

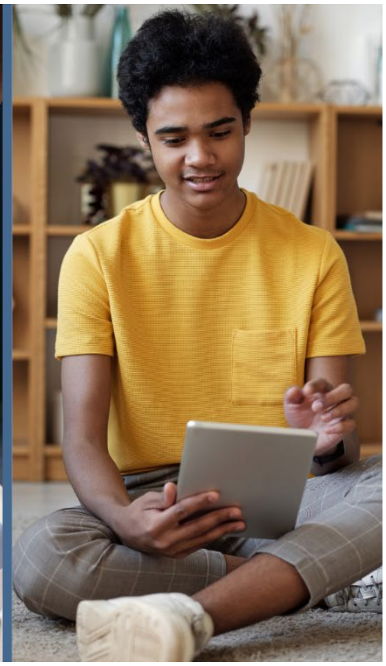

Regulatory Determinations Report to the Legislature

Safer Products for Washington Cycle 1 Implementation Phase 3

Hazardous Waste and Toxics Reduction

Washington State Department of Ecology

Olympia, Washington

June 2022, Publication 22-04-018

DEPARTMENT OF ECOLOGY
State of Washington

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Related Information

- Safer Products for Washington Cycle 1 Implementation Phase 2 Report to the Legislature on Priority Consumer Products[1]
- Safer Products for Washington Cycle 1 Implementation Phase 3 Draft Report to the Legislature on Regulatory Determinations[2]
- Safer Products for Washington Stakeholder Engagement Process[3]

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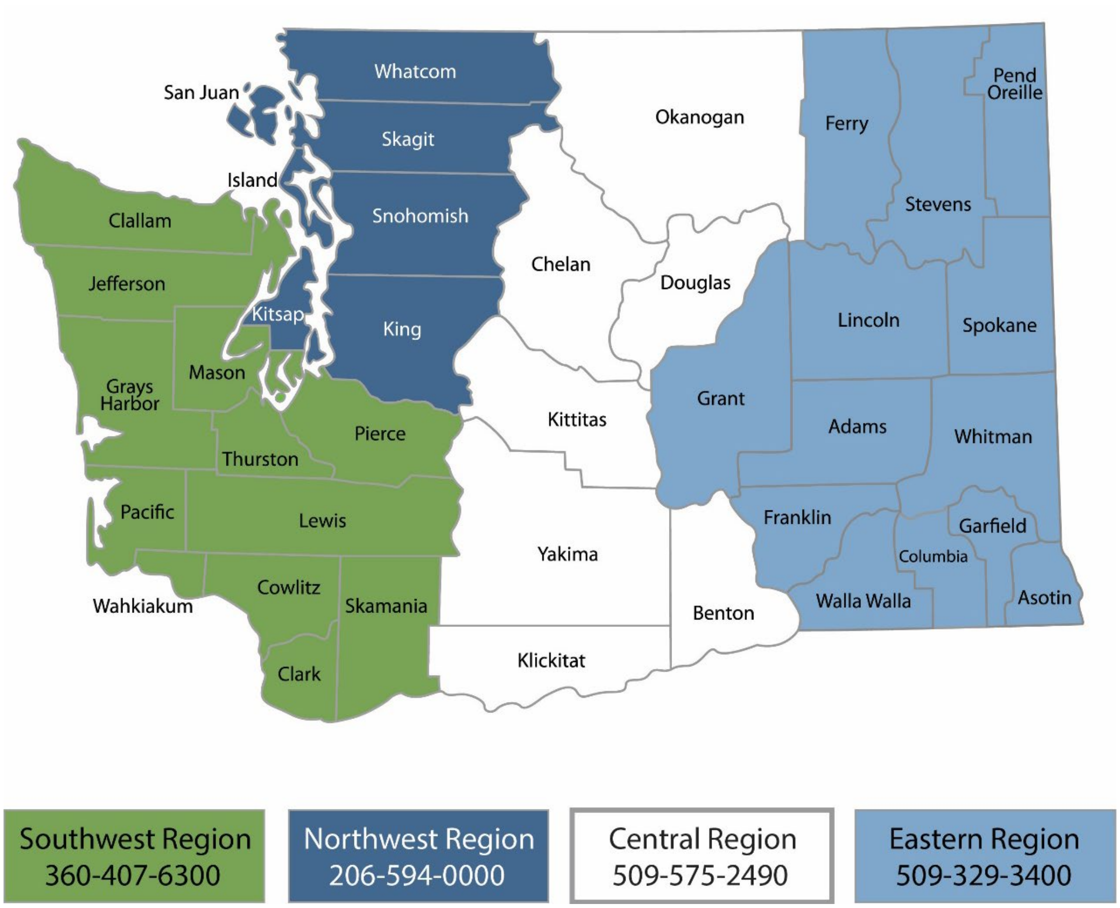
[1] https://apps.ecology.wa.gov/publications/summarypages/2004019.html
[2] https://apps.ecology.wa.gov/publications/summarypages/2104047.html
[3] https://www.ezview.wa.gov/Portals/_1962/Documents/saferproducts/Updated2021_Stakeholder_Engagement_Process.pdf
[4] www.ecology.wa.gov/contact

Department of Ecology's Regional Offices

Map of Counties Served



Region	Counties served	Mailing Address	Phone
Southwest	Clallam, Clark, Cowlitz, Grays Harbor, Jefferson, Mason, Lewis, Pacific, Pierce, Skamania, Thurston, Wahkiakum	PO Box 47775 Olympia, WA 98504	360-407-6300
Northwest	Island, King, Kitsap, San Juan, Skagit, Snohomish, Whatcom	PO Box 330316 Shoreline, WA 98133	206-594-0000
Central	Benton, Chelan, Douglas, Kittitas, Klickitat, Okanogan, Yakima	1250 W Alder St Union Gap, WA 98903	509-575-2490
Eastern	Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Spokane, Stevens, Walla Walla, Whitman	4601 N Monroe Spokane, WA 99205	509-329-3400
Headquarters	Across Washington	PO Box 46700 Olympia, WA 98504	360-407-6000

Report to the Legislature Regulatory Determinations

Safer Products for Washington
Cycle 1 Implementation Phase 3

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Washington State Department of Ecology
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ECOLOGY
State of Washington

Table of Contents

List of Figures and Tables

Figures

Tables

Legislative Report

The Washington Department of Ecology, in consultation with the Washington Department of Health, developed the Regulatory Determinations Report to the Legislature (this report) during Phase 3 in the implementation process for Chapter 70A.350 Revised Code of Washington (RCW).[5] This report is required by RCW 70A.350.040(1)[6]:

"(1) Every five years, and consistent with the timeline established in RCW 70A.350.050, the department, in consultation with the Department of Health, must determine regulatory actions to increase transparency and to reduce the use of priority chemicals in priority consumer products. The department must submit a report to the appropriate committees of the Legislature at the time that it determines regulatory actions."

The law specifies that Ecology may make one the following regulatory determinations for each chemical-product combination in this report (RCW 70A.350.040(1)):

- Determine that no regulatory action is currently required.
- Require a manufacturer to provide notice of the use of a priority chemical or class of priority chemicals consistent with RCW 70A.430.060.[7]
- Restrict or prohibit the manufacture, wholesale, distribution, sale, retail sale, use, or any combination thereof, of a priority chemical or class of priority chemicals in a consumer product.

To make a determination to restrict priority chemicals in priority products, Ecology must confirm the following (RCW 70A.350.040(3)):

- Safer alternatives are feasible and available.
- The restriction will either reduce a significant source or use of a priority chemical, or is necessary to protect the health of sensitive populations or sensitive species.

[5] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350
[6] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.040
[7] http://app.leg.wa.gov/RCW/default.aspx?cite=70A.430.060

Regulatory determinations

Table 1 below summarizes the information supporting the regulatory determinations. If at any point federal action preempts our ability to implement the restrictions in Table 1, we will require reporting of priority chemicals in those priority products.

