Safer Alternatives to PFAS in Food Packaging

Second report to the Legislature pursuant to RCW 70A.222.070

Hazardous Waste and Toxics Reduction Program

Washington State Department of Ecology

Olympia, Washington

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State of Washington

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Related Information

- The first PFAS in Food Packaging Alternatives Assessment Report to the Legislature[1]
- The first PFAS in Food Packaging Alternatives Assessment[2]

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[1] https://apps.ecology.wa.gov/publications/summarypages/2104007.html
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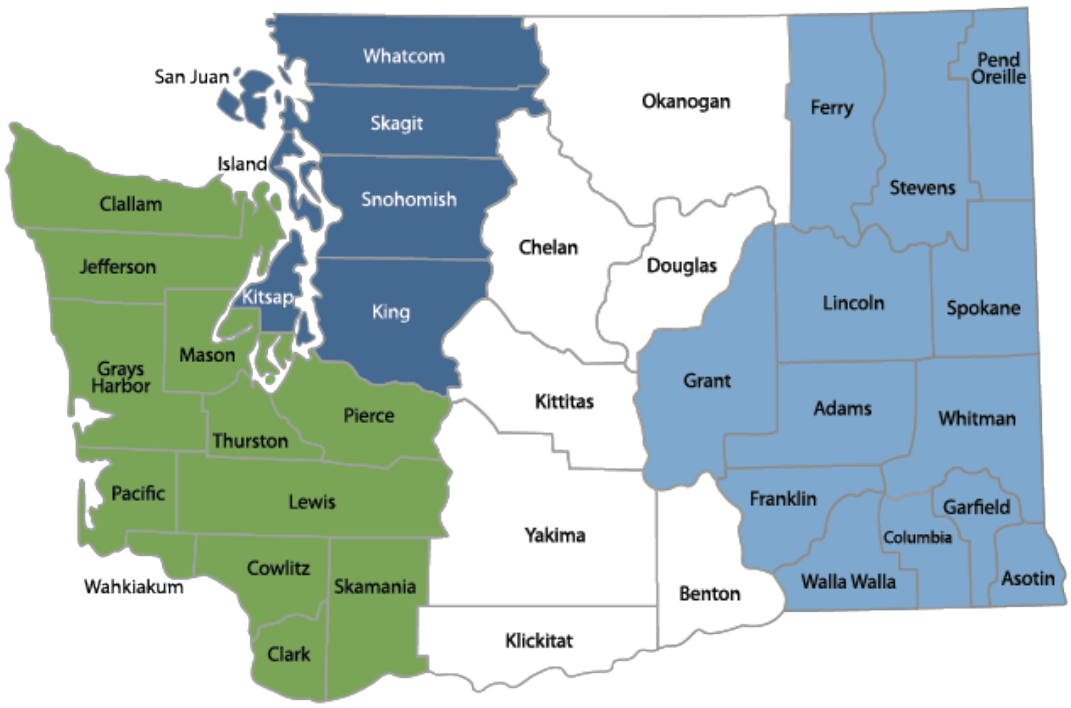

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Table of Contents

List of Tables

Executive Summary

As directed by Revised Code of Washington (RCW) 70A.222.070,[4] the Washington Department of Ecology (Ecology) conducted an alternatives assessment for various food packaging items containing intentionally added PFAS (per- and polyfluoroalkyl substances). This is the second alternatives assessment conducted by Ecology pursuant to RCW 70A.222.070.

PFAS are a class of substances that persist in the environment indefinitely, because there is no natural process that eliminates them. These substances can be toxic and are potentially linked to a variety of human health concerns, including increases in cholesterol levels, immune suppression, and lower birthweights. Some studies associate higher exposures with some cancers, such as testicular and kidney cancers.

Ecology previously submitted a legislative report in February 2021 describing an alternatives assessment that identified safer alternatives for four out of ten types of food packaging. In this second alternatives assessment, Ecology re-evaluated those six remaining alternatives to determine whether the results of the first alternatives assessment changed.

For some parts of the second assessment, Ecology updated methods used in the first assessment following an internal review of our methods and input from stakeholders. Ecology modified two elements of the assessment methodology.

First, we reorganized our concept of a "food packaging application" to focus on the function of the food packaging as opposed to a name. This allowed us to consider the various applications in five categories instead of six. Stakeholder input supported that this change was appropriate—a food boat holds French fries just as well as a container labeled "French fry container," and market information may be available for one but not the other. Food packaging that does the same job should be considered the same application.

Second, we relied on market availability and marketability to demonstrate cost and availability instead of a direct price comparison of final products. We made this change based on stakeholder input and a close review of the requirements in the Interstate Chemicals Clearinghouse (IC2) Alternatives Assessment Guide (IC2 Guide). We determined that in our first alternatives assessment, the strict ten percent price premium:

- Did not adequately address rapid price changes in the market.
- Did not give sufficient weight to consumer judgment. Consumers weigh a variety of factors when deciding whether they want to pay the asking price for a product. Food packaging products have a number of different factors that could warrant a price increase, not just the presence or absence of PFAS. Our initial approach assumed all cost increases were attributable to PFAS and did not account for other factors.

Find more information about our application of the IC2 Guide on price and availability in the relevant section below.

[4] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.222

Following the IC2 Guide, Ecology assessed the hazard, exposure, performance, and cost and availability of food packaging applications in five revised categories. Ecology evaluated 18 alternatives to PFAS, including both chemical and non-chemical options.

As directed by the statute, Ecology evaluated the hazard of each alternative and also assessed whether each alternative performed as well as the PFAS choice, whether the alternative was readily available, whether it was comparable in cost to the PFAS choice, and whether individuals or the environment were more likely to be exposed to the alternative compared to PFAS.

As part of the assessment, Ecology conducted a stakeholder involvement process that directly built on the process in the first alternatives assessment. Ecology sought input on a variety of issues, including:

- Project scoping, including categories of food packaging products and chemical and non-chemical alternatives to be evaluated.
- Information on substance identity and formulation for PFAS-free food packaging alternatives.
- Additional resources, areas of concern, and other issues requiring attention.

Ecology also engaged with stakeholders through interactive webinars and regular email updates about the process and status. Ecology invited comments from all stakeholders and created a dedicated eComments webpage[5] to simplify comment submission. Stakeholders can view all comments submitted on this comments page.

The Northeast Waste Management Official Association's Interstate Chemicals Clearinghouse assembled a committee to conduct a statutorily mandated peer review of the alternatives assessment. The peer reviewers all have expertise in at least one aspect of the review—including specialties in PFAS, alternatives assessments, and safer alternatives in food packaging. A summary of the peer review comments, Ecology's response, and the changes made accordingly are included in the Peer Review section of this report.

Conclusions

Ecology's second alternatives assessment identified less hazardous alternatives that are readily available at a comparable cost and that meet performance requirements for all five food packaging applications, as noted in Table 1.

[5] http://hwtr.ecology.commentinput.com/comment/extra?id=a8U4i

Table 1. Safer alternatives identified for specific food packaging applications.

Application	Safer alternatives	Total number identified
Bags and sleeves	Densified paper and wax-coated options	2
Bowls	Clay-coated, polylactic acid-coated, polylactic acid foam, and reusable options	4
Flat serviceware	Clay-coated, polylactic acid-coated, polylactic acid foam, and reusable options	4
Open-top containers	Clay-coated, densified paper, wax-coated, polylactic acid-coated, polylactic acid foam, aluminum, and reusable options	7
Closed containers	Clay-coated, polylactic acid-coated, polylactic acid foam, and aluminum options	4

Next steps

As specified in RCW 70A.222.070(5),[6] the prohibition against manufacturing, sale, and distribution of PFAS-containing food packaging in these five food packaging applications will take effect two years from the date of submission of this report to the Legislature.

