manufacturers of PFAS to make chemical structures public and provide validated analytical methods for detection of PFAS.***

- ***Work with users of PFAS and public stakeholders (consumers) to develop public registries of products containing PFAS and work to establish comprehensive labeling for products with PFAS.***

- ***Make public, annual statistical data on production, imports and exports of PFAS.***

- ***Establish PFAS-specific science-policy-public health taskforce to review the government's approach for PFAS chemicals management. This taskforce would require a balanced participation of stakeholders that represent downstream users of current PFAS applications, consumers, workers, public stakeholders and public health officials. Companies that have developed transparently safer PFAS-free alternatives to current uses of PFAS should be a priority voice in policy discussions to advance the circular economy.***

7. Circular Economy as an Emerging Policy for Textiles and Paper

The need to integrate chemical hazard considerations into product life cycle management is an essential component for a sustainable circular economy. In September 2018 a group of Canadian companies and think tanks formed the Circular Economy Leadership Coalition to shift towards a circular economy which they define: 'where resource productivity is increased, items are designed to use less material, last longer, be reused or be repaired, pollutants and toxins are eliminated from the system and any generated waste becomes an input back into the system."[82]

The Province of Ontario has enacted the Resource Recovery and Circular Economy Act 2016 in order to minimize the use of raw materials; maximize the useful life of materials and other resources through resource recovery, and minimize waste generated at the end of life of products and packaging. [83] In Part 1 of the Act, under Provincial Interest, the act notes that it is in the provincial interest that Ontario has a system of resource recovery and waste reduction that aims to decrease hazardous and toxic substances in products and packaging. The Strategy for a Waste Free Ontario: Building the Circular Economy released in February 2017,[84] outlined the government's intention to designate materials for diversion that includes carpets, mattresses and furniture by 2019 and beyond. To achieve the strategy goals, the provincial government "will require a fresh approach to waste management and resource recovery – one that accounts for shifting global context… and enlists the support of all Ontarians. New product design and management thinking will help Ontario avoid the volume and toxicity of waste materials while conserving and recovering resources." No regulatory proposals to advance this strategy goal has been made at this time.

On October 29, 2009, the Canadian Council of Ministers of the Environment (CCME) approved a Canada-wide Action Plan for Extended Producer Responsibility (EPR). EPR is an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle.[85] The Canadian Council of Ministers of the Environment (CCME) launched an action plan on Extended Producer Responsibility (EPR) with a commitment to address furniture, textiles and carpets in 2017.[86] However to date there has been no development on integrating these product sectors into EPR programmes. A review of online CCME EPR policy documents does not address the issue of chemical hazards in products unlike the integration of toxicity considerations by the Circular Economy Leadership Coalition.

Textiles, Carpets and Furnishings – Recycling and disposal in the Great Lakes-St Lawrence River Ecosystem

A Circular Economy goal will increasingly focus on carpet, textiles and furnishings due to the extent of these materials going into landfill. An estimated 230 to 270 million kilograms of waste carpet is generated in Canada annually[87] with the majority going to landfill.

The Ontario Textile Diversion Collaborative (TDC) has estimated that textiles (apparel, home textiles, fabric off cuts and other industry products made of fibres) accounts for 4-11 percent of landfill volume, by weight, in Ontario's landfills.[88] TDC is encouraging the development of a textile recycling industry in Ontario and is asking the Ontario government to take a more active role in textile waste diversion.

In 2010 the Canadian Carpet Recovery Effort (CCRE) launched an industry-led voluntary initiative to work with municipalities in Ontario to pilot test carpet recycling with CCRE.[89] According to this organization, 99% of post-consumer carpet is going to landfill and 95% of commercial carpet is going to landfill. However the CCRE initiative no longer has an online presence and has communicated no updates since then.

A waste audit conducted in 2017 in Nova Scotia found over 25,000 tonnes of textiles and footwear in municipal solid waste (MSW) (11% to 16% of materials in Nova Scotia landfills are textiles). In 2014, Nova Scotia proposed a ban on textiles to landfill to curb the 30,000 tonnes of textiles that ended up in provincial landfills each year and are seeking to implement the textile ban by 2020. There is no data available on footwear disposed or recycled for any jurisdiction in Canada.

A 2014 report on the state of waste management in Canada[90] found no provincial or territory-wide diversion programs for textiles or furnishings. Charitable organizations supply an informal recycling or re-use system for textiles and furnishings in many Canadian municipalities although there is no Canada-wide data available on how many participate or what volumes are collected for recycling or re-use.

Internationally, California has prioritized action on carpet recycling and has recently mandated that carpet recycling rates more than double from 2015 to 2020. The proposal to list PFAS as Candidate Chemicals in the Safer Consumer Products Act allows a comprehensive approach to carpet recycling goals.