Table 1. Regulatory determinations.

Priority chemical class	Priority product	Is there a safer, feasible, available alternative?	Would a restriction reduce a significant source/use?	Regulatory determination
Organohalogen flame retardants (HFRs)	Electric and electronic equipment (plastic device casings)	Yes, safer flame retardants are feasible and available.	Yes	Restriction on HFRs in external plastic device casings for electric and electronic products intended for indoor use.* Reporting of HFRs in external plastic device casings for electric and electronic products intended for outdoor use.
HFRs and organophosphate flame retardants (OPFRs) listed in RCW 70A.430[8]	Recreational polyurethane foam products	Yes, flame retardant free foam is feasible and available.	Yes	Restriction on HFRs and OPFRs listed in RCW 70A.430 in polyurethane uncovered foam, covered floor mats, covered flooring, and outdoor recreational products.* Reporting of HFRs and OPFRs listed in RCW 70A.430 in covered wall padding.
Polychlorinated biphenyls (PCBs)	Paints and printing inks	Yes, paints with lower concentrations of PCBs are feasible and available. Yes, printing inks with lower concentrations of PCBs are feasible and available.	Yes	No action. We believe we are preempted by federal Toxic Substances Control Act (TSCA) regulations (see more detail).
Per- and polyfluoroalkyl substances (PFAS)	Carpets and rugs	Yes, safer treatments and untreated carpets and rugs are feasible and available.	Yes	Restriction on PFAS in carpets and rugs.*

[8] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.430

Priority chemical class	Priority product	Is there a safer, feasible, available alternative?	Would a restriction reduce a significant source/use?	Regulatory determination
PFAS	Leather and textile furnishings	Yes, safer untreated, inherently stain-resistant alternatives are feasible and available for indoor furnishings. There was insufficient information to identify feasible alternatives for outdoor leather and textile furnishings.	Yes	Restriction on PFAS in indoor leather and textile furnishings.* Reporting of PFAS in outdoor leather and textile furnishings.
PFAS	Aftermarket stain- and water-resistance treatments	Yes, safer treatments and alternative processes are feasible and available.	Yes	Restriction on PFAS in aftermarket treatments applied to textile and leather consumer products.*
Phenolic compounds (bisphenols)	Food and drink cans (can linings)	Yes, safer can linings are feasible and available for drink cans. There was insufficient information to identify safer food can linings.	Yes	Restriction on most bisphenols in drink can linings (excluding tetramethyl bisphenol F, or TMBPF).* Reporting of most bisphenols in food can linings (excluding TMBPF).
Phenolic compounds (bisphenols)	Thermal paper	Yes, safer chemicals and alternative processes are feasible and available.	Yes	Restriction on bisphenols in thermal paper.*
Phenolic compounds (alkylphenol ethoxylates)	Laundry detergent	Yes, safer chemicals are feasible and available.	Yes	Restriction on APEs in laundry detergent.*
Ortho-phthalates	Vinyl flooring	Yes, safer chemicals are feasible and available.	Yes	Restriction on ortho-phthalates in vinyl flooring.*
Ortho-phthalates	Personal care and beauty products (fragrances)	Yes, safer chemicals are feasible and available.	Yes	Restriction on ortho-phthalates used in fragrances in personal care and beauty products.*

Note: * = If at any point federal action preempts our ability to implement the restrictions in Table 1, we will require reporting of priority chemicals in those priority products.

What this report includes

This report includes two distinct sections:

- **Legislative report, pages 12 to 16**: This section presents our regulatory determinations.
- **Technical analysis, pages 17 to 363** (incorporated by reference into the legislative report):
    - The determinations section outlines our approach to evaluating relevant information and briefly summarizes the information that supports the determinations.
    - Chapters 1 through 6 provide detailed information about our analysis regarding safer, feasible, and available alternatives. These chapters also summarize how a restriction would reduce a significant source or use of each priority chemical.
    - Appendices A through E detail acronyms, references, and our technical methods.
    - Appendix F summarizes actions taken by other states and nations on priority chemicals addressed in this report.
    - Appendix G overviews the products we are exempted from considering under the Safer Products for Washington program.

When the 2023 legislative session adjourns, unless the Legislature takes an action to change the regulatory determinations in this report, the regulatory determinations will be finalized. Our program will conduct rulemaking to adopt the final determinations—as RCW 70A.350.050[9] requires. We will use a rulemaking process to define the details of these determinations, including product descriptions, possible exemptions, existing stock allowances, compliance timeframes, concentration limits, and other considerations. Stakeholders and the public will have opportunities to contribute to the draft rule development in 2022 and a chance review and comment on the formal draft in 2023.

[9] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.050

Technical Analysis
Regulatory Determinations

Safer Products for Washington
Cycle 1 Implementation Phase 3

Hazardous Waste and Toxics Reduction Program
Washington State Department of Ecology
Olympia, WA

June 2022 | Publication 22-04-018

DEPARTMENT OF
ECOLOGY
State of Washington

Regulatory Determinations

Legislative requirement

In 2019, the Washington State Legislature directed Washington Department of Ecology (Ecology), in consultation with Washington Department of Health (Health), (jointly "we") to implement a regulatory program to reduce toxic chemicals in consumer products (Chapter 70A.350 RCW).[10] The implementation program is called **Safer Products for Washington.**

The law requires Ecology to determine regulatory actions to:

- Increase transparency.
- Reduce the use of priority chemicals in priority consumer products.

This report explains the basis of our regulatory determinations. It identifies how the priority chemical-product combinations (identified in our 2020 Priority Consumer Products Report to the Legislature[11]) meet the criteria in the law for taking regulatory actions.

This report details our approach and technical analyses to identify safer, feasible, and available alternative chemicals or alternative processes for each chemical-product combination. Based on these evaluations, we identify regulatory determinations for each chemical-product combination. This report does not establish regulations or restrictions on these chemical-product combinations.

Background

Steady releases of chemicals coming from millions of consumer products are the largest source of toxics entering Washington's environment. While our exposure from each product may be small, these sources of exposure add up. When combined, they can harm our health and Washington's environment. The Safer Products for Washington program includes a regulatory process designed to help keep harmful chemicals out of homes, workplaces, schools, and the environment.

Safer Products for Washington is a systematic approach to reducing exposure to toxic chemicals found in consumer products. The law directs us to take the following actions:

1. **Phase 1**: Identify priority chemical classes.
    - The 2019 Legislature identified the priority chemical classes for the first cycle (May 2019 – June 2023) of the Safer Products for Washington program.
2. **Phase 2**: Identify priority products that are significant sources or uses of those chemicals.

[10] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350
[11] https://apps.ecology.wa.gov/publications/summarypages/2004019.html

    - We submitted the Priority Consumer Products Report to the Legislature,[12] and the list of priority products became final at the end of the 2021 legislative session.
3. **Phase 3**: Determine if safer alternatives are available and feasible. Decide whether to restrict, require reporting, or take no action on priority chemical-product combinations.
    - We published a Draft Regulatory Determinations Report to the Legislature[13] in November of 2021. This report is the final version of that draft report.
4. **Phase 4**: Adopt restrictions or reporting requirements, if any, through a rulemaking process by June 1, 2023.

The regulatory determinations described in this report are general. They align with the three options outlined in RCW 70A.350.040(1).[14] RCW 70A.350.050[15] requires that we adopt rules to implement the regulatory actions identified in this report. Meeting the Administrative Procedure Act's rulemaking requirements[16] includes considering public comments, preparing a small business economic impact statement, and conducting both a least burdensome analysis and a cost-benefit analysis.