Starting in 2022, Ecology will continue the alternatives assessment process. The findings of the first and second alternatives assessments cover food packaging used to hold, serve, and transport recently prepared food. Future alternatives assessments will focus on alternatives to PFAS in other types of food packaging, such as packaging used to store food for longer periods of time or designed to be used in the cooking process, such as microwavable popcorn bags.

Ecology expects to begin enforcing the restrictions on PFAS for the food packaging applications identified in the first alternatives assessment, published February 2021, starting in February 2023:

- Wraps and liners.
- Plates.
- Food boats.
- Pizza boxes.

Starting in 2024, Ecology expects to begin enforcing the restrictions on PFAS-containing food packaging for the five applications with safer alternatives outlined in this report.

We anticipate enforcement will involve working with manufacturers, distributors, wholesalers, and retailers to ensure they comply with the law, and assisting them in achieving compliance, if necessary. Ecology will also aim to engage stakeholders—including manufacturing associations, grocery and retail associations, hospitality organizations, environmental advocates, and end-users of affected products—to promote the adoption of safer alternatives in all food packaging.

[6] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.222.070

Introduction

What are PFAS and why are they a problem?

PFAS (per- and polyfluoroalkyl substances) are a family of over 4,700 synthetic organic chemicals. One of the many uses for some of these chemicals is to provide oil, grease, and water resistance for paper-based foodservice products. Currently, 19 specific PFAS chemicals are approved by the U.S. Food and Drug Administration (FDA) for use in plant-based food packaging (EDF, 2018a); (21 CFR 176.160[7] and 21 CFR 173.170[8]).

In Washington, people are exposed to PFAS through:

- The food they eat (including breastmilk).
- The water they drink and use to prepare food and beverages.
- Use of consumer products that contain PFAS.
- Workplaces that treat products with PFAS.
- Contaminated soil, indoor dust, and air.

Individuals are exposed to PFAS in food by "eating food that was packaged in material that contains PFAS" (CDC, 2020a).

Unfortunately, there is little toxicity or safety data for most of the commonly used PFAS chemicals, including those that are currently used in food packaging. The most well-characterized PFAS are associated with liver damage, increased cholesterol levels, thyroid problems, decreased antibody response to vaccines, increased risk of asthma, and problems with reproduction and development. Newer PFAS have even less toxicity or safety data available. But as we learn more about them, we see some similar health concerns, particularly related to increases in cholesterol levels, decreased antibody response to vaccines, and liver damage (CDC, 2018).

Once they enter the environment, PFAS chemicals persist for a long time. No natural processes can break down these substances. Even after they are phased out of consumer and other products, these "forever chemicals" will continue to cause exposures for many decades.

[7] https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=176.160
[8] https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=176.170

Legislation

In 2018, the Legislature adopted Substitute House Bill 2658, subsequently codified at RCW 70A.222.070.[9] This legislation provides that, beginning January 1, 2022, "no person may manufacture, knowingly sell, offer for sale, distribute for sale, or distribute for use in this state food packaging to which PFAS chemicals have been intentionally added in any amount."

In order for the prohibition to take effect:

1. Ecology must conduct a peer-reviewed alternatives assessment, following the guidelines issued by the Interstate Chemicals Clearinghouse (IC2). The assessment must evaluate chemical hazards, exposure, performance, cost, and availability.
2. Ecology must use the results of the alternatives assessment to determine that less hazardous alternatives are readily available in sufficient quantity and at a comparable cost, and that they perform as well or better than PFAS chemicals in a specific food packaging application. Options that meet all these criteria are considered safer alternatives.
3. Ecology must publish findings in the Washington State Register on whether safer alternatives are available for each assessed food packaging application.
4. Ecology must submit to the appropriate committees of the Legislature a report with its findings and the feedback from a peer review of the alternatives assessment.

The legislation also provides that if Ecology does not determine safer alternatives are available by January 1, 2020, the prohibitions would not take effect January 1, 2022. Ecology must then annually review and report on alternatives for food packaging applications until safer alternatives are identified.

Ecology submitted its first report in February of 2021. Because we identified no safer alternatives for some food packaging applications, we reassessed alternatives for those applications in this report (with revised categories based on function). Based on our findings of safer alternatives, the sale of specified PFAS-containing food packaging applications will be prohibited beginning in 2024, two years from the date this report is submitted to the Legislature, in accordance with RCW 70A.222.070(5).

[9] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070

Food packaging market

RCW 70A.222.010(4)[10] defines a food package as "a package or packaging component that is intended for direct food contact and is comprised, in substantial part, of paper, paperboard, or other materials originally derived from plant fibers." This definition includes items used to enclose food (such as bags or takeout boxes) and items used to consume food (such as bowls or trays). These products are also collectively referred to as foodservice items. Common materials used to manufacture single-use foodservice items are plant-based fibers, plastics, and aluminum.

There are currently 19 different PFAS chemicals approved by the FDA for use in food packaging products. However, some nongovernmental organizations have challenged safety determinations for these substances. A number of challenges to specific PFAS chemicals led to FDA actions to remove approval for some PFAS uses in food contact materials. In 2016, the FDA revoked approval for three PFAS previously used in paper and paperboard food packaging (Nelter, 2016). In 2020, the FDA announced the voluntary phase-out of additional PFAS-containing chemicals used in food packaging due to potential health risks (FDA, 2020).

IC2 Alternatives Assessment Guide

An alternatives assessment is "a process for identifying, comparing and selecting safer alternatives to chemicals of concern (including those in materials, processes, or technologies) on the basis of their hazards, performance, and economic viability" (BizNGO, 2020).

The IC2 is a program of the Northeast Waste Management Officials' Association (NEWMOA), which provides management and staff support for IC2 and serves as its fiscal agent (IC2, 2014). Washington state is a member of IC2.

IC2 developed and published its first Alternatives Assessment Guide (the IC2 Guide) in 2014. The IC2 Guide was updated (Version 1.1) and re-released in 2017 (IC2, 2017). As directed in the legislation, Ecology followed the guidelines in Version 1.1 to complete the alternatives assessment.

[10] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.010

Alternatives assessment modules

The IC2 Guide involves the following distinct steps:

1. **Identify the chemical of concern:** The underlying legislation identified "PFAS" as the subject of the alternatives assessment. Ecology prioritized using information from well-studied PFAS when possible. This approach ensures we don't assume a PFAS is safer just because it hasn't been studied and its dangers aren't identified.
2. **Initial evaluation:** Ecology did not complete this module (used to determine whether an alternatives assessment is needed) because the alternatives assessment is required by statute.
3. **Scoping stakeholder involvement:** This module determines the degree of stakeholder involvement needed. Ecology used a robust stakeholder involvement process to identify and address concerns from interested parties. A more detailed explanation about our stakeholder involvement process is provided below.
4. **Identification of alternatives:** Ecology considered a variety of possible alternatives, including non-PFAS chemicals and reusable options. Some alternatives we evaluated in the first alternatives assessment, but we also added new alternatives based on stakeholder input. You can find more detail about this below.
5. **Evaluate alternatives:** Like the first alternatives assessment, Ecology used the IC2 Guide's four assessment modules to evaluate possible alternatives:
    - Hazard—used to determine what hazards exist for the chemical of concern and how they compare to potential alternatives.
    - Performance evaluation—used to ensure the alternatives under consideration meet the necessary performance requirements.
    - Cost and availability—used to evaluate whether alternatives are cost competitive and whether they are available in sufficient quantity.
    - Exposure assessment—used to determine if alternatives pose a greater exposure risk to human health and the environment.

We explain the results of each of these modules in more detail below.