To date, France is the only country in the world implementing an EPR policy for end-of-use clothing, linen and shoes which they introduced in 2007.[91] France has set a 50% (about 300,000 tonnes, 4.6 kg/person/year) collection target for annual sales and the amount collected now is three times as much as what was collected 10 years ago. In 2006, 65,000 tonnes were collected while around 210,000 tonnes were collected in 2016. The material recovery rate of the post-consumer textiles can reach 90%, 50% of which can be directly reused. However, the 'reuse' stream is facing some challenges because its main market is in Africa and many African countries are considering banning the import of used textiles to encourage a competitive textiles industry locally and internationally. Textile and clothing manufacturer importers and distributors can accomplish their legal obligation to meet collection, recycling and reuse targets through two distinct ways: either by financially contributing to an accredited Producer Responsibility

Organization (PRO) or by setting-up an individual take-back program approved by the French public authorities.

The programme's PRO collected €17.2 million from fashion retailers and this tariff has been employed to promote increasing collection and recycling rates; maintain transparent material and financial flows; fund research and development projects to identify solutions and create opportunities for textiles producers as well as recyclers; and support social inclusion for socially excluded workers. Some researchers consider the French implementation of the EPR policy a model, for jurisdictions[92] – however there is no legal requirement to consider toxicity exposure at end of life textile waste processing. Considering that end of life textiles are commonly recycled into insulation and used widely in the construction of new and renovated buildings in Northern France and Paris, it would be precautionary to monitor for the presence of PFAS in recycling and reuse applications.

Recommendations for Section 7:

The Governments of Canada and Provinces (specifically Ontario and Quebec) should:

- ***Develop outreach, education and awareness programs for the textile, paper and furniture sectors in the Great Lakes-St Lawrence River Ecosystem to adopt EPR programs with a focus on PFAS chemicals.***

- ***CCME, which ECCC is a member of, should set up a multi-stakeholder committee to develop a model EPR programme with a focus on PFAS in paper, textiles, furnishing and carpets for adoption across Canada with a specific focus in the Great Lakes-St Lawrence River Ecosystem.***

- ***Convene a stakeholder group of company leaders that have achieved PFAS-free materials use to communicate how they have advanced non-fluorinated products within circular materials management.***

- ***The Ontario government should fully implement its Strategy for a Waste-free Ontario and The Resource Recovery and Circular Economy Act, 2016, with specific activities to advance new product design and management that will reduce the volume and toxicity of products including carpets, textiles and furniture that contains PFAS.***

8. PFAS Emissions from Textile, Furnishing and Carpet Disposal and Recycling in the Great Lakes- St. Lawrence River Ecosystem

Landfill and landfill leachates as significant point sources of PFAS

As stated earlier, landfill leachate contains greater concentrations of PFAS than most other environmental media with the exception of firefighting training and manufacturing impacted sites.[93]

There are 1973 operating landfills across Canada that accept MSW.[94] Of this total 880 operate in Ontario and 104 operate in Quebec. Ontario has the largest number of operating landfills operated by any Canadian province but for the 880 landfills currently operating, only 30 of these are large landfills, the rest are small (<40,000m3).

Canadian monitoring of PFAS near landfill and urban centers notes that despite the 2000 to 2002 phase-out of PFOS and its C8 precursors, leaching from consumer products during use likely continues to be a major source to the environment as well as from end of life disposal.[95]

Studies have demonstrated that carpet and clothing are likely sources of PFAS in landfill leachate. The concentrations of 70 PFAS in the aqueous phase of anaerobic model landfill reactors filled with carpet or clothing showed a differentiation in the types of PFAS measured. Clothing in the test reactors revealed a predominance of PFOA releases while other PFAS (5:3 fluorotelomer and PFHxA) were dominant in the carpet reactors.[96]

Concentrations of 70 PFAS in 95 samples of leachate were measured in a survey of U.S. landfills. The survey estimated that in 2013, PFAS releases to landfill leachate entering WWTPs was between 563 and 638 kg for the whole country. [97]

A 2010 study by Norwegian researchers measured a sum of 16 perfluorinated compounds in landfill leachate at one landfill in Norway at 6231 ng/L (ppt) and in another landfill at 2191 ng/L (ppt). The authors note that an effective removal method for PFAS and other persistent compounds from landfill leachates has been a major challenge, since commonly used treatment technologies are based on aeration and sedimentation which are ineffective in degrading PFAS chemicals.[98]

Based on an Environment Canada study of 12 landfills sampled for leachate between 2008-2014, PFAS had a detection rate of 100% in both pre and post-treatment samples. In pre-treated leachate, the range of total PFAS was a minimum of 320 ng/L to a maximum of 9400 ng/L and a median value of 3227 ng/L. In post-treatment samples, the range of total PFAS was a minimum of 800 ng/L to a maximum of 14201 ng/L with a median value of 4498 ng/L. The average on-site landfill treatment resulted in a 22.1% increase in concentration of total PFAS. Ten out of the twelve landfills sampled are located in the Great Lakes Basin. [99]

Landfills fall under provincial jurisdiction and most provinces have been moving towards regionalization of landfill facilities over the past 10-20 years – generally closing smaller, older, unlined facilities and using fewer, larger, lined facilities constructed to meet improved environmental standards. Exceptions do apply. These upgrades however, will not prevent ongoing PFAS releases. There is no inclusion of PFAS monitoring in leachate or air emissions at the provincial and territorial level.