Based on those analyses and public comments, we will use the rulemaking process to determine the scope and details of the potential rules. That means during rulemaking, we will develop specific provisions and requirements, including:

- Refining or narrowing the scope of products to which these regulatory actions apply.
- Outlining compliance timelines for when restrictions and reporting requirements take effect.
- Determining concentration limits for priority chemicals in priority products.
- Including exemptions or exceptions to a restriction on a priority chemical in a consumer product (as RCW 70A.350.040 authorizes).

We selected eleven categories of priority consumer products in Phase 2.[17] The first set of priority consumer products, organized by the priority chemical class they contain, are:

- Flame retardants
    - Organohalogen flame retardants (HFRs)
        - Electric and electronic enclosures (plastic device casings)
    - HFRs and organophosphate flame retardants (OPFRs) identified in RCW 70A.430.010[18]
        - Recreational polyurethane foam
- Per- and polyfluoroalkyl substances (PFAS)
    - Aftermarket stain- and water-resistance treatments

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[12] https://apps.ecology.wa.gov/publications/summarypages/2004019.html
[13] https://apps.ecology.wa.gov/publications/summarypages/2104047.html
[14] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.040
[15] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.050
[16] https://app.leg.wa.gov/rcw/default.aspx?cite=34.05
[17] https://ecology.wa.gov/Waste-Toxics/Reducing-toxic-chemicals/Safer-products#gallery
[18] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.430.010

    - Carpets and rugs
    - Leather and textile furnishings
- Polychlorinated biphenyls (PCBs)
    - Paints and printing inks
- Phenolic compounds
    - Laundry detergent
    - Thermal paper
    - Food and drink cans (linings)
- Ortho-phthalates
    - Personal care and beauty products (fragrances)
    - Vinyl flooring

Milestones in the first cycle

The following are key milestones during the first cycle of implementing the Safer Products for Washington program:

- May 2019: The Washington State Legislature passed the Pollution Prevention for Healthy People and Puget Sound Act.[19]
- January 2020: We published our Draft Priority Consumer Products Report to the Legislature.[20] We considered feedback from stakeholders and the public to finalize our list of priority consumer products.
- March 2020: We published an overview of our stakeholder engagement process.[21]
- July 2020: We submitted the Priority Consumer Products Report to the Legislature.[22]
- February 2021: We published drafts of our technical methods:
    - Criteria for safer.
    - Criteria for feasible and available.
- April 2021: The Priority Consumer Products Report to the Legislature became effective at the end of the 2021 legislative session.
- October 2021: We updated our stakeholder engagement process.[23]
- November 2021: We published the Draft Regulatory Determinations Report to the Legislature.[24] We considered feedback from stakeholders and the public to finalize our regulatory determinations in this report.

[19] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350
[20] https://apps.ecology.wa.gov/publications/summarypages/2004004.html
[21] https://www.ezview.wa.gov/Portals/_1962/Documents/saferproducts/Stakeholder_Engagement%20_Process.pdf
[22] https://apps.ecology.wa.gov/publications/summarypages/2004019.html
[23] https://www.ezview.wa.gov/Portals/_1962/Documents/saferproducts/Updated2021_Stakeholder_Engagement_Process.pdf
[24] https://apps.ecology.wa.gov/publications/summarypages/2104047.html

Stakeholder advisory process

RCW 70A.350.050(4)[25] requires Ecology to create a stakeholder advisory process. Phase 3 furthered our efforts to engage stakeholders from past phases of the work. We provide regular updates via our webpages and email list during key project phases and use these distribution channels to share ways for stakeholders to engage—such as webinars and input opportunities. As a result of outreach and engagement efforts in Phase 3, we grew our email list from 225 to 551 subscribers. We describe this work in detail in our stakeholder engagement process.[26] Key highlights are below.

We engaged stakeholders in our Phase 3 technical analysis process by hosting a series of three webinars (between October 2020 and March 2021, each with a morning and evening time to accommodate varying time zones and work schedules), publishing detailed technical methods, and offering stakeholders an informal comment opportunity. This approach to sharing our technical methods helped ensure:

- Clarity in our process and goals.
- Input opportunities for stakeholders early and often in the process.
- Stakeholders could both understand and evaluate the labeling and certification programs we used in Phase 3.

Between May and August 2021, we hosted six half-day webinars focused on the specific chemical-product combinations we are assessing in the first cycle of the program. These webinars intended to:

- Share our potential regulations with stakeholders earlier in the process than required, significantly extending the input timeframe.
- Offer a meaningful opportunity for stakeholders to contribute to the structure of potential regulations through dialogue with the Safer Products for Washington team.
- Communicate areas where additional information or input from stakeholders would benefit our analysis.
- Prevent surprises for interested parties during the comment period in late 2021.

Each webinar addressed two products, and we provided a minimum of one hour for discussion about each product. The discussions focused on individual products to encourage stakeholders with specific expertise to contribute to our process. However, each webinar also included an overview of progress across product categories to frequently update stakeholders and invite participation. All six webinars included attendance from all the required stakeholder groups outlined in the law we are implementing. Each webinar also included multiple representatives whose business or organization focuses on the specific products we discussed.

[25] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.050

[26] https://www.ezview.wa.gov/Portals/_1962/Documents/saferproducts/Updated2021_Stakeholder_Engagement_Process.pdf

Environmental justice

Research shows that low-income populations and communities of color are disproportionately exposed to higher concentrations of toxic chemicals from some consumer products and other pollution sources. This represents an environmental injustice. We are concerned about exposures for sensitive populations leading to health disparities.

Some key efforts to address environmental justice in our implementation process include:

- Completing a Government Alliance on Race and Equity (GARE) Analysis in 2019, which helped us focus on choosing the priority products that low-income communities use and the products that might benefit overburdened communities as much or more than other populations.
- Creating a broadly accessible and bilingual pathway for the public to contribute to decision-making for this report and to hear how we used their feedback. We did this through a multimedia campaign, including a four-question survey open November 2021 through January 2022.
- Copiloting new efforts in 2022 to contract with community-based organizations in order to support their work providing culturally and linguistically appropriate education.
- Investing resources to offer technical assistance and multilingual informational materials to support partnerships with community-based organizations and respond to their needs.

Through community engagement events, partnerships, and public education, we are working to involve overburdened populations (and the community organizations supporting them) in our process. We recognize the need to grow this participation and engagement. Find more details about our efforts to involve stakeholders—including our ongoing public education campaign and our community engagement goals—in our stakeholder engagement process.[27]

Process for making regulatory determinations

When making regulatory determinations, we consider whether safer alternatives are feasible and available, and whether a restriction would reduce a significant source or use or is necessary to protect sensitive populations or species. We can also consider:

- Hazards of the priority chemical class (RCW 70A.350.040(4)).
- Criteria to be listed as a priority product (RCW 70A.350.040(4)).
- Existing regulations from other states and nations (RCW 70A.350.040(4)(b)).

[27] https://www.ezview.wa.gov/Portals/_1962/Documents/saferproducts/Updated2021_Stakeholder_Engagement_Process.pdf

Identifying safer, feasible, and available alternatives

Prior to restricting the use of a priority chemical, we are required to confirm that alternatives are safer, feasible, and available. The law we are implementing does not define feasible or available. To determine whether an alternative is safer, feasible, and available, we evaluate:

- Whether the chemical is functionally necessary
- The hazards of the priority chemical class
- The hazards of the alternative
- Whether manufacturers use the alternative for the relevant application

Safer alternatives

RCW 70A.350.010[28] defines safer as "less hazardous to humans or the environment than the existing chemical or process." To implement this law, we focus on pollution prevention. Pollution prevention involves reducing, eliminating, and preventing pollution at the source. Safer Products for Washington contributes to pollution prevention by reducing significant sources or uses of priority chemicals when safer alternatives are feasible and available. Reducing hazardous chemicals in products reduces risks for people and the environment.