Alternatives assessment framework

The IC2 Guide provides three possible frameworks for conducting an alternatives assessment:

- **Sequential framework**: Data is collected and evaluated one module at a time, in order, and only potential favorable alternatives continue through the process. Unfavorable alternatives are "screened out" and may not be evaluated in all modules.
- **Simultaneous framework**: Data from all modules are evaluated at the same time for all potential alternatives.
- **Hybrid framework**: Hazard and/or performance evaluation modules are performed sequentially, eliminating unfavorable alternatives. The remaining modules are then reviewed simultaneously.

For this assessment, Ecology selected a hybrid framework because it provided substantial information for decision-making and eliminated the need to further analyze alternatives that are not less hazardous than PFAS. We determined this approach allowed for the most efficient and productive use of available resources.

Ecology's Alternatives Assessment Process

Ecology conducted the second PFAS in food packaging alternatives assessment in partnership with the Washington Department of Health from February 2021 to September 2021. The IC2 Guide and stakeholder feedback were key resources that supplemented Ecology's research and requests for information from chemical and product manufacturers.

Stakeholder involvement

Ecology built on the Level 2 stakeholder process that was initiated during the first alternatives assessment, conducted from May 2018 to August 2020. A Level 2 process directs Ecology to:

- Identify potential stakeholders, such as chemical manufacturers, product manufacturers, retailers, end-users, consumers, environmental advocates, and waste, composting, or recycling companies.
- Identify potential stakeholder concerns.
- Address or mitigate stakeholder concerns when possible or document the reasons if not possible.
- Incorporate stakeholder concerns into the decision-making process and document how that is done.
- Determine if stakeholder concerns are serious enough to identify an alternative as unfavorable.

With this in mind, Ecology sought stakeholder input on key items, such as:

- Project scoping, including definitions of food packaging products and specific alternatives that would be evaluated.
- Evaluation methodologies derived from the IC2 Guide and used in the first alternatives assessment.
- Information on substance identity and formulation for PFAS-free food packaging alternatives.

Ecology engaged stakeholders through regular emails, updates to the PFAS in Food Packaging Alternatives Assessment webpage,[11] and informational webinars. Ecology invited stakeholders to provide feedback—both on the methods used in the first alternatives assessment and the project scope for the second alternatives assessment—using a dedicated eComments webpage to gather electronic comments.[12]

Whenever feasible, we incorporated stakeholder feedback into our work. For example, stakeholders expressed concern that the definitions Ecology used to describe types of food packaging in the first assessment did not reflect how food packaging is actually used in food service. This feedback prompted us to revise our definitions to group food packaging by function.

[11] https://www.ezview.wa.gov/site/alias__1962/37610/pfas_in_food_packaging_alternatives_assessment.aspx
[12] http://hwtr.ecology.commentinput.com/?id=a8U4i

Food packaging assessment scope

Pursuant to 70A.222.070(5), Ecology used this alternatives assessment to re-evaluate alternatives to PFAS for those types of food packaging where no safer alternatives were identified in the first alternatives assessment. As part of the re-evaluation, Ecology revised how types of food packaging were grouped together to define food packaging applications.

In the previous assessment, we defined food packaging applications as groups of food packaging items with similar structures, used to hold food in a similar way (i.e., a clamshell is a hinged container with a built-in closure, such as a tab that keeps the lid secure during transport). In the first alternatives assessment, we did not identify safer alternatives for six food packaging applications:

- Bags and sleeves.
- Bowls.
- Trays.
- French fry cartons.
- Clamshells.
- Interlocking folded containers.

Ecology received stakeholder feedback that we should revise the food packaging applications in the first alternatives assessment. We agreed with stakeholders who shared that categorizing food packaging items both by their structure and how they are used to hold food ignores how items that hold food in a similar way are often used interchangeably, regardless of structural similarity. For example, clamshells and interlocking folded containers are used interchangeably to hold food for transport.

Consequently, we defined food packaging applications using their function. Items used to hold food in a similar way are grouped into one application. In this alternatives assessment, we reviewed alternatives for five types of food packaging products:

- Bags and sleeves.
- Bowls.
- Flat serviceware (which includes items like plates or trays).
- Open-top containers (which includes items like French fry containers or food cups).
- Closed containers (which includes items like clamshells).

Like the first alternatives assessment, Ecology only considered food packaging products intended for short-term storage or for holding freshly prepared food.

Consideration of PFAS in this alternatives assessment

In this alternatives assessment, Ecology assessed PFAS as a group rather than identifying a specific PFAS to represent the class. This change incorporates stakeholder feedback, and aligns the PFAS in food packaging alternatives assessment process more closely with similar work Ecology is completing as part of the Safer Products for Washington program (Chapter 70A.350 RCW[13]).

This change did not materially impact how information about PFAS was used for most of the alternatives assessment, with the exception of the chemical hazard evaluation. In that section, we collected publicly available information for all well-studied PFAS and used it to determine the expected chemical hazards for PFAS as a group of similar substances. We also used this information to determine what evidence would be required to demonstrate an alternative was less hazardous than this group of substances.

Alternative options reviewed

As in the first alternatives assessment, Ecology compiled an initial inventory of possible alternatives through stakeholder feedback and by researching PFAS-free products. Ecology prioritized the possible alternatives, giving preference to materials and substances that:

- Are used in many types of food packaging.
- Were previously identified as being of low hazard concern.
- Have a larger market share.

The scope of Ecology's assessment is based on input from stakeholders and research about alternative chemicals and materials that are already established and readily available in the marketplace. We focused our review on products that have been tested for PFAS.

The alternatives we evaluated in the first alternatives assessment are again considered in this assessment. These include non-chemical alternatives, chemical alternatives, and system alternatives like reusable products. The chemical alternatives were all alternative coatings that could be applied to paper or other fiber-based materials or used to make a plastic material instead of using paper, including:

- Bio-based plastics such as polylactic acid (PLA).
- Waxes such as beeswax or petroleum-based waxes.
- Clay-based coatings.
- Silicones and plastics, such as polyvinyl alcohols (PVOH and EVOH), and polyethylene terephthalate (PET).

Some bioplastic and plastic chemical alternatives could be used either to coat plant fiber materials or as a material that replaces plant fibers. Each chemical alternative was evaluated as multiple alternatives, one for each possible use.

[13] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350

In response to stakeholder feedback after the first assessment, Ecology added five plastic alternatives that are commonly used to make food packaging products:

- Low density polyethylene (LDPE).
- Linear low density polyethylene (PE).
- High density PE.
- Polypropylene (PP).
- PP-Talc mixtures.

Ecology also considered aluminum as a chemical alternative. In total, Ecology assessed 18 alternatives to PFAS in this alternatives assessment.

Chemical hazard evaluation

The goal of the hazard evaluation module in the alternatives assessment is to determine the hazard associated with potential alternatives and identify those alternatives that are less hazardous than PFAS. Like the first alternatives assessment, Ecology used the strategy described in the Level 2 Hazard Module.

Chemical hazard evaluation tools

A Level 2 evaluation uses GreenScreen®,[14] a freely available tool to assess and compare the human or environment health hazards of different substances. Ecology also identified two additional tools, Scivera GHS+[15] and ChemFORWARD,[16] which assess chemicals for the same health hazards and can be used to compare substances that have been evaluated using GreenScreen®.

GreenScreen® evaluations assign chemicals a score ranging from a low of "Benchmark-1" to a high of "Benchmark-4." At the low end of the scale, a Benchmark-1 indicates the available evidence demonstrates the substance poses a hazard to human health or the environment. In contrast, a score of Benchmark-4 indicates there is sufficient evidence to demonstrate the substance does not pose a hazard to human health or the environment. A chemical may also receive a score of Benchmark-2 or -3, which indicates the available evidence shows the substance poses a reduced hazard than a Benchmark-1 substance, but more hazard than a Benchmark-4 substance.