For example the Landfill Standards Regulation 232/98 under the Ontario Environmental Protection Act lays out operational requirements which address groundwater protection, air emissions, surface water conditions, buffer areas, final cover, landfill gas control, monitoring requirements, leachate contingency plans, site closure and post-closure care provisions; and financial assurance requirements – but no chemicals are designated as chemicals of concern for action. However owners and operators are required to ensure a program is carried out for monitoring the quality and quantity of leachate, groundwater and surface water. This includes analysis of a list of parameters. An assessment of the measured parameters is used to amend procedure or implement contingency plans if needed.

PFAS have been shown to be present in landfill gas but the fate of PFAS in the flaring process is unknown.[100] Considering the Stockholm Convention's Guidelines on preferred temperature attainment for PFAS thermal destruction, landfill gas flaring at sub-optimal temperatures may be an uncharacterized source of PFAS to the environment. A 2011 Environment Canada report using 2009 data indicated that fourteen of the sixty-eight large sites (active sites of more than 40,000 tonnes per year capacity) surveyed used recovered methane for energy purposes; thirty-six sites flared it, while eighteen both flared and utilized landfill gas for energy purposes.[101]

Dealing with legacy waste containing PFOS is a focus in the Stockholm Convention. At the 6th meeting of POPRC[102] delegates drew up the following recommendations on risk reduction for PFOS in existing stocks. They recommended that in the short term governments should identify and cease using stocks containing PFOS (fire-fighting foams, carpets and others). These stocks should be collected and stored. To raise awareness of the environmental and human health effects of PFOS, governments should provide training for relevant professionals in how to handle collection, storage and disposal of PFOS. In the medium term they recommend governments develop and implement strategies to destroy stocks containing PFOS.

Textile Recycling as a source of PFAS exposure

If goals for textile waste diversion are successful and textile recycling increases in Canada, the presence of PFAS in carpets, apparel and furnishings will present new exposure risks both from legacy PFAS use and current PFAS use. According to the Carpet and Rug Institute, the industry trade group representing 90 percent of US carpet manufacturers, "most residential and commercial carpets are treated" with PFAS-based stain- and soil-repellents.[103]

According to the USEPA, global production of fluorotelomers and associated side-chain fluorinated polymers was estimated at 20 million pounds (~9,071,847.4 kgs) in 2006. Textiles and apparel accounted for approximately 50 percent of the volume, with carpet and carpet care products accounting for the next largest share in consumer product uses. Coatings, including those for paper products, were the third largest category of consumer product uses.[104]

Outdoor textiles exhibit high levels of fluorotelomers (FTOH) and have been identified as major sources of FTOH in indoor environments as they are released from these products.[105] A 2017 Report by the Commission for Environmental Cooperation analyzed articles of clothing and performance apparel, including children's items, purchased from 27 cities across North America. Targeting 31 PFAS compounds, it found that 68.6%, showed detectable results for at least one of the PFAS. Of the articles tested, outdoor jackets presented the highest number of "positive hits".[106]

There are no publicly available mass balance calculations of the amount of PFAS in textiles sold or disposed of in the Great Lakes-St. Lawrence River Ecosystem including exports of such waste.

The California Department of Toxic Substance Control (DTSC) "has identified carpets, rugs, indoor upholstered furniture, and their associated care and treatment products, as the largest potential sources of significant and widespread PFAS exposures."[107] According to California's review of PFAS in carpets, PFAS from carpets and rugs can be found in home and office air samples, and in the blood of residents and office workers. Compared to outdoor air, indoor air can have >1,000 times higher levels of FTOHs from the presence of FTOHs as manufacturing impurities or intermediate degradation products.[108]

PFAS-containing treatments can be applied to carpets at four stages: during the manufacturing of the carpet fibers; during the carpet and rug manufacturing process at the mill; at a separate finishing facility or in stores at the time of sale; or post-sale of the carpet by consumers or professional cleaners.[109]

Carpet floor coverings fall into two categories: broadloom and tile. Tile is more common in commercial buildings than residences, where broadloom predominates. An industry report from 2000 estimates that fifty percent of a fluorochemical treatment may be lost over a nine year lifespan of carpet due to walking and vacuuming. The same report indicates that an additional forty percent of the fluorochemical treatment may be removed by steam cleaning throughout the carpet's life thereby becoming a source of PFAS contamination in water.[110]

No mass balance of PFAS use in carpets is publicly available for Canada. However given that the average lifetime of a carpet is 14 years -- carpets containing PFOS are still entering the waste stream long after key manufacturers phased-out PFOS production.