Safer alternatives to priority chemicals can be either:

- Alternative chemicals
- Alternative products or processes that eliminate the need for priority chemicals or alternative chemicals

To determine whether alternative chemicals are safer than priority chemicals, we developed hazard-based criteria (described in Appendix C). The criteria for safer (Appendix C) focuses on how we identify safer alternative chemicals that function like priority chemicals. It should be thought of as a spectrum, with minimum and additional criteria for safer. In most cases, alternatives that meet the minimum criteria are less hazardous than priority chemicals. However, we can use the additional criteria to identify safer alternatives when the chemicals used in the product meet the minimum criteria. This ensures that the alternatives are safer than the existing chemical or process.

To assess priority chemical classes, we focus on the data rich chemicals—those that authoritative bodies reviewed or those with publicly available hazard assessments. Using authoritative lists and existing hazard assessments is efficient because it helps us avoid duplicating work. In this report, we rely on authoritative lists from government agencies and intergovernmental organizations—including the United States (U.S.), the European Union (EU), and the United Nations (UN). We used many of these lists in previous regulations, including the Children's Safe Products Act List of Chemicals of High Concern to Children.[29]

We also relied on existing hazard assessments that:

[28] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.010
[29] https://ecology.wa.gov/Regulations-Permits/Reporting-requirements/Reporting-for-Childrens-Safe-Products-Act/Chemicals-of-high-concern-to-children

- Have transparent criteria for hazard evaluation
- Have transparent data requirements
- Are either third-party reviewed or publicly available

Hazard assessments collect existing data into a single report and score or rank the chemical. They provide a systematic way to integrate data from multiple sources. Other government agencies and industry often use these hazard assessment methods. That means we can integrate our methods with tools that manufacturers already use, making collaboration and information sharing easier. Appendix E identifies existing hazard assessment methods and certifications that meet our transparency and independence requirements and criteria for safer.

Feasible and available alternatives

We based our process for identifying feasible and available alternatives on the Interstate Chemicals Clearinghouse (IC2) Guide. It provides a framework that aligns with other authoritative bodies, while still offering enough flexibility to meet the requirements in the law we are implementing. Based on the IC2 Guide, we set criteria to identify feasible and available alternatives. These criteria (included in Appendix D) focus on identifying alternatives that manufacturers already use in the relevant application.

Reducing a significant source or use of a priority chemical class

We identified these products as significant sources or uses of priority chemicals in our 2020 Priority Consumer Products Report to the Legislature.[30] That report became effective at the end of the 2021 legislative session, on April 25, 2021. Based on that report, we determined that restricting any of the priority chemical-product combinations would reduce a significant source or use of a priority chemical class. As a result, further evaluating whether a restriction would reduce a significant source or use (RCW 70A.350.040(3)(b)(ii)) is not required by statute.

Making regulatory determinations

We made our regulatory determinations based on the above evaluations. If safer alternatives are feasible and available, and the restriction would reduce a significant source or use, then our regulatory determination is a restriction. If a restriction would reduce a significant source or use, but we did not identify any safer, feasible, and available alternatives, then our regulatory determination is a reporting requirement.

Find our full evaluation of safer, feasible, and available alternatives—as well as a summary describing how each priority product meets the criteria in the law to be a significant source or use—in Chapters 1 through 6. We considered:

- Input from the public and stakeholders we heard throughout the process.
- Peer-reviewed scientific data, government reports, and publicly available economic and market information.

[30] https://apps.ecology.wa.gov/publications/summarypages/2004019.html

- Regulations from other states and nations as well as voluntary actions to reduce sources and uses of priority chemicals. (Appendix F provides a list of existing and pending regulatory actions by other states and nations, as well as relevant voluntary actions by manufacturers, retailers, and others related to these, or similar, chemicals and products.)

Regulatory determinations

We consulted peer-reviewed scientific data, government reports, and publicly available economic and market information to determine whether each product category met the criteria for a proposed restriction or reporting requirement under RCW 70A.350.040.[31] This section reviews our regulatory determinations and the information supporting them but does not include references. We cite the information we referenced in each technical chapter and in the appendices. Appendix B includes a complete reference list.

In some cases, other regulatory agencies already established regulations to address these priority chemical classes in similar products. In other cases, our program would be the first agency to make regulatory determinations for these chemical classes in the relevant products. (See more in Appendix F.) Table 2 summarizes the regulatory determination we made for each category—restricting priority chemicals in priority products, implementing requirements for manufacturers to report their use of priority chemicals in priority products, or taking no action. If at any point federal action preempts our ability to implement the restrictions in Table 2, we will require reporting of priority chemicals in those priority products.

Table 2. Priority chemical classes, priority products, and regulatory determinations required under RCW 70A.350.040.

Priority chemical or chemical class	Priority product	Phase 3 regulatory determination
Organohalogen flame retardants (HFRs)	Electric and electronic equipment (plastic device casings)	Restriction on HFRs in external plastic device casings for electric and electronic products intended for indoor use.* Reporting of HFRs in external plastic device casings for electric and electronic products intended for outdoor use.
HFRs and organophosphate flame retardants (OPFRs) listed in RCW 70A.430[32]	Recreational polyurethane foam products	Restriction on HFRs and OPFRs listed in RCW 70A.430 in polyurethane uncovered foam, covered floor mats, covered flooring, and outdoor recreational products.* Reporting of HFRs and OPFRs listed in RCW 70A.430 in covered wall padding.

[31] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.040
[32] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.430

Priority chemical or chemical class	Priority product	Phase 3 regulatory determination
Polychlorinated biphenyls (PCBs)	Paints and printing inks	No action. We believe we are preempted by federal Toxic Substances Control Act (TSCA) regulations (see more detail).
Per- and polyfluoroalkyl substances (PFAS)	Carpet and rugs	Restriction on PFAS in carpets and rugs.*
PFAS	Leather and textile furnishings	Restriction on PFAS in indoor leather and textile furnishings.* Reporting of PFAS in outdoor leather and textile furnishings.
PFAS	Aftermarket stain- and water-resistance treatments	Restriction on PFAS in aftermarket treatments applied to textile and leather consumer products.*
Phenolic compounds (bisphenols)	Food and drink cans (can linings)	Restriction on most bisphenols in drink can linings (excluding tetramethyl bisphenol F, or TMBPF).* Reporting of most bisphenols in food can linings (excluding TMBPF).
Phenolic compounds (bisphenols)	Thermal paper	Restriction on bisphenols in thermal paper.*
Phenolic compounds (alkylphenol ethoxylates)	Laundry detergent	Restriction on APEs in laundry detergent.*
Ortho-phthalates	Vinyl flooring	Restriction on ortho-phthalates in vinyl flooring.*
Ortho-phthalates	Personal care and beauty products (fragrance)	Restriction on ortho-phthalates used in fragrances in personal care and beauty products.*

Note: * = If at any point federal action preempts our ability to implement the restrictions in Table 2, we will require reporting of priority chemicals in those priority products.

Why we made these regulatory determinations

These regulatory determinations would reduce significant sources or uses of priority chemicals. We identified safer, feasible, and available alternatives for most of the priority chemical-product combinations. The following section summarizes:

- The hazards of each priority chemical class.
- How people and the environment can be exposed to priority chemicals from priority products.
- Whether there are safer alternatives.
- Our regulatory determination.

Flame retardants

The Legislature identified organohalogen flame retardants as a class and five organophosphate flame retardants (identified in RCW 70A.430[33]) as priority chemicals. In our Priority Consumer Products Report to the Legislature,[34] we define organohalogen flame retardants as meeting both of the following criteria:

1. The chemical is used with the intended function of slowing ignition and progression of fires.
2. The chemical contains one or more halogen elements bonded to carbon.