We did not use these evaluation tools for low hazard concern substances on EPA's Safer Chemicals Ingredients List (SCIL) that meet the Safer Choice criteria (USEPA, 2020). The other chemical hazard evaluation tools and SCIL assessments use similar criteria and data. Ecology determined that it was unnecessary to conduct full hazard assessments on SCIL alternatives because an authoritative body already deemed them to be of low hazard concern.

[14] https://www.greenscreenchemicals.org/learn/what-is-greenscreen
[15] https://www.scivera.com/ghsplus/
[16] https://www.chemforward.org/our-approach

Chemical hazard evaluation of PFAS

Ecology reviewed publicly available GreenScreen® evaluations for PFAS and used them to determine what information would be needed to evaluate whether an alternative is less hazardous than PFAS.

We found 14 publicly available evaluations for PFAS substances, all of which scored the subject PFAS substance Benchmark-1 or very likely Benchmark-1 (when hazards are known but no formal chemical hazard evaluation has been done). These substances were all highly persistent and demonstrated many of the human health and environmental concerns highlighted above. Based on this review, Ecology determined that only alternatives that were lower-hazard substances—those with a score of Benchmark-2, Benchmark-3, or Benchmark-4 in a hazard evaluation—would be considered less hazardous than PFAS.

Low-hazard substances

For this assessment, the following alternatives were listed on the SCIL as low-hazard substances (designated on SCIL with a green circle):

- Cellulose and cellulose pulp (paper, which is used two make two of the alternatives we evaluated).
- Petroleum wax.
- Bio-based wax.
- Substances that are used to make clay coatings.
- PVOH.

Ecology determined these substances are less hazardous chemical and non-chemical alternatives to PFAS.

Hazard evaluation tool results

Ecology reviewed ten substances that could be used to make 12 alternatives using either GreenScreen® or Scivera GHS+ evaluations. When using a Scivera GHS+ evaluation, Ecology converted the results of the evaluation to the corresponding GreenScreen® Benchmark score. This facilitated comparisons between substances. Table 2 summarizes the results of each assessment.

Polyethylene alternatives come in three types: low density, linear low density, and high density. Because these substances are made using different methods, they were evaluated separately. PLA can be used to make three alternatives – because the same method is used, they were evaluated as a single substance.

Table 2. Alternative substances hazard assessment results.

Item	CASRN	Approach	Hazard Assessment Result
Siloxanes*	68083-19-2	Evaluated using GreenScreen® in first alternatives assessment	Benchmark-1: Avoid – Chemical of High Concern
PET^	25038-59-9	Evaluated using GreenScreen®	Consistent with Benchmark-1: Avoid – Chemical of High Concern
PP-Talc mixture	9003-07-0, 14807-96-6	Evaluated using GreenScreen®	Consistent with Benchmark-1: Avoid – Chemical of High Concern
PP^	9003-07-0	Evaluated using GreenScreen® and Scivera GHS+	Consistent with Benchmark-2: Use but Search for Safer Substitutes
Aluminum~	1344-28-1	Evaluated using GreenScreen® and Scivera GHS+	Consistent with Benchmark-2: Use but Search for Safer Substitutes
LDPE^	9002-88-4	Evaluated using GreenScreen® and Scivera GHS+	Consistent with Benchmark-2: Use but Search for Safer Substitutes
Linear low density PE^	9002-88-4	Insufficient information was available to evaluate using a chemical hazard evaluation tool	Insufficient information provided to Ecology to allow a conclusion
High density PE^	9002-88-4	Insufficient information was available to evaluate using a chemical hazard evaluation tool	Insufficient information provided to Ecology to allow a conclusion
PLA^	9051-89-2	Evaluated using GreenScreen® in first alternatives assessment	Consistent with Benchmark-3: Use but Still Opportunity for Improvement
EVOH	26221-27-2	Evaluated using GreenScreen®	Benchmark-3: Use but Still Opportunity for Improvement

Table notes:

- * indicates the substance was assessed using vinyl silicone polymer.
- ^ indicates the substance was assessed using residual chemicals and breakdown products.
- ~ indicates the substance was assessed using aluminum oxide.

Ecology determined that of the ten alternative substances evaluated, five were less hazardous than PFAS. Of the remaining five, three alternative substances—siloxanes, PET, and PP-talc mixtures—were Benchmark-1 substances, which are not less hazardous than PFAS. We could not evaluate the other two—linear low density PE and high density PE—because we did not have enough information. Following the hybrid decision framework, Ecology did not evaluate these five alternative substances further in this alternatives assessment.

Exposure evaluation

The exposure evaluation module in the alternatives assessment is used to determine whether risk is reduced even if exposure levels increase. Like the first alternatives assessment, Ecology used the strategy described in the Level 1 Basic Comparative Exposure Evaluation.

Preliminary screening results

The IC2 Guide does not require an exposure evaluation if the hazard evaluation identified an alternative as either much safer or too hazardous to be considered a viable alternative. Table 3 lists seven substances we identified as much safer ("low hazard concern"). As noted above, Ecology's use of a hybrid review framework means we did not evaluate exposure for the three Benchmark-1 substances and the two substances lacking enough information to undergo the hazard evaluation.

Table 3. Alternative substances that did not require exposure assessments.*

Item	CASRN	Hazard Concern	Exposure Assessment
Untreated or densified paper	N/A	Non-chemical alternative – low concern	Low hazard concern – no exposure assessment required
Petroleum-based waxes	Various	U.S. EPA Safer Chemical – low concern	Low hazard concern – no exposure assessment required
Bio-based waxes	Various	U.S. EPA Safer Chemical – low concern	Low hazard concern – no exposure assessment required
Kaolin clay	1332-58-7	U.S. EPA Safer Chemical – low concern	Low hazard concern – no exposure assessment required
PVOH	9002-89-5 and 25213-24-5	U.S. EPA Safer Chemical – low concern	Low hazard concern – no exposure assessment required
EVOH	26221-27-2	Benchmark-3: Use but Still Opportunity for Improvement	Low hazard concern – no exposure assessment required
PLA^	9051-89-2	Consistent with Benchmark-3: Use but Still Opportunity for Improvement	Low hazard concern – no exposure assessment required

Table notes:

- * indicates two of these alternative substances are used to make multiple alternatives. Paper pulp is used to make untreated paper or densified paper, and PLA is used to PLA-coatings, PLA foam, and rigid PLA.
- ^ indicates the substance was assessed using residual chemicals and breakdown products.

Comparing exposure potential of PFAS and alternatives

For substances that were neither "low concern" nor eliminated in the hazard module, Ecology did a basic exposure evaluation. A basic exposure evaluation uses information about how the substances are expected to behave under normal conditions of use. This allowed Ecology to determine if there are substantial differences in the degree to which humans or the environment will be exposed to the substances in the food packaging. If an alternative has a similar or lower exposure potential than PFAS, it is a favorable alternative.

Ecology did an exposure evaluation for three alternative substances: aluminum, PP, and low density PE. We collected information about the properties of each alternative and two well-studied PFAS substances previously identified in food packaging.

All substances, including PFAS, can contaminate food or beverages during use, and can also contaminate the environment when disposed of. Additionally, unlike PFAS or aluminum, LDPE and PP are capable of producing microplastics as they age. These extremely small pieces of plastic increase exposures to LDPE and PP and may also increase exposure to other environmental pollutants. However, we currently do not know how hazardous microplastics are, nor how likely single-use LDPE and PP products are to create them.