In 2011, the European Commission studied waste issues related to PFOS, and determined that old carpet contains, on average, 75 parts per million (ppm) PFOS, and contributes a total of 146,000 kilograms of PFOS (from 1.94 million tons of carpet discarded per year) to the waste stream. In addition, it estimated that carpet still in use contains 1.64 million kg PFOS in 21.7 million tons of carpet.[111]

The recycling process itself presents new exposure routes through carpet shredding operations. A report by Healthy Building Network notes that carpet waste shredding facilities supply shredded carpet to cement kilns for burning and to carpet manufacturers for recycling where workers may be inhaling and ingesting PFAS – the same mechanism thought to be responsible for the elevated levels of flame retardants in workers in carpet pad recycling facilities. However no health or body burden studies for carpet recycling workers appear to have been conducted.[112] Air emissions from the shredding operation will also create PFAS releases to surrounding air. According to the US Department of the Navy and Agency for Toxic Substances and Disease Registry, workers involved in the production of PFAS and/or PFAS-containing materials, such as carpets, are more likely to be exposed than the general population to PFAS chemicals via inhalation, dermal contact, and ingestion – inhalation being the likely route of exposure. [113, 114]

California's Department of Toxic Substances and Control notes that industrial workers, carpet installers, carpet cleaners and workers in furniture, furnishings, outdoor clothing, and carpet stores may experience above average PFAS exposure levels.[115]

There are no required occupational health and safety exposure limits to PFOS, PFOA or long-chain PFCAs for Canadian workers applying PFAS in textile mills, in coating facilities or in carpet shredding plants. Current provincial Occupational and Health regulations or protocols do not address PFAS exposure.

At the 6th meeting of the Stockholm Convention's POPRC[116] in 2010 delegates also addressed risk reduction for recycling of articles containing PFOS. The committee recommended that in the short term governments should cease the recycling of carpets containing PFOS and make Parties aware that the use of carpets containing PFOS in applications other than those for which they were originally intended, such as in gardening, may lead to releases. Furthermore, they recommend that governments should cease deposition of consumer products and materials identified as containing PFOS (in particular carpets, furniture and textiles) in landfills and to store them to await proper destruction. In the medium and long term it is further recommended that governments should assess the extent to which PFOS releases occur in the recycling of paper, textiles and impregnated furniture, assess whether other material recycling streams are affected by materials containing PFOS, monitor releases of PFOS, among other contaminants, from municipal landfills as well as groundwater, surface water and biota that could be affected by releases from landfills. Guidance issued in 2017 recommended that Parties collect all waste with PFOS at levels of 50 mg/kg or higher in carpets, leather and apparel, textiles and upholstery and paper and packaging for incineration at high enough temperatures to thermally mineralize the fluorinated polymer.[117,118]

Market and Policy Trends to PFAS-free carpets and textiles

A market shift to PFAS-free carpet fiber and textiles is underway by company leaders. The world's largest manufacturer of modular carpet for commercial and residential applications stopped using PFAS-based treatments on its face fibers several years ago having found an alternative way to achieve stain resistance in carpet fibers.[119]

According to the Healthy Building Network leading carpet fiber manufacturer have made progress in developing alternatives that promote water repellency, soil and stain resistance without relying on fluorinated substances. This would meet the growing interest of the carpet and textile floor covering industry to replace the presently used C6-fluorochemicals with PFAS-free alternatives.[120]

A report by Greenpeace International summarizes the results of their seven year international Detox campaign to eliminate chemicals of high concern in the apparel and footwear sector. All brands had made significant progress in eliminating PFAS and substituting them where necessary. Over seventy percent of the companies targeted in this campaign achieved total PFAS elimination from their product lines with remaining companies making progress towards elimination of PFAS in their products.[121]

The state of California is requiring carpet manufacturers to achieve a 24 percent recycling rate for post-consumer carpet by January 1, 2020.[122] Since the bill was passed in 2017, the state has moved forward with a focus on chemicals of concern in carpets. As discussed in Section 2, a product - chemical approach has been taken by the California DTSC which is proposing to list carpets and rugs containing PFAS as a Priority Product. Manufacturers making Priority Products are required to notify the state and may be required to conduct an alternatives assessment. DTSC has also nominated all PFAS for inclusion on the Candidate Chemicals List and DTSC is currently evaluating adverse impact and exposure criteria for the entire class of PFAS.[123] The Candidate Chemicals List is not a list of Chemicals of Concern until it is the basis for a product being listed as a Priority Product. In the meantime manufacturers and consumers are given notice that this product – chemical focus is underway. The state proposes that manufacturers of consumer products may voluntarily choose to proactively review the Candidate Chemicals List to discover chemical hazard traits in the products they produce while consumers may find the list helpful to be better informed about chemicals in the products they own or are considering purchasing.[124]

The City of San Francisco has mandated PFAS-free carpets in city procurement specifications.[125]

Recommendations for Section 8:

The Government of Canada should:

- ***Investigate the flaring of landfill gas with PFAS constituents as an additional source of exposure.***

- ***Place a moratorium to prohibit landfilling of products containing PFOS, in support of recommendations made by the POPRC of the Stockholm Convention in 2010.***

- ***Assess the capacity of provinces and territories to follow the Guidelines produced under the Stockholm Convention to identify the presence of PFAS, particularly PFOS, in carpets, leather and apparel, textiles and upholstery and paper and packaging; collect all waste; and achieve incineration at high enough temperatures to thermally mineralize the fluorinated polymer and not produce further POPs.***