Some organohalogen flame retardants are linked to human and environmental health problems—including carcinogenicity, reproductive and developmental toxicity, and hormone disruption. Once these chemicals are in the environment, they can also be toxic to fish. These traits are especially concerning because many organohalogen flame retardants are persistent and bioaccumulative. That means they stay in the environment and our bodies for a long time and build up in wildlife as they move up the food chain.

Some of the organophosphate flame retardants RCW 70A.430 identifies are less hazardous than organohalogen flame retardants. However, they are still linked to health concerns. In cases where flame retardants are necessary, these chemicals may be safer alternatives at this point in time. However, in cases where flame retardants are not necessary, and it is possible to maintain fire safety in other ways, avoiding adding any flame retardants is the least hazardous option.

Recreational polyurethane foam products

Recreational polyurethane foam products include mats and foam pits. These products are often found in gymnastics facilities but can be present in other businesses, too. Mats and foam pits made from polyurethane foam with added flame retardants can expose people using these facilities.

These products degrade when people use them, and flame retardants can build up in dust and indoor air. Studies show gymnasts have higher exposure to flame retardants after using foam pits. Intervention studies find that exposure is reduced when foam with flame retardants is replaced with flame retardant free foam. In addition to removing sources of flame retardants, deep cleaning may also be necessary to remove persistent chemicals from indoor environments.

Flammability standards are one way to promote and maintain fire safety. Manufacturers add flame retardants to products to meet flammability standards. However, most recreational polyurethane products are not required to meet flammability standards. Most products that are required to meet these standards can do so without adding flame retardants. For example, we found flame retardant free foam products that meet surrogate flammability standards—such as the standards required in California Technical Bulletin (TB) 117-2013.

[33] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.430
[34] https://apps.ecology.wa.gov/publications/summarypages/2004019.html

Polyurethane foam pits, covered floor mats, covered flooring, and outdoor recreational products without flame retardants are safer, feasible, and available. We did not identify safer, feasible, and available alternatives to polyurethane wall pads. None of the flame retardant free wall padding products we identified met the required standards.

Restricting the use of flame retardants in recreational foam would reduce a significant source of exposure. Our regulatory determinations are:

- A restriction on organohalogen flame retardants—and the flame retardants listed in RCW 70A.430[35]—in uncovered foam, covered floor mats, covered flooring, and outdoor foam products.
- A reporting requirement for organohalogen flame retardants—and the flame retardants listed in RCW 70A.430—in polyurethane wall padding.

Electric and electronic equipment (plastic device casings)

The plastic device casings around electric and electronic equipment expose people and the environment to organohalogen flame retardants. Flame retardants released from products can accumulate in indoor dust. House dust exposes babies and young children to these chemicals because they spend more time on the floor. Some flame retardants are persistent and bioaccumulative, so they are concerning when they make their way into the environment.

Safer, feasible, and available alternatives can replace organohalogen flame retardants used in electric and electronic equipment intended for indoor use. Restricting organohalogen flame retardants in electric and electronic equipment would reduce a significant source of exposure for people and the environment. Our regulatory determinations are:

- A restriction on organohalogen flame retardants in plastic device casings for electric and electronic equipment intended for indoor use.
- A reporting requirement for organohalogen flame retardants in plastic device casings for electric and electronic equipment intended for outdoor use.

Polychlorinated biphenyls (PCBs)

RCW 70A.350.010[36] defines PCBs as a class of chemicals that consist of two benzene rings joined together and containing one to ten chlorine atoms attached to the benzene rings. This priority chemical class includes all of the 209 distinct PCBs.

In 1979, the Toxic Substances Control Act (TSCA) restricted the use of PCBs as a class. However, PCBs are still unintentionally created during manufacturing processes. Nearly everyone has PCBs in their bodies. PCBs are linked to many human health and environmental concerns. The entire class is carcinogenic, developmentally toxic, and toxic to fish. The toxicity these chemicals show is particularly concerning because they are also persistent and bioaccumulative. That means they remain in the environment and in our bodies for a long time,

[35] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.430
[36] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.010

and they build up in the food chain. Washington state rules list some PCBs as persistent, bioaccumulative, and toxic chemicals (WAC 173-333-310[37]).

We believe we cannot implement a restriction on inadvertent PCBs in paints and inks due to federal preemption at this time. In 1984, EPA established an exemption (under 49 Fed. Reg. 28172) from the statutory ban on PCBs for inadvertently generated PCBs below certain concentrations (40 CFR Section 761.1). Under 1976 TSCA Section 18(a)(2)(B), states cannot establish requirements on applicable substances unless they are one of the following:

- Identical to EPA requirements
- Adopted under another federal law (such as the Clean Water Act)
- Prohibiting the use of the substance in a state

Prohibiting PCBs would mean none are allowed. Our draft regulatory determination did not propose prohibiting all PCBs in paints and inks. Instead, we proposed restricting the allowable concentration. The only other option for a restriction would be implementing rules identical to EPA. Identical rules would not further reduce PCB concentrations in products, meaning they would not lessen our exposure or prevent releases to the environment.

We also considered whether we could implement a reporting requirement for PCBs in paints or inks. RCW 70A.350.040 states that we may "require a manufacturer to provide notice of the use of a priority chemical or class of priority chemicals." Because PCBs are not purposefully used in paints or inks, but are present as inadvertent contaminants, this is not a viable option. Therefore, the only possible regulatory determination available to us is to recommend no action.

We recognize PCBs pose important environmental problems. These toxic chemicals disproportionately impact:

- Those reliant on local, resident fish for subsistence and recreation in Washington state
- Communities of color

While the majority of PCB exposure comes from legacy contamination, reducing new PCB releases helps prevent future contamination. Safer alternatives are feasible and available, and a restriction would reduce a significant source of new PCBs to the environment, reducing potential exposure for us and for wildlife.

We hope these findings support transparency so retailers and customers can identify and use products with lower PCB concentrations. Stricter PCB limits in these products are feasible. Manufacturers, retailers, and other regulatory bodies should review and implement these findings to reduce PCBs in products.

Paints

Paints—including building paints, spray paints, children's paints, and road paints—can contain PCBs as contaminants. Paint can contain inadvertent PCBs that are generated during pigment production. PCBs found in these products can escape from painted material and contaminate

[37] https://apps.leg.wa.gov/wac/default.aspx?dispo=true&cite=173-333-310

the environment. Restricting PCBs in paints would reduce a significant source of PCBs to people and the environment. We analyzed existing data from peer-reviewed literature and government reports, and tested paint products. We found that the concentration of inadvertent PCBs in paints varies.

Because pigments are the likely source of PCBs, we organized the paint samples by color. We found paints with lower and higher PCB concentrations in every color of paint we evaluated—indicating that paints with lower PCB concentrations are feasible. We purchased the paints to include in these studies in Washington—indicating that they are available on the commercial market.

Therefore, safer alternatives (paints with lower PCB concentrations) are feasible and available. However, because we believe we are preempted by federal TSCA regulations, our regulatory determination on PCBs in paints is no action.

Printing inks

Printing inks can also contain PCBs as inadvertent contaminants from pigment production. Product testing often detects PCBs from printing inks on printed material, which can escape into the environment during use and disposal. Restricting PCBs in inks would reduce a significant source of PCBs to people and the environment. We tested ink products to measure the amount of PCBs in the most common colors of printing inks (cyan, magenta, yellow, and black). Similar to paints, we found variability in the concentrations of PCBs. For oil- or petroleum-based offset lithography inks, we found—for every color tested—PCB concentrations were well below TSCA limits. We purchased the inks with lower PCB concentrations from stores in Washington—indicating that they are available.

Therefore, safer alternatives (inks with lower PCB concentrations) are feasible and available. However, because we believe we are preempted by federal TSCA regulations, our regulatory determination on PCBs in printing inks is no action.