Since the properties of aluminum do not differ from PFAS in a way that would change the exposure risk, we determined that aluminum has a similar exposure potential compared to PFAS (Table 4). The potential for LDPE and PP to generate microplastics is an additional way for the two substances to interact with the environment that is not currently well understood. Therefore, we determined there is not enough information to evaluate the exposure potential of LDPE and PP in this assessment (Table 4).

In summary, all alternative substances evaluated for exposure potential in this assessment were either favorable, or there was not enough information at this time to complete the exposure evaluation.

Table 4. Alternative substances comparative exposure evaluation results.

Item	CASRN	Approach	Exposure Assessment
LDPE	9002-88-4	Comparative exposure assessment	Insufficient information available to Ecology to allow a conclusion
PP	9003-07-0	Comparative exposure assessment	Insufficient information available to Ecology to allow a conclusion
Aluminum	1344-28-1	Comparative exposure assessment	Similar exposure potential-favorable

Performance evaluation

The performance evaluation module aims to determine whether potential alternatives meet the functional needs of a product. This evaluation did not consider secondary performance characteristics, such as the visual appearance of the product or the disposal methods for the product. Like the first alternatives assessment, we used the strategy described in the Level 1 Basic Performance Evaluation.

Performance specifications

Ecology used questions derived from the IC2 Guide to determine if the alternative substances being evaluated can be used to make products that meet the Level 1 performance standards:

1. Is the alternative being used for the same or a similar function?
2. Is the alternative available on the commercial market?
3. Do promotional materials state the alternative provides the desired function?

If the answer to each of these three questions is "yes," the substance is determined to be favorable. In cases where the answer to one of these questions is "no," the IC2 Guide provides additional lines of inquiry for determining whether alternatives meet the relevant performance specifications.

To determine if alternative substances meet performance requirements, Ecology compiled an inventory of alternative products and reviewed associated promotional and marketing material. Ecology evaluated whether alternative products claimed to provide oil and grease resistance and, where applicable, leak resistance. Key phrases in promotional materials that indicated performance standards included:

- Greaseproof.
- Oil and/or grease resistance or OGR.
- References to Kit Test levels or penetration rates.
- Non-stick.
- Moisture resistance.
- Leak resistance.
- References to wet strength.
- Products advertised as soup bowls or soup cups (where leak resistance would be vital).

For most alternatives, further inquiries were unnecessary. Except as noted below, all the alternatives evaluated in this assessment met the performance standards.

Performance results

Detailed answers for each alternative are presented in the full alternatives assessment.[17] Ecology identified promotional information or expert opinion for most of the possible alternatives that confirm each as having oil and grease resistance and, where applicable, leak resistance.

Ecology could not identify performance information for untreated paper indicating it met requirements. In the first alternatives assessment, we assessed uncoated paper as a single non-chemical alternative. In this alternatives assessment, it is divided into untreated paper, which has not been specially manufactured to increase oil and grease resistance, and densified paper, which has been physically treated to enhance resistance to oil and moisture.

Ecology also determined that clear plastic PLA performs as well as PFAS when used to package cold or room temperature foods, but not hot foods. We therefore determined that this type of PLA alternative would only be favorable for some uses.

Ecology concluded that all other alternatives met performance requirements.

Cost and availability evaluation

The cost and availability module determines if candidate alternatives that seem feasible are actually cost prohibitive or unavailable, rendering them unfavorable options. Ecology used the strategy described in the Level 1 Basic Cost and Availability Evaluation. We determined that a Level 1 evaluation—which asks a few basic questions about whether an alternative is used in cost competitive products for the application of interest—is sufficient to address the requirement in RCW 70A.222.070(3)[18] that safer alternatives be "readily available in sufficient quantity and at a comparable cost."

Cost and availability specifications

In the first alternatives assessment, Ecology conducted a Level 1 Basic Cost and Availability Evaluation. We developed methods that would allow us to determine if alternatives were readily available and cost comparable for the end-users of those food packaging products. This method was difficult to implement, and stakeholders expressed concern that it poorly reflects a market where food packaging prices change rapidly and are inconsistent among purchasers. Whatever price information Ecology could obtain would be out-of-date by the time any analysis was completed.

Stakeholders were also concerned that Ecology's original method did not account for manufacturers rapidly moving away from PFAS to meet end-user demand. This approach did not give sufficient weight to consumer judgment and did not acknowledge that purchasers might base purchasing decisions on something other than the presence or absence of PFAS in the final product (such as perception of quality, durability, or disposal options). The fact that a

[17] https://apps.ecology.wa.gov/publications/summarypages/2204007.html
[18] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.222.070

product is PFAS-free may account for a small portion of the total cost, and may or may not be relevant to any higher final price.

Our initial methodology did not account for this and instead attributed the entire cost differential to the presence or absence of PFAS in the product. In this second alternatives assessment, we updated our methods to focus on whether alternative substances were readily available and cost comparable for manufacturers who make food packaging products. This change removes price differentials attributable to other factors and more closely aligns with the IC2 Guide.

Following the rationale in the Level 1 evaluation, manufacturers using a less hazardous alternative in food packaging products is sufficient evidence that the alternative is both available to manufacturers and can be used in products in a manner that is cost competitive with PFAS.

To make this determination, we looked at the alternative substances manufacturers use in place of PFAS in the food packaging applications under investigation. We also continued to look for reports or other evidence of industry concerns about the supply of any alternative substances. We presume that a lack of reports or other information about shortages or concerns about availability means the alternative is readily available to manufacturers.

Cost and availability results

Ecology did not find any evidence of alternative substance supply shortages or other potential events affecting the availability of these materials for food packaging manufacture. This was a change from our previous alternatives assessment, in which evidence indicated potential issues with the supply of PLA. However, new information indicates that PLA supply is increasing, and that supply concerns should no longer affect the availability of PLA as an alternative substance for food packaging products.

For each food packaging application under assessment, we collected information on example products that 1) represent one of the five food packaging applications under evaluation and 2) use an alternative that is less hazardous than PFAS. For each food packaging application, we then had a list of alternative substances that manufacturers use instead of PFAS. We determined these substances are available and cost comparable.

Ecology found available and cost competitive options in each of the five main applications of food packaging under evaluation (bags and sleeves, bowls, flat serviceware, open-top containers, and closed containers).

Favorable alternative substances used in bags and sleeves:

- Densified paper
- Untreated paper
- Wax-coated paper

We did not identify reusable bags and sleeves as an available and cost comparable option.

Favorable alternative substances used in bowls:

- Clay-coated paper
- LDPE-coated paper
- PLA foam
- PLA-coated paper
- Rigid PLA
- Rigid PP
- Wax-coated paper, when used in portion cups for condiments

Additionally, we identified reusable bowls as an available and cost comparable option for some end-users.

Favorable alternative substances used in flat serviceware:

- Clay-coated paper
- PLA foam
- PLA-coated paper
- Rigid PLA
- Untreated paper

Additionally, we identified reusable plates and trays as an available and cost comparable option for some end-users.

Favorable alternative substances used in open-top containers:

Open-top containers can also include food packaging products that would otherwise be categorized as examples of bowls or bags, since the food items packaged in open-top containers could also be placed in bowls or bags. Therefore, alternative substances we identified in example bag and sleeve or bowl products are also available and cost competitive alternatives for open-top containers.

- Aluminum
- Clay-coated paper
- Densified paper
- LDPE-coated paper
- PLA foam
- PLA-coated paper
- Rigid PLA
- Rigid PP
- Wax-coated paper

Additionally, we identified reusable food boats or bowls as an available and cost comparable option for some end-users.

Favorable alternative substances used in closed containers:

Some bowls or open-top containers can function as closed containers when fitted with an appropriate lid. Therefore, certain example bowl or open-top products are also included.