- ***Require monitoring of PFAS in landfill leachates and air emissions and make the results publicly available.***

- ***Work with provinces in the Great Lakes-St. Lawrence River Ecosystem to integrate PFAS requirements into regulations for landfill waste management and WWTPs management with a focus on PFAS releases in water, soil and air.***
- ***Conduct analysis of use and release of PFAS in carpets, destined for recycling and make these results public.***
- ***Require disclosure of all PFAS in products sent for recycling to facilitate the segregation of these materials prior to recycling.***
- ***Require labeling of all products to increase consumer awareness.***
- ***The government of Canada should take regulatory action to prohibit products containing PFAS, including PFOS, PFOA and long-chain PFCAs that are imported into the Great Lakes-St. Lawrence River Ecosystem.***
- ***Work with stakeholders to integrate PFAS monitoring and labeling into provincial occupational health and safety regulations.***
- ***Designate PFAS as harmful pollutants under the Canada Ontario Agreement and require alternatives assessments for all PFAS use in products with a priority to assess PFAS-free substitutes.***
- ***Require municipalities to monitor and report to provincial government the PFAS loading and releases to water in WWTPs and landfill leachate and air emissions from waste management facilities with a priority on PFOS, PFOA and long-chain PFCAs.***
- ***Require PFAS monitoring in air and water at recycling facilities.***
- ***Provincial governments in the Great Lakes- St. Lawrence River Ecosystem should set Certificates of Approval that incorporate most stringent best in class standards for discharge limits for PFAS, with a focus on the pulp and paper mills, recycling facilities, and textile facilities.***

9. PFAS Emissions from Composting of Food Contact Materials (FCM) and emerging evidence of PFAS in paper mill sludge application

Paper and Food Contact Material

The Circular Economy promotes composting to increase the use of organic material back into land eco-systems. Many municipalities promote the use of Food Contact Material (FCM) as organic matter in food composting schemes. The National Zero Waste Council,[126] a coalition of Canadian municipalities has prioritized food composting and packaging recycling. Canada-wide, organics composting (of food and leaf/yard waste) has seen a 125% increase in diversion over the last decade.[127] For other food packaging that is not contaminated with food residues, paper and board is generally collected for recycling.

The Canada-wide strategy for sustainable packaging sets out EPR requirements for all types of packaging used for non-hazardous products, including service packaging such as in-store packaging and take-away food containers. CCME will fund the development of a national standard and certification program for compostable packaging which will assist producers and consumers in selecting more sustainable packaging materials and will facilitate better end-of-life management or compostable packaging waste.

PFAS have been used in paper and cardboard food packaging since the 1950's, mostly as coatings to prevent the paper material from soaking up fats and water, but also in printing inks and as moisture barriers. These coatings are used in applications intended to be heated in the packaging or stored for an extended period and examples include fast food paper, microwave popcorn bags, cake forms, sandwich and butter paper, chocolate paper, paper for dry foods and pet foods.[128]

There are generally two types of barriers against grease or fat for paper and cardboard. The function of fat repellency can be achieved by a physical barrier or a chemical barrier. For a physical barrier, the paper structure itself can serve as an obstacle to grease penetrating the paper – for example traditionally, liquid uptake was prevented by making cellulose fibers very fine (microfibrillated) and cross bonded, or by using sulphuric acid to make parchment. A chemical barrier could also be used in the paper to repel grease and is achieved either by the addition of chemicals to the pulp or as a surface coating. PFAS can be used as an internal and external sizing agent, and in a surface coating.

Another way to repel grease and moisture in paper and board is by laminating an extra layer of plastic or aluminum onto the material. The disadvantage is that the machines must have laminating facilities and the material is difficult to recycle.

The PFAS coatings used in paper and cardboard are mainly polyfluorinated compounds with residuals (for PFOS) and impurities (fluorotelomers and others) typically also present.[129] According to the Nordic Council "general guidelines for dosages of fluorochemicals for surface treatment could be in the range of 0.2 up to 1.0 wt% solid on paper." Documentation from fluorochemical producers shows that up to 88% of the fluorochemicals added to paper are retained on the paper material, whereas 8% are bound to sludge and 4% are released into the environment with the wastewater. A total amount of fluorochemicals up to 4% (dry weight) of the paper mass can be used when mixed into the pulp.

PFAS have a strong preference for binding to proteins and this is consistent with numerous studies which find that PFAS primarily are present in foods rich in proteins (especially liver, fish, and red meat). Food is estimated to be a main source of human exposure to PFASs – but Health Canada notes that exposure from food is still well below what is considered unsafe to human health.[130]

Studies conducted by Health Canada's Food Research Division using data from 2006/2007 have demonstrated that food packaging is not a significant source of some PFAS such as PFOA and PFOS, in food.[131] In Canada the safety of all materials used for packaging foods is controlled under the Food and Drugs Act and Regulations, which state "[n]o person shall sell any food in a package that may yield to its contents any substance that may be injurious to the health of a consumer of the food". Because of the general nature of this requirement, packaging materials intended for use with foods may be submitted voluntarily to the Food Directorate (FD) for a premarket assessment of their chemical safety. There are no prohibitions on PFAS in food contact materials, however when a potential safety concern is identified, a maximum level for chemical contaminants in food could be established by Health Canada and enforced by the Canadian Food Inspection Agency.