Per- and polyfluoroalkyl substances (PFAS)

RCW 70A.350.010[38] defines perfluoroalkyl and polyfluoroalkyl substances as a class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom. This priority chemical class includes the full class of PFAS.

PFAS are called forever chemicals because they do not break down in the environment. Some bioaccumulate, so they build up in species higher up the food chain. Nearly all of us have PFAS in our bodies. This poses a problem because many PFAS are associated with human and environmental health concerns. Many of the PFAS with enough data are carcinogenic, reproductive, and developmental toxicants and toxic to fish. Washington state rules list some

[38] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.010

PFAS as persistent, bioaccumulative, and toxic chemicals (WAC 173-333-310[39]) and chemicals of high concern to children (WAC 173-334-130[40]).

Leather and textile furniture and furnishings

Leather and textile furniture and furnishings can expose people and the environment to PFAS. Manufacturers apply PFAS topically on furniture and furnishings to make them easier to clean. In some furniture and furnishings, such as outdoor furnishings, PFAS applied topically may make the surface of the furnishing more water-resistant. Over time, PFAS can wear off, ending up in house dust and escaping into the environment.

For indoor furnishings, alternative materials and processes that do not require surface stain treatments are safer, feasible, and available. These include designing furniture so consumers can remove and wash the upholstery, using inherently stain-resistant fabric, or using wipeable materials. In many cases, untreated upholstery performs how consumers expect.

For outdoor furnishings, alternative materials and processes that do not require surface stain treatments are safer and available. However, we did not identify an alternative textile or leather material used in outdoor furnishings that does not require a surface stain treatment. We conclude that these alternative materials and processes are not feasible for outdoor furnishings at this time.

Restricting the use of PFAS in leather and textile furniture and furnishings would reduce a significant source of exposure for people and the environment. Our regulatory determinations are:

- A restriction on PFAS in indoor leather and textile furniture and furnishings.
- A reporting requirement on PFAS in outdoor leather and textile furniture and furnishings.

Carpets and rugs

Carpets and rugs can expose people and the environment to PFAS. PFAS from carpet escape into house dust, indoor air, and ultimately the environment. Babies and young children spend more time on the floor, so they are more exposed to PFAS from carpets and rugs. A recent study replaced PFAS-containing carpets and furniture with PFAS-free carpets and furniture. The PFAS levels in the dust decreased by more than 70%.

Alternatives to PFAS used in carpets and rugs are safer, feasible, and available. They include not only safer carpet treatments but also alternative processes to avoid the need for carpet treatments all together. Restricting the use of PFAS in carpets and rugs would reduce a significant source of exposure for people and the environment. Our regulatory determination is a restriction on PFAS in carpets and rugs.

[39] https://apps.leg.wa.gov/wac/default.aspx?dispo=true&cite=173-333-310
[40] https://apps.leg.wa.gov/wac/default.aspx?dispo=true&cite=173-334-130

Aftermarket stain- and water-resistance treatments

Consumers apply aftermarket stain- and water-resistance treatments to finished products made of leather or textiles. This product category does not include treatments manufacturers apply. Examples of products to which consumers apply aftermarket treatments include:

- Outdoor apparel and gear—raincoats, shoes, tents, and gear.
- Outdoor textiles—furniture or other upholstery.
- Indoor textiles—carpets and rugs, furniture, or other upholstery.

Aftermarket stain- and water-resistance treatments can expose people to PFAS when they apply the treatment or as it wears off over time. Similarly, PFAS in these products can escape into the environment during use (for outdoor products, especially), laundering, and disposal.

Safer aftermarket treatments and alternative processes that avoid the need for aftermarket treatments are feasible and available. Restricting the use of PFAS in aftermarket treatments would reduce a significant source of exposure for people and the environment. Our regulatory determination is a restriction on PFAS in aftermarket stain- and water-resistance treatments used for leather and textile products (including indoor and outdoor furniture and upholstery, and outdoor apparel and gear).

Phenolic compounds—bisphenols

RCW 70A.350.010[41] defines phenolic compounds as bisphenols and alkylphenol ethoxylates. Bisphenol A and bisphenol S are the most studied bisphenols. However, other bisphenols are also included in this priority chemical class.

Almost everyone is exposed to bisphenols. That’s a problem because some bisphenols are linked to cancer, hormone disruption, reproductive toxicity, and developmental toxicity. Some are also toxic to fish. Bisphenol A and bisphenol S are chemicals of high concern to children (RCW 70A.240[42]).

One bisphenol, TMBPF (tetramethyl bisphenol F), does not share the same hormone disrupting traits, reproductive toxicity, or developmental toxicity as other well-studied bisphenols. Based on this evidence, TMBPF may be a safer alternative in some product applications.

Food and drink cans with linings

Food and beverage can linings can expose people and the environment to bisphenols. Bisphenols found in can linings can migrate into food or beverages. Authoritative bodies estimate diet is the largest source of exposure to bisphenols (including canned food and beverages). Children are more exposed to bisphenols from their diet than adults are, because they consume more relative to their body weight. Restricting the use of bisphenols in food and drink cans would reduce a significant source of exposure to people and the environment.

[41] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.010

[42] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.240

Safer alternatives to replace bisphenols in beverage can linings are feasible and available. We did not identify safer, feasible, and available alternatives to replace bisphenols in food can linings. Food and drink cans have many different properties and performance needs. These differences affect the composition of the lining, so the safer alternatives we identified for beverage cans are not applicable to food cans. We identified bisphenol-free food can linings, but without a transparent list of ingredients, we could not evaluate their hazards. Our regulatory determinations are:

- A restriction on bisphenols (excluding TMBPF) in beverage can linings.
- A reporting requirement on bisphenols (excluding TMBPF) in food can linings.

Thermal paper

Thermal paper—including receipts, tickets, and packing labels—can expose people and the environment to bisphenols. Authoritative bodies estimate thermal paper is the second largest source of bisphenol exposure (behind diet). People are exposed to bisphenols from touching thermal paper. Retail workers handle receipts on the job, and often have higher levels of bisphenols in their bodies than the general population. Thermal paper also releases bisphenols into the environment through recycling, wastewater treatment plant effluent, and landfill leachate.

Safer alternatives to replace bisphenols in thermal paper are feasible and available. Bisphenols are developers in the reaction that adds color onto thermal paper. Alternatives include safer developers and processes that avoid using thermal paper all together. Restricting the use of bisphenols in thermal paper would reduce a significant source of exposure for people and the environment. Our regulatory determination is a restriction on bisphenols in thermal paper.

Phenolic compounds—alkylphenol ethoxylates

RCW 70A.350.010[43] defines phenolic compounds as bisphenols and alkylphenol ethoxylates (APEs). Nonylphenol ethoxylates and octylphenol ethoxylates are the most commonly used and well-studied APEs. However, other APEs are also included in the priority chemical class. APEs and their breakdown products are associated with health and environmental concerns—such as hormone disruption, aquatic toxicity, and persistence. Monitoring studies find APEs in almost all environmental media in Washington.

Laundry detergent

Laundry detergent can expose people and the environment to APEs. Manufacturers use APEs in laundry detergents as surfactants to help clean clothing and linens. We estimated that laundry detergents are likely the largest use of APEs currently in commerce. When we wash laundry detergents with APEs down the drain, they make their way through wastewater treatment plants to water bodies. There, they can harm aquatic life.

Manufacturers use safer surfactants in laundry detergents, and they are available for purchase. That means we consider them feasible and available. Restricting the use of APEs in laundry

[43] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.010

detergent would reduce a significant source of exposure for people and the environment. Our regulatory determination is a restriction on APEs in laundry detergent.