- Aluminum
- Clay-coated paper
- LDPE-coated paper
- PLA foam
- PLA-coated paper
- Rigid PLA
- Rigid PP

We did not identify reusable closed containers as an available and cost comparable option.

For certain alternative substances, we did not identify examples of manufacturers using the alternative in relevant food packaging products. This could mean either these alternatives are not currently available and cost competitive in these five applications, or that they are used in relevant products but not advertised as such. We concluded these alternatives have insufficient information for this assessment module.

Ecology Findings and Determination

For each food packaging application, Ecology assessed each alternative separately to determine whether it met the criteria for a safer alternative. To be considered safer, the alternative:

- Must be less hazardous than the chemical of concern according to the hazard evaluation.
- Must have a similar or lower exposure risk than the chemical of concern or be sufficiently less hazardous according to the exposure evaluation.
- Must perform as well or better than PFAS according to the performance evaluation.
- Must be readily available in sufficient quantity according to the cost and availability evaluation.
- Must be cost comparable with similar PFAS-containing products according to the cost and availability evaluation.

The alternative substances listed below do not include those that failed to meet the hazard criterion, either because they were not less hazardous than PFAS (siloxanes, PET, and PP-talc mixture), or because there was not enough information to evaluate the alternative in the hazard module (linear low density PE, high density PE).

Based on results of the four evaluations (hazard, exposure, performance, and cost and availability), Ecology made one of the following findings for each alternative:

- Yes, this is a safer alternative that meets all five criteria.
- Yes, this is a safer alternative that meets all five criteria for some but not all users (such as a food truck not having the cleaning equipment to accommodate reusable options).
- No, this is not a safer alternative, failing to meet at least one criterion.
- Ecology does not have sufficient data to reach a conclusion for at least one criterion.

Food packaging application: Bags and sleeves

Ecology evaluated 13 possible alternatives for bags and sleeves and reached the conclusions in Table 5.

Table 5. Summary of assessment modules outcomes for bags and sleeves.

Alternative substance	Hazard module	Exposure module	Performance module	Cost & availability	Safer alternative?
Untreated paper	Low concern – Favorable	Not applicable	Not favorable	Favorable	No
Densified paper	Low concern – Favorable	Not applicable	Favorable	Favorable	Yes
Wax-coated	Low concern – Favorable	Not applicable	Favorable	Favorable	Yes
Clay-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient information	Insufficient information
PVOH-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient information	Insufficient information
EVOH-coated	BM 3 – Favorable	Not applicable	Favorable	Insufficient information	Insufficient information
LDPE-coated	BM 2 – Favorable	Insufficient information	Favorable	Insufficient information	Insufficient information
PLA-coated	BM 3 – Favorable	Not applicable	Favorable	Insufficient information	Insufficient information
PLA Foam	BM 3 – Favorable	Not applicable	Favorable	Insufficient information	Insufficient information
Rigid PLA	BM 3 – Favorable	Not applicable	Favorable for some uses	Insufficient information	Insufficient information
Rigid PP	BM 2 – Favorable	Insufficient information	Favorable	Insufficient information	Insufficient information
Aluminum	BM 2 – Favorable	Favorable	Favorable	Insufficient information	Insufficient information
Reusable bags	Not applicable	Not applicable	Not applicable	Not favorable	No

Findings

Ecology determined there are at least two safer alternatives that are readily available in sufficient quantity, at a comparable cost, and that perform as well or better than PFAS-coated bags and sleeves.

One alternative fails to meet the performance criterion and is not considered safer.

Another alternative currently fails to meet the cost and availability criteria, so is not a safer alternative at this time.

Ecology had insufficient information to reach conclusions on nine other alternatives.

Food packaging application: Bowls

Ecology evaluated 13 possible alternatives for bowls and reached the conclusions in Table 6.

Table 6. Summary of assessment modules outcomes for bowls.

Alternative substance	Hazard module	Exposure module	Performance module	Cost & availability	Safer alternative?
Untreated paper	Low concern – Favorable	Not applicable	Not favorable	Insufficient information	No
Densified paper	Low concern – Favorable	Not applicable	Favorable	Insufficient information	Insufficient information
Wax-coated	Low concern – Favorable	Not applicable	Favorable	Favorable for some uses	Yes for some users
Clay-coated	Low concern – Favorable	Not applicable	Favorable	Favorable	Yes
PVOH-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient information	Insufficient information
EVOH-coated	BM 3 – Favorable	Not applicable	Favorable	Insufficient information	Insufficient information
LDPE-coated	BM 2 – Favorable	Insufficient information	Favorable	Favorable	Insufficient information
PLA-coated	BM 3 – Favorable	Not applicable	Favorable	Favorable	Yes
PLA Foam	BM 3 – Favorable	Not applicable	Favorable	Favorable	Yes
Rigid PLA	BM 3 – Favorable	Not applicable	Favorable for some uses	Favorable	Yes for some users
Rigid PP	BM 2 – Favorable	Insufficient information	Favorable	Favorable	Insufficient information
Aluminum	BM 2 – Favorable	Favorable	Favorable	Insufficient information	Insufficient information
Reusable bowls	Not applicable	Not applicable	Not applicable	Yes for some end-users	Yes for some users

Findings

Ecology determined there are at least three safer alternatives that are readily available in sufficient quantity, at a comparable cost, and that perform as well or better than PFAS-coated bowls.

Another three alternatives are readily available and at comparable cost to some users, or meet the performance requirements for some users.

One alternative failed to meet the performance criterion and is not considered safer.

Ecology had insufficient information to reach conclusions on six other alternatives.

Food packaging application: Flat serviceware

Ecology evaluated 13 possible alternatives for flat serviceware and reached the conclusions in Table 7.

Table 7. Summary of assessment modules outcomes for flat serviceware.

Alternative substance	Hazard module	Exposure module	Performance module	Cost & availability	Safer alternative?
Untreated paper	Low concern – Favorable	Not applicable	Not favorable	Favorable	No
Densified paper	Low concern – Favorable	Not applicable	Favorable	Insufficient information	Insufficient information
Wax-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient information	Insufficient information
Clay-coated	Low concern – Favorable	Not applicable	Favorable	Favorable	Yes
PVOH-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient information	Insufficient information
EVOH-coated	BM 3 – Favorable	Not applicable	Favorable	Insufficient information	Insufficient information
LDPE-coated	BM 2 – Favorable	Insufficient information	Favorable	Insufficient information	Insufficient information
PLA-coated	BM 3 – Favorable	Not applicable	Favorable	Favorable	Yes
PLA Foam	BM 3 – Favorable	Not applicable	Favorable	Favorable	Yes
Rigid PLA	BM 3 – Favorable	Not applicable	Favorable for some uses	Favorable	Yes for some uses
Rigid PP	BM 2 – Favorable	Insufficient information	Favorable	Insufficient information	Insufficient information
Aluminum	BM 2 – Favorable	Favorable	Favorable	Insufficient information	Insufficient information
Reusable flat serviceware	Not applicable	Not applicable	Not applicable	Yes for some end-users	Yes for some users

Findings

Ecology determined there are at least three safer alternatives that are readily available in sufficient quantity, at a comparable cost, and that perform as well or better than PFAS used in flat serviceware.

Another two alternatives are readily available and at comparable cost to some users, or meet the performance requirements for some users.

One alternative failed to meet the performance criterion and is not considered safer.

Ecology had insufficient information to reach conclusions on seven other alternatives.

Food packaging application: Open-top containers

Ecology evaluated 13 possible alternatives for open-top containers and reached the conclusions in Table 8.

Table 8. Summary of assessment modules outcomes for open-top containers.