A 2017 assessment by the Nordic Council of the role of FCMs to total human exposure notes information gaps in exploratory data for the identities, compositions, and concentrations of PFAS and their precursors in technical mixtures used for FCMs. This lack of data inhibits adequate analysis needed for a quantitative risk assessment of human exposure. The Nordic Council suggests creating Early Action Regulations (EARs) which will limit human and environmental exposure until adequate risk assessments can be performed, as well as to prohibit the use of the class of PFAS in paper and board FCMs in order to decrease their release into the environment and their contamination of feed, food, and drinking water.[132]

A similar observation on the lack of hazard data and need for chemical identify in FCM was made in a recent research paper on fluorinated compounds in US Fast Food Packaging. Noting that prior studies that found PFASs in fast food packaging were based on relatively few samples and inconsistent analytical methods, the researchers used particle-induced gamma-ray emission (PIGE) spectroscopy as a rapid screening method to test more than 400 samples of food packaging from fast food restaurants.[133] Six of the 20 samples (collected in 2014 and 2015) contained detectable levels of PFOA years after voluntary phase out by US producers. Total peak areas for known and unknown PFASs varied by more than three orders of magnitude. For many samples, the signal for unknown polyfluorinated compounds was similar to, and sometimes much larger than, the signal for known PFAS compounds, suggesting that a substantial portion of organofluorine in these samples cannot be ascribed to known PFAS.

FCM containing PFAS are known to contaminate compost. A July 2018 article in Biocycle notes that because PFOA and PFOS have been ubiquitous in daily use for decades, wastewater, biosolids, digestates, and other residuals (e.g. residuals from recycled paper mills) typically contain single digit to tens of µg/kg (ppb) concentrations each of PFOA and PFOS. In addition, many non-biosolids include measurable levels (e.g. single digit ppb), which could be due to PFAS transferred to food scraps from food packaging.[134] Tests have shown higher levels of PFOA and PFOS exiting a wastewater treatment facility or in finished compost compared to the levels in wastewater influent or composts feedstock. This phenomenon is due, in part, to the breakdown of precursors.

An analysis of ten compost samples from across the United States that is in process of being published in 2019 with more detailed data, found PFAAs at higher levels in the seven samples that had feedstocks of mixed food and yard waste and included compostable food service ware.

In contrast, low levels of PFAS were found in the three samples which did not include compostable food service ware in the feedstock.[135] No publicly available Canadian studies on PFAS in compost were found.

The Biodegradable Products Institute (BPI) is North America's leading certifier of compostable products and packaging. BPI's certification program ensures that products and packaging displaying the BPI logo have been independently tested and verified according to scientifically based standards. The Institute's goal is to promote best practices for the diversion and recovery of compostable materials through municipal and commercial composting. Concerns by composters led to the BPI announcing in late 2017 that its strict certification program for compostable products will begin to include a limit on total fluorine content of 100 mg/kg – a limit already in place in European composting standards. The limit becomes effective in 2019.[136]

PFAS use in pulp and paper mills and paper processing

A total of 61 Canadian pulp and paper mills operate in the Great Lakes-St Lawrence River Ecosystem. In Ontario eight mills discharge their treated effluent into rivers and eight discharge their effluent into municipal WWTPs.[137] In Quebec four mills discharge to WWTPs and 49 mills discharge to rivers.

PFAS can be used as water, oil, soil and grease repellents for use on surface and paper-based applications, food packaging but there is no publically available data for PFAS use in paper mills.

With the restrictions on the use, manufacture and import of PFOS/PFOA and LC-PFCAs these substances should not come into Canada as a pure substance for use in paper mills. However other non-regulated PFAS are permitted for use in paper coating.

There is no estimate for the amount of PFAS used in FCMs in Canada or in the Great Lakes-St Lawrence River Ecosystem. This makes estimation of the presence in effluents difficult. Food packaging materials submissions to Health Canada are strictly voluntary as there is no statutory requirement at present under the Food and Drugs Act and Regulations for the pre-market clearance of food contact materials in Canada. However, Health Canada has received reports on the use of short chain PFAS as ingredients in packaging materials.[138]

Sludge from paper mills have been documented as significant sources of PFAS contamination to drinking water. In August 2018 it was reported that tap water in Parchment, Michigan was declared safe to drink after a state of emergency stopped the use of water from PFAS-contaminated wells, connected to the nearby Kalamazoo drinking water system. Drinking water contamination had been caused by PFAS leachate from landfills containing paper mill waste. The city of Kalamazoo flushed uncontaminated water through the Parchment water system and into the sewers and WWTP. The Michigan Department of Environmental Quality is now working with a local pulp and paper mill to identify the source of per- and polyfluoroalkyl substances that contaminated the city of Parchment's water supply and private wells.[139]