Ortho-phthalates

Based on the definitions in RCW 70A.350.010[44] and in the National Library of Medicine, this priority chemical class includes ortho-phthalates.

Nearly everyone is exposed to ortho-phthalates. Ortho-phthalates are associated with carcinogenicity, reproductive and developmental toxicity, and hormone system disruption. Washington state rules list some ortho-phthalates as chemicals of high concern to children (RCW 70A.240[45]). Ortho-phthalates do not persist in the environment, but their constant release has led to recontamination of cleanup sites.

Vinyl flooring

Vinyl flooring can expose people and the environment to ortho-phthalates. Manufacturers use ortho-phthalates as plasticizers to add flexibility to vinyl flooring. They are not bound to the product. That means they can escape into house dust, indoor air, and the environment when consumers use and dispose products. Babies and young children spend more time on the floor and therefore face more exposure to chemicals in house dust. Children living in homes with vinyl flooring have higher levels of ortho-phthalates in their bodies.

During our stakeholder engagement process, industry representatives shared that they already moved away from using ortho-phthalates in vinyl flooring. We used our authority under RCW 70A.350.040 to request information from vinyl flooring manufacturers. The information we received to date showed most manufacturers moved away from ortho-phthalates and are already using safer alternatives. However, some manufacturers still reported using ortho-phthalates. Vinyl flooring is a significant source of ortho-phthalate exposure for people purchasing these products.

Manufacturers widely use safer plasticizers in vinyl flooring products, meaning safer alternatives are feasible and available. Restricting the use of ortho-phthalates in vinyl flooring would reduce a significant source of exposure for people and the environment. Our regulatory determination is a restriction on ortho-phthalates in vinyl flooring.

Personal care and beauty products

Fragrances in personal care and beauty products expose people and the environment to ortho-phthalates. Manufacturers add ortho-phthalates to fragrances as solvents and fixatives to preserve scents. People are exposed through these products when they inhale, ingest, or absorb ortho-phthalates dermally.

During our engagement process, industry stakeholders shared that many manufacturers already moved away from ortho-phthalates in fragrances. However, lingering ortho-phthalate

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[44] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.010
[45] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.240

use can lead to disproportionate exposures. As recently as 2018, studies analyzing hair care products marketed to black people detected ortho-phthalates in the majority of products tested. Washington's Low Income Survey and Testing Project found that exposure to ortho-phthalates used in fragrances is higher in low-income women of childbearing age and teenagers than the general Washington population. We can avoid these disproportionate exposures.

Safer alternatives are feasible and available to replace ortho-phthalates used in fragrances in personal care and beauty products. Fragrances are complex mixtures, so we identified a wide variety of safer alternatives that are marketed as solvents and fixatives and currently used in personal care and beauty products. We did not identify any types of products where safer alternatives are not currently in use.

Restricting the use of ortho-phthalates in fragrances in personal care and beauty products would reduce a significant source of exposure and begin addressing disproportionate exposures. Our regulatory determination is a restriction on ortho-phthalates used in fragrances for personal care and beauty products.

Technical analyses overview

In the following chapters of this report, the priority products are organized by the priority chemical class they contain. These chapters outline the results of the technical analysis (required in RCW 70A.350.040[46]) aiming to identify safer, feasible, and available alternative chemicals or processes for each priority chemical-product combination. Each chapter includes:

- A definition of the scope of the priority chemical class.
- An overview of the hazards of the priority chemical class.
- A review of the technical analysis for each priority product including:
    - The scope of the priority product under consideration.
    - The function of the priority chemical in the priority product.
    - An assessment of whether alternatives are safer, feasible, and available.
    - A summary of how the potential regulation would reduce a significant source or use of the priority chemical.

Conclusion

Our regulatory determinations are restrictions on the following chemical-product combinations:

- Organohalogen flame retardants in:
    - External plastic device casings for electric and electronic products intended for indoor use.
- Organohalogen and organophosphate flame retardants in RCW 70A.430[47] in recreational polyurethane:

[46] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.040
[47] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.430

    - Uncovered foam
    - Covered floor mats
    - Covered flooring
    - Outdoor recreational products
- PFAS in:
    - Carpets and rugs
    - Indoor leather and textile furnishings
    - Aftermarket stain- and water-resistance treatments for leather and textile products
- Bisphenols in:
    - Thermal paper
    - Drink can linings
- APEs in laundry detergent
- Ortho-phthalates in:
    - Vinyl flooring
    - Fragrances used in personal care and beauty products

Our regulatory determinations are reporting requirements for the following chemical-product combinations:

- Organohalogen flame retardants in external plastic device casings for electric and electronic products intended for outdoor use
- Organohalogen and organophosphate flame retardants listed in RCW 70A.430[48] in recreational polyurethane covered wall padding
- PFAS in outdoor leather and textile furniture and furnishings
- Bisphenols in food can linings

[48] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.430

Chapter 1: Flame Retardants

Chapter overview

The Washington State Legislature identified two groups of flame retardants as priority chemicals:

- The class of organohalogen flame retardants (HFRs).
- Five organophosphate flame retardants (OPFRs) identified under Chapter 70A.430[49] RCW.

Ecology and Health (jointly "we") identified electric and electronic enclosures and recreational polyurethane foam products containing flame retardants as priority products.

We considered the hazards associated with HFRs as a class and the individual OPFRs. We determined HFRs as a class do not meet our minimum criteria as outlined in our criteria for safer (see the hazards of organohalogen flame retardants section of this chapter).

We determined that three of the five organophosphate flame retardants identified under RCW 70A.430 did not meet our minimum criteria for safer. Two met our minimum criteria, but not our additional criteria for safer (see the hazards of organophosphate flame retardants section of this chapter).

We approach "safer" as a spectrum. The OPFRs that met our minimum criteria for safer are less hazardous than HFRs, which do not meet our minimum criteria for safer. In cases where flame retardants are necessary to meet flammability standards, these OPFRs are safer alternatives.

Therefore, we focused our analysis on alternatives that do not require flame retardants (recreational polyurethane foam) and alternatives to HFRs (electric and electronic enclosures). This step reduces the use of chemicals that fail to meet our minimum criteria for safer. However, the OPFRs that meet our minimum criteria for safer are not optimal chemicals. As the field of safer chemistry progresses, it may be possible to move beyond our minimum criteria and identify flame retardants that meet our additional criteria for safer. In cases where flame retardants are not necessary and it is possible to maintain fire safety in other ways, avoiding any flame retardants is the least hazardous option.

Based on the relative difference in hazards between OPFRs and HFRs and the relevant performance requirements for electric and electronic enclosures and recreational polyurethane foam products, we scoped our analysis to assess:

- Safer, feasible, and available alternatives to HFRs and the OPFRs identified in RCW 70A.430 in recreational polyurethane foam products.
- Safer, feasible, and available alternatives to HFRs in electric and electronic enclosures.

[49] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.430

Recreational polyurethane foam

We considered the volume of flame retardants (HFRs and those identified under RCW 70A.430[50]) used in recreational polyurethane foam products and their contribution as a source of flame retardants in the environment and a source of potential human exposure (see the reducing a significant source or use section of this chapter). We identified recreational polyurethane foam that does not contain flame retardants as a safer alternative process that is feasible and available. (See the alternatives are safer, feasible, and available subsection of the recreational polyurethane foam section of this chapter.)

Electric and electronic enclosures

We considered the volume of organohalogen flame retardants (HFRs) used in electric and electronic enclosures and their contribution as a source of flame retardants in the environment and a source of potential human exposure (see the reducing a significant source or use section of this chapter). We identified safer chemical alternatives for use in electric and electronic enclosures that meet our minimum or additional criteria and that are feasible and available. We also identified safer alternative processes that do not require the use of flame retardants. (See the alternatives are safer, feasible, and available subsection of the electric and electronic enclosures section of this chapter.)