Alternative substance	Hazard module	Exposure module	Performance module	Cost & availability	Safer alternative?
Untreated paper	Low concern – Favorable	Not applicable	Not favorable	Insufficient information	No
Densified paper	Low concern – Favorable	Not applicable	Favorable	Favorable	Yes
Wax-coated	Low concern – Favorable	Not applicable	Favorable	Favorable	Yes
Clay-coated	Low concern – Favorable	Not applicable	Favorable	Favorable	Yes
PVOH-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient information	Insufficient information
EVOH-coated	BM 3 – Favorable	Not applicable	Favorable	Insufficient information	Insufficient information
LDPE-coated	BM 2 – Favorable	Insufficient information	Favorable	Favorable	Insufficient information
PLA-coated	BM 3 – Favorable	Not applicable	Favorable	Favorable	Yes
PLA Foam	BM 3 – Favorable	Not applicable	Favorable	Favorable	Yes
Rigid PLA	BM 3 – Favorable	Not applicable	Favorable for some uses	Favorable	Yes for some uses
Rigid PP	BM 2 – Favorable	Insufficient information	Favorable	Favorable	Insufficient information
Aluminum	BM 2 – Favorable	Favorable	Favorable	Favorable	Yes
Reusable open-top containers	Not applicable	Not applicable	Not applicable	Yes for some end-users	Yes for some uses

Findings

Ecology determined there are at least six safer alternatives that are readily available in sufficient quantity, at a comparable cost, and that perform as well or better than PFAS used in open-top containers.

Another two alternatives are readily available and at comparable cost to some users, or meet the performance requirements for some users.

One alternative failed to meet the performance criterion and is not considered safer.

Ecology had insufficient information to reach conclusions on four other alternatives.

Food packaging application: Closed containers

Ecology evaluated 13 possible alternatives for closed containers and reached the conclusions in Table 9.

Table 9. Summary of assessment modules outcomes for closed containers.

Alternative substance	Hazard module	Exposure module	Performance module	Cost & availability	Safer alternative?
Untreated paper	Low concern – Favorable	Not applicable	Not favorable	Insufficient information	No
Densified paper	Low concern – Favorable	Not applicable	Favorable	Insufficient information	Insufficient information
Wax-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient information	Insufficient information
Clay-coated	Low concern – Favorable	Not applicable	Favorable	Favorable	Yes
PVOH-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient information	Insufficient information
EVOH-coated	BM 3 – Favorable	Not applicable	Favorable	Insufficient information	Insufficient information
LDPE-coated	BM 2 – Favorable	Insufficient information	Favorable	Favorable	Insufficient information
PLA-coated	BM 3 – Favorable	Not applicable	Favorable	Favorable	Yes
PLA Foam	BM 3 – Favorable	Not applicable	Favorable	Favorable	Yes
Rigid PLA	BM 3 – Favorable	Not applicable	Favorable for some uses	Favorable	Yes for some uses
Rigid PP	BM 2 – Favorable	Insufficient information	Favorable	Favorable	Insufficient information
Aluminum	BM 2 – Favorable	Favorable	Favorable	Favorable	Yes
Reusable closed containers	Not applicable	Not applicable	Not applicable	Not favorable	No

Findings

Ecology determined there are at least four safer alternatives that are readily available in sufficient quantity, at a comparable cost, and that perform as well or better than PFAS-coated bowls.

One alternative met the performance criterion, but only for some users.

One alternative failed to meet the performance criterion and is not considered safer. Another is not readily available at this time.

Ecology had insufficient information to reach conclusions on six other alternatives.

Determination summary

For all of the five food packaging applications reviewed, Ecology determined there are food packaging alternatives that are less hazardous and have a lower exposure risk than PFAS-based food packaging options. These alternatives are also readily available in sufficient quantity, are comparable in cost, and have equivalent performance to PFAS-based options.

Peer Review

Peer review process

RCW 70A.222.070(1)[19] requires that any determination that safer food packaging alternatives exist must be "supported by feedback from an external peer review of the department's alternatives assessment."

Ecology contracted with the Northeast Waste Management Official's Association (NEWMOA), which manages the IC2 program, to facilitate an external peer review of the alternatives assessment. NEWMOA extended an invitation to participate to anyone who was from an IC2 member organization, or a member of the Association for the Advancement of Alternatives Assessments. Organizations that previously submitted public comments about the PFAS alternatives assessment project were not eligible to participate.

The four selected peer reviewers (whose bios are below) all have experience with one or more of the following:

- PFAS drinking water contamination.
- PFAS in consumer products, including food packaging products.
- Alternatives assessments.

Dr. Simona Bălan

Simona Bălan, PhD is a senior environmental scientist at the California Department of Toxic Substances Control (DTSC), where she implements the Safer Consumer Products (SCP) regulations and leads the SCP teams researching and regulating the use of perfluoroalkyl and polyfluoroalkyl substances (PFASs) in certain consumer products. She is also a lecturer at the University of California, Berkeley, in the School of Public Health and the Department of Environmental Science, Policy, and Management. Before joining DTSC, she was a senior scientist at the Green Science Policy Institute, managing international projects on the use of flame retardants and PFASs in consumer products. She has a PhD in Environmental Science, Policy and Management from UC Berkeley and a BSc in Earth and Planetary Sciences from Jacobs University Bremen, Germany.

Michelle Gaither

Michelle Gaither has served as an industrial engineer at the Pollution Prevention Resource Center (PPRC) for over 20 years. She has expertise in pollution prevention opportunity assessments in manufacturing sectors, and some commercial sectors, especially focusing on minimization of hazardous materials use and exposure, and minimizing generation of hazardous wastes, emissions, and effluent. Gaither has an M.S. in Environmental Science and a B.S. in Industrial Engineering and career experience in both areas. The two disciplines complement each other in addressing environmental issues and solutions. Prior to PPRC, Gaither managed research projects for the Clean Washington Center to develop new products made from

[19] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070

recycled commodities, helped initiate the environmental sustainability group at Battelle's Pacific Northwest National Labs, and worked in manufacturing engineering at a successful electronics company.

Jen Jackson

Jen manages the Toxics Reduction & Healthy Ecosystems Program at the San Francisco Department of the Environment. She and her team lead a variety of programs and implement policies that reduce the use of toxic chemicals and support proper disposal of hazardous waste. Prior to joining San Francisco in 2015, Jen worked in wastewater pollution prevention at the East Bay Municipal Utility District, stormwater pollution prevention for the City of San Pablo, and began her environmental career in the non-profit sector as a community organizer at Sierra Club and Save The Bay. Jen earned her master's degree in Geography, Resource Management & Environmental Planning and wrote her thesis on the sources of endocrine disrupting chemicals in wastewater.

Dr. Amelia Nestler

Dr. Amelia Nestler brings to Northwest Green Chemistry (NGC) her background in biochemistry research, teaching, event management, and alternatives assessment. Amelia serves NGC's mission to enhance human and environmental health via green chemistry and engineering by leading NGC's webinar series for green technology entrepreneurs, performing research on diverse green chemistry and engineering subjects, and contributing to project and program development and the operational management of the organization. Recently, Amelia published Promising Practices for Alternatives Assessment: Lessons from a Case Study of Copper-free Antifouling Coatings with Dr. Lauren Heine in the Integrated Environmental Assessment and Management journal. Amelia led research and preparation of NGC's Washington State Antifouling Boat Paint Alternatives Assessment report, Alternatives to Five Phthalates of Concern to Puget Sound, and the OR DEQ Roadmap: Evaluating Alternatives to Food Packaging Materials Containing Per- or Poly-fluorinated Substances (PFASs). She also led NGC's facilitation of the Emerald Corridor Green Chemistry & Engineering Roadmap (2018 – 2023): Goals & Recommendations for Collective Impact. Previously, Amelia supported GreenScreen® for Safer Chemicals at Clean Production Action by presenting at workshops in the green building sector and developing materials for online training courses. Amelia earned her doctorate in Biochemistry at the University of Wisconsin-Madison and her B.A. in Biochemistry at Lewis & Clark College.