In a more recent case PFOS was detected in cow's milk from Stoneridge Farm in Arundel, Maine requiring the farmer to dispose of his milk. The original source of the anomalously high level of PFOS in the western field soil of the Farm is uncertain, but data from the Maine Department of Environment Protection (DEP) investigation suggest it is likely something other than the municipal biosolids that were land applied on several fields as fertilizer and soil amendment from the late 1980s to 2004. The Stoneridge Farm was also licensed to receive paper mill residuals, which it apparently did in the 1980s, according to Maine DEP records. Some industrial material of this sort is hypothesized to be the likely source of the anomalously high PFOS on the Farm's western field.[140]

The use of PFAS in paper and board can add to the contamination of feed, food and drinking water via environmental contribution. For example, a German study has shown that feed grown on farmland with paper mill sludge mixed into the "soil improver" did accumulate PFAS, and this was transferred to grazing cattle, to grain, and to pigs, hens, and their eggs after eating the contaminated feed[141]

Regulation of PFAS in pulp and paper mills and paper waste sludge in Canada

The management of pollution in Canada is a responsibility shared by the federal, provincial and territorial governments. ECCC has implemented a number of regulatory and non-regulatory actions related to the management of pulp and paper effluent but currently there is no regulation on the use and releases of PFAS in pulp and paper mills.

Pulp and paper mills are subject to the Pulp and Paper Effluent Regulations (PPER).[142] The regulations apply to all pulp and paper mills in Canada by setting national effluent quality standards. The purpose of the regulations is to manage threats to fish, fish habitat, and use of fish for consumption by limiting the deposit of deleterious substances into fish bearing waters from pulp and paper mills. The regulations set maximum quantities of the amounts of biochemical oxygen demand (BOD) matter and suspended solids that may be deposited by mills, and prohibit deposits of effluents that are acutely lethal to fish.

In addition to the PPER, mills are subject to the Pulp and Paper Mill Defoamer and Wood Chip Regulations and the Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations. The purpose of those Regulations is to prevent the formation of dioxins and furans and to limit the discharge of these substances from pulp and paper mills using a chlorine bleaching process. Finally, ECCC published the Guidelines for the Reduction of Dyes Released from Pulp and Paper Mills. These Guidelines apply to a mill that uses a dye called MAPBAP acetate. The Guidelines set out standards and good practices to observe in order to limit dye quantities released in the final effluent. ECCC also concluded a voluntary performance agreement in 2017 with paper recycling mills to minimize the risk of environmental impacts from their effluent releases of bisphenol A (BPA) to the greatest extent practicable.

There is no federal regulation that regulates PFAS in pulp and paper sludge.

In Ontario, pulp and paper mills must obtain Environmental Compliance Approvals (ECA) from the Ministry of the Environment, Conservation and Parks prior to operation. A preliminary review of waste disposal ECAs for Resolute paper mill, Thunder Bay found on the interactive map location in the Access Environment website, showed no requirement to monitor or report on PFAS use or emissions.[143]

The Ontario Environmental Protection Act (Ontario Regulation 760/93)[144] also sets out monitoring and effluent limits for the pulp and paper sector that require producers to monitor and control the quality of effluent discharged from the plants with a focus on Adsorbable Organic Halogens" (in this case the halogens chlorine, bromine and iodine) and 2, 3, 7, 8-tetrachlorodibenzo-para-dioxin. There are no requirements to monitor for PFAS.

Paper mills using PFASs may be a significant source of contamination to water and potentially to air and compost but there is no publicly available information about PFAS levels in paper mill sludge used in Canada. In a Freedom of Information Request obtained in 2018, by the US-based NGO Environmental Defense Fund, researchers discovered four Food Contact Substance Notifications (FCNs) submitted in 2009-2010 by two companies, Daikin America and Chemours to sell PFASs for paper and paperboard application in food packaging. All four assessments based their estimates on what they called a "typical" paper mill that produces 825 tons of PFAS-coated paper per day and discharges 26 million gallons of water per day.

Data on specific CAS numbers and Food Contact Notifications are available online.[145] The details below are worth listing for the amounts of wastewater discharge in ng/L (ppt).

- Chemours estimated 95 pounds/day of its PFAS in the wastewater discharge at 43,000 ppt.
- In a separate food contact notification for the same PFAS, Chemours increased the amount in paper from 0.42% to 0.8% resulting in 183 pounds per day in the wastewater discharge at 83,000 ppt.
- Daikin estimated 180 pounds/day of its PFAS in the wastewater discharge at 83,000 ppt.
- Daikin estimated 225 pounds/day of a similar PFAS in the wastewater discharge at 103,000 ppt.

The two companies also estimated that nine pounds of PFASs would end-up in biosolids for each pound released to water and that these materials would go to a sanitary landfill or be incinerated.

There are no environmental standards to compare this to in order to provide context for the Canadian situation. There are no standards for PFAS effluent in pulp mills and this should be integrated in all regulatory approvals.

Market and Policy trends:

PFAS-free alternatives exist for all food contact material applications other than the use of PFAS in molded paper board which is a current focus for alternatives assessment.[146]

The state of Washington has developed a state wide Chemical Action Plan on PFAS that includes proposed restrictions on PFAS use in AFFF and PFAS use in food packaging.[147]
San Francisco became the first city in the US to prohibit PFAS chemicals in single-use food service ware. This provision in the new law will become effective on January 1, 2020.[148]

Recommendations for Section 9:

The Government of Canada should:

- ***Work with regulatory authorities in the Great Lakes-St. Lawrence River Ecosystem should convene a dialogue with current certifiers of compostable FCM to better understand the presence of PFAS in specific compostable products. An assessment of current initiatives to restrict PFAS, including the Biodegradable Products Institute certification, will enhance awareness of health implications of potential PFAS exposure from compostable FCM with PFAS content as well as implications for compost use in agricultural and nonagricultural applications.***

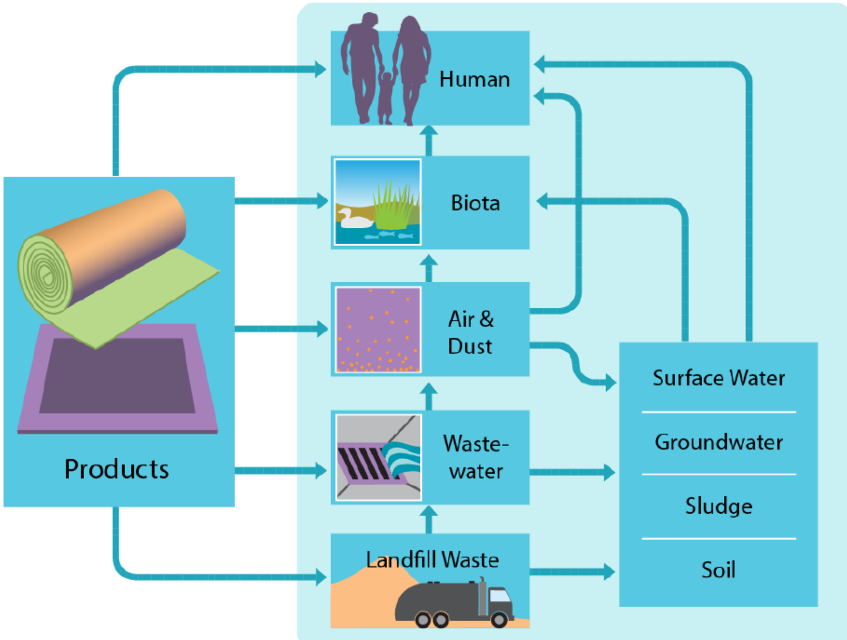
- ***Monitor for PFAS in recycled content. Paper that has been treated with PFAS and with no food contact contamination can be sent for paper recycling. Recycled paper can therefore be a source of PFAS release.***

- ***Assess levels of PFAS in compost in Canada and the contribution of FCM to PFAS load.***

- ***Assess the amount of PFAS being used and released by paper and pulp mills into the Great Lakes-St. Lawrence River Ecosystem, based on the sixteen PFAS monomers that were identified as relevant to PFAS FCM (personal communication with Environmental Defense in the US) and make this information publicly available.***

- ***Convene a taskforce of representatives from the food sector, consumers, public health bodies and packaging manufacturers to collect information on PFAS-free FCM and promote their use widely.***

Figure 1



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Measures to reduce or eliminate releases from stockpiles and wastes
1. In order to ensure that stockpiles consisting of or containing chemicals listed either in Annex A or Annex B and wastes, including products and articles upon becoming wastes, consisting of, containing or contaminated with a chemical listed in Annex A, B or C, are managed in a manner protective of human health and the environment, each Party shall:
(a) Develop appropriate strategies for identifying: (i) Stockpiles consisting of or containing chemicals listed either in Annex A or Annex B; and (ii) Products and articles in use and wastes consisting of, containing or contaminated with a chemical listed in Annex A, B or C;
(b) Identify, to the extent practicable, stockpiles consisting of or containing chemicals listed either in Annex A

PFAS are not labeled, thus it is difficult to identify products and articles in use and wastes consisting of, containing or contaminated with PFAS chemicals. In addition, information on current production volumes and past and present uses of PFOA, its salts and PFOA related compounds in different applications is limited.
Further, quantitative information on imported products containing PFOA and related compounds as well as information related to waste streams and recyclates containing or contaminated with those substances is missing. Based on the available information and data, it was not possible to investigate relevant waste streams in detail as it has been done for other substances under the SC.

Unless Low POPs Concentration Limit is defined for PFOA/PFOS in waste, waste containing PFAS should be safely handled, collected, transported and stored in an environmentally sound manner; as required by Article 6 of the Stockholm Convention. When defined, possible low POP concentration limits might implicate considerable changes in waste treatment, as some wastes will not be permissible for recycling or landfilling anymore but will inevitably have to be destroyed or irreversibly transformed using combustion or non-combustion technologies
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