Summary of peer review comments and Ecology response

Reviewers agreed that Ecology's findings and conclusion—that safer alternatives to PFAS exist for all evaluated food packaging applications—were supported by the information in the assessment. Reviewers also determined that Ecology chose methods based on the IC2 AA Guide that were appropriate and scientifically sound. In this section, we briefly discuss specific feedback peer reviewers provided, and Ecology's responses to those comments.

Specific feedback provided by peer reviewers

Reviewers recommended changes to the assessment text and provided additional information to consider in certain sections. None of the recommendations questioned the assessment findings or methods. These recommendations and Ecology's responses are summarized here.

One reviewer recommended we use language other than "safer alternative" to describe alternatives that met all the criteria in RCW 70A.222.070.[20] While we understand that readers unfamiliar with the term may assume it only refers to those alternatives that are less hazardous than PFAS, we believe it is important to use the terminology in the statute. We provided our definition of a safer alternative at multiple points in the assessment to try to minimize reader confusion.

Reviewers requested further details about how the alternative substances we assessed are approved for use in food packaging products. When additional information would clarify the alternative substances being evaluated—such as noting that aluminum foil with a non-stick coating was not considered as one of our alternatives—we made changes in the text. Some requested information, such as the allowable thickness of a plastic film used in food packaging. This was not included because the food packaging manufacturer is responsible for complying with such specifications, and such information is not directly relevant to this assessment.

Relatedly, reviewers asked us to include more commentary on the end-of-life considerations of different alternatives—even if they are not explicitly considered as part of our assessment of the alternatives. To that end, we acknowledged in the assessment that end-of-life considerations, while not relevant to the alternatives assessment we conducted, are highly relevant to any food packaging user who wants to compare potential products for their own use.

Regarding the hazard module, one reviewer recommended filling in certain human health hazard data gaps appearing in the hazard assessment of a specific chemical. We did not make the recommended change. In the GreenScreen® hazard assessment method, chemicals are allowed to have data gaps for certain human health hazards and still receive a score of BM-2. Our approach in the hazard module is to identify alternative substances that are less hazardous than PFAS as a class. All PFAS we evaluated in this module showed hazards consistent with BM-1 chemicals. Despite data gaps for certain hazard endpoints, we expect substances that score BM-2 to be less hazardous alternatives than BM-1 chemicals.

[20] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070

The same reviewer also recommended we consider how the physical form of a chemical might influence the conclusions of a hazard assessment. In our analysis of chemical hazard, we generally don't consider the influence of form-specific hazards unless there is ample evidence demonstrating that the specific form of the chemical being evaluated is not relevant to our alternatives assessment. For example, the form-specific hazards of talc included in the chemical hazard assessment could reasonably be anticipated to exist within the lifecycle of talc used in food packaging.

In the exposure assessment module, reviewers requested we clarify the process we used to conclude that the alternatives we evaluated are not materially different from PFAS. The reviewers did not disagree with our conclusion in this module. We revised the text to make our exposure evaluation process clearer.

Several comments focused on our evaluation of the plastic alternatives low density polyethylene (LDPE) and polypropylene (PP). In the hazard module, one reviewer asked us to clarify how chemical additives (those that are not less hazardous than PFAS and may be added to plastics in small amounts) impact the hazard evaluations of these substances. We added information about the hazards of potential plastic additives. We also clarified how the variability in the potential hazards of plastic additives impacted our final hazard evaluation.

Reviewers asked us to clarify some of our decisions regarding how we evaluated LDPE and PP microplastic particles in the hazard and exposure modules. In the hazard module, we clarified that we evaluated microplastic particles as an impurity because they are not intentionally added but instead generated as the plastic is broken. In the exposure module, we reviewed our evaluation of the exposure potential of microplastic particles coming from single-use plastic food packaging. We recognize that microplastic particles are an area of emerging concern. However, there is limited information available about the impact of these particles or the likelihood that food packaging will generate them. Therefore, we determined there is not enough information to complete our exposure evaluation of LDPE and PP as alternative substances. We updated our exposure evaluation findings and our conclusions to reflect this.

One reviewer asked for further clarification about PFAS use in LDPE, PP, and other plastics. We are aware that certain substances that meet our definition for PFAS are approved for use by the U.S. Food and Drug Administration as processing aids in plastics that come into direct contact with food. We are also aware that PFAS have been found in non-food packaging plastic. However, we do not believe the food packaging products we identified contain intentionally added PFAS as processing aids.

We previously asked food packaging manufacturers about PFAS in their plastic-containing products. As far as the manufacturers are aware, PFAS is not being used in the products we identified. In response to reviewer comments, we a similar explanation in the alternatives assessment.

Reviewers also recommended a few additional references, which we added to the assessment when appropriate.

Minor clarifications made in text

Reviewers asked for minor clarifications regarding background information, evaluation methods, and conclusions in the sections concerning:

- The introduction of the AA framework we used.
- The introduction to the food packaging applications.
- Our description of end-users who may have an interest in this AA.
- The information provided about specific PFAS chemicals.
- Which PFAS are approved for use in food packaging.
- Which alternatives were and were not included in this assessment.
- The chemical hazard assessment methods used to assess different chemicals.
- How we used physiochemical properties to compare the exposure potential of different substances.
- How we collected and used different performance information.
- How we used example products to evaluate performance.

We made minor edits to address these requests.

One reviewer requested we add the Chemical Abstract Services Registration Number (CASRN) after each substance the first time it is introduced. We did not make this change. The same name or acronym is used consistently when referring to a substance. We included CASRNs when they would be relevant for a reader to look up additional information (such as in the table summarizing chemical hazard evaluations). Further uses of CASRNs are not expected to provide additional context, and may confuse non-technical readers.

Finally, we corrected a number of typographical errors reviewers identified.

Conclusions and Next Steps

Findings and results

Ecology completed an alternatives assessment and found at least one safer alternative available for all five applications. As a result, a restriction on the sale and use of PFAS in food packaging will apply to these food packaging applications:

- Bags and sleeves.
- Bowls.
- Flat serviceware.
- Open-top containers.
- Closed containers.

The restriction will begin in April of 2024, and will be in addition to the restriction on food packaging applications where we identified safer alternatives in the first alternatives assessment:

- Wraps and liners.
- Plates.
- Food boats.
- Pizza boxes.

Future work

Starting in 2022, Ecology will continue the alternatives assessment process. The findings of the first and second alternatives assessments cover food packaging used to hold, serve, and transport recently prepared food. Future alternatives assessments will focus on alternatives to PFAS in other types of food packaging, such as packaging that is used to store food for longer periods of time.

Starting in 2023, Ecology expects to begin enforcing the restrictions on PFAS-containing food packaging for the initial four food packaging applications where we found safer alternatives. We anticipate this will involve working with manufacturers, distributors, wholesalers, and retailers to ensure they comply with the law and, when necessary, assisting them with compliance. Ecology will also engage with stakeholders, including not only manufacturing associations and environmental advocates, but also grocers, retailers, hospitality organizations, and other end-users of affected products. Ecology's outreach efforts may include developing focus sheets, webpages, and other educational materials to encourage the adoption of safer alternatives.

Starting in 2024, Ecology expects to begin enforcing the restrictions on PFAS-containing food packaging for the five applications with identified safer alternatives noted above. The restrictions on PFAS in these food packaging applications will be in addition to those identified in the first alternatives assessment.

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