Scope of priority chemical class

The law identifies two groups of flame retardants as priority chemicals:

- Organohalogen flame retardants.
- Flame retardants identified by the department under RCW 70A.430.

Class of organohalogen flame retardants

Organohalogen flame retardants (HFRs) are defined as a class on the basis of their chemical structure, physiochemical properties, and functional use. HFRs contain at least one atom of chlorine, bromine, fluorine, or iodine bonded directly to a carbon atom. Functionally, flame retardants are chemicals intentionally added to other materials and intended to slow ignition and progression of fires. Flame retardants are added to products to meet flammability standards and are sometimes used as part of an approach to address fire safety. Specific HFRs already identified under RCW 70A.430 are also included in the scope of this priority chemical class.

[50] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.430

Organophosphate flame retardants

Flame retardants identified by the department under the Children's Safe Product Act (RCW 70A.430[51]) include five organophosphate flame retardants (OPFRs). These OPFRs are listed as chemicals of high concern to children:

- Triphenyl phosphate (TPP).
- Tri-n-butyl phosphate (TNBP).
- Ethylhexyl diphenyl phosphate (EHDPP).
- Tricresyl phosphate (TCP).
- Isopropylated triphenyl phosphate (IPTPP).

Because OPFRs are not identified in the law as a chemical class, we evaluate them as individual chemicals identified under RCW 70A.430 and listed in WAC 173-334-130.[52]

Hazards of organohalogen flame retardants (HFRs)

Organohalogen flame retardants as a priority chemical class

We approach HFRs as a class because RCW 70A.350.010 defines HFRs collectively as a priority chemical. In addition, the statute's directive is reasonable and well supported for several reasons:

- HFRs are persistent in the environment.
- Studies associate many HFRs with adequate toxicology information with adverse health effects, including carcinogenicity, mutagenicity, reproductive and developmental toxicity, and endocrine activity.
- Discontinued use of some HFRs led to increased use of other HFRs—growing the potential for exposure to both currently used HFRs and cumulative exposure to current and persistent legacy HFRs.

HFRs are persistent in the environment. This is due to the inherent strength of carbon-halogen bonds and the high energy required to break them. As they are used in and released from products, persistent chemicals (such as HFRs) will continue to build up in the environment (Cousins, 2019a). Consequently, as levels in the environment continue to increase, the potential for exposure also increases. This scenario warrants caution—continual and increasing exposure to HFRs may lead to presently unforeseen effects and adverse impacts.

Further, once persistent chemicals distribute in the environment, it is difficult, costly, and in some instances nearly impossible to address the contamination in a reasonable timeframe. Put simply, once these chemicals are released, it is much more difficult to control the consequences.

[51] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.430
[52] https://apps.leg.wa.gov/wac/default.aspx?cite=173-334-130

This context matters because studies already associate many HFRs used in products with adverse health and environmental impacts. Several well-studied members of the HFRs class:

- Are known carcinogens.
- Cause demonstrable, adverse effects on development.
- Can act as endocrine disruptors.

Many HFRs are also toxic to aquatic life, and some have the potential to bioaccumulate. We discuss this in more detail below.

Further, HFRs as a class have a history of regrettable substitution. An example of this is a group of flame retardants known as polybrominated biphenyls (PBBs), which are HFRs that were used in the 1970s. PBBs were banned in 1976 after impacts on animals and in humans were observed following an accidental contamination of livestock feed with PBBs in 1973 (EPA, 2017a). The long-term effects in humans exposed to PBBs from this incident continue to be documented (MDHHS, n.d.; Rollins School of Public Health, n.d.).

As the use of PBBs was discontinued, the use of a group of HFRs called polybrominated biphenyl ethers (PBDEs) increased. PBDEs became widely used as flame retardants in electric and electronic equipment, furniture, textiles, and other household products. Again, as studies linked adverse impacts with exposure, PBDEs were regulated in some jurisdictions, including Washington. Production progressively ceased in the U.S., followed by a significant new use rule EPA published in 2012 (EPA, 2017b).

This led manufacturers to increase their use of other HFRs—many show adverse effects in scientific studies, and only some are subject to regulation (see Appendix F for more information). Although PBBs and PBDEs are largely no longer used in product manufacturing, they are still found in the environment and in people—long after we became aware of their impacts and discontinued the majority of uses (Chang et al., 2020; Sjödin et al., 2019). Legacy HFRs are highly persistent—highlighting the potential for both:

- Exposure to currently used HFRs.
- Cumulative exposure to currently used HFRs in combination with legacy HFRs.

Approaching the use of HFRs in consumer products on a single chemical basis imparts unacceptable potential adverse effects on the environment and human health for future generations. With this in mind, it is necessary to consider HFRs together as a chemical class for several reasons:

- The persistent nature of HFRs.
- The association between exposure to many HFRs and adverse impacts on human health and the environment.
- The historical context of regrettable substitution for this class of chemicals that has led to the potential for ongoing and cumulative exposures.

Although it is difficult to predict the long-term impacts of currently used HFRs, it is practical to consider the potential for exposure to these chemicals proactively because of their high environmental persistence. In addition to concerns about the persistence of HFRs, there are also end-of-life concerns related to their use in products (Needhisasan et al., 2014; Perkins et al., 2014; Soderstrom & Marklund, 2002). Therefore, to protect human health and the environment, it is necessary to consider the HFRs priority chemical class as a whole.

At request of the Consumer Product Safety Commission (CPSC), the National Academies of Science (NAS) developed a scoping plan to address HFRs as a chemical class (NAS, 2019). The NAS concluded, in part, that "the only possible practical approach for a set of chemicals as large as the organohalogen flame retardants is a class approach." They also outlined that HFRs "have several characteristics that could define them as a single class" and that "those characteristics could define them as a single class for some decision contexts, but are not entirely workable for conducting a hazard or risk assessment under the CPSC regulations."

Our regulatory framework, and as a result our decision context, is different from the CPSC risk assessment context. RCW 70A.350.040 authorizes Ecology to restrict priority chemicals in priority consumer products when safer alternatives are feasible and available and a restriction would reduce a significant source or use. Based on the requirements in RCW 70A.350, we conclude that for our decision context, it is reasonable to address HFRs as a class of chemicals.

Approach for setting the criteria for safer

We approach safer as a spectrum, using minimum or additional criteria to identify safer alternatives. We based both our minimum and additional criteria on 18 hazard endpoints and we describe them in detail in Appendix C. Our evaluation of the hazards of the priority chemical class informs the criteria alternatives need to meet to be considered safer than the existing chemical or process.

We applied elements of the hazard assessment scoping plan from the National Academies of Sciences' Class Based Approach to Organohalogen Flame Retardants (NAS, 2019) to assess the hazards of HFRs as a class.

We first determined whether the class definition in the law is unified by "structure, physiochemical properties, biology, or some combination thereof." We concluded that HFRs can be defined by structure based on the RCW 70A.350.010[53] definition of organohalogen: "any chemical containing one or more halogen elements bonded to carbon."

As described above, the National Academies of Sciences determined that HFRs could not be addressed as a class for a CPSC regulation based on hazard or risk assessment. Conversely, for different decision contexts, they concluded that the class could be grouped by structure, physiochemical properties, biology, or some combination thereof. We determined HFRs can be grouped as a class when identifying safer alternatives.

We then reviewed the data rich chemicals within the class. Data rich chemicals either:

- Were evaluated by authoritative sources.
- Have third-party reviewed or publicly available hazard assessments that we can compare against our criteria for safer.

[53] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.010

We determined whether each data rich chemical met or failed to meet our minimum criteria for safer. This approach assumes that data poor chemicals within the class are potentially hazardous. It helps us avoid the pitfalls of assuming chemicals with limited hazard data or data gaps are not hazardous. If the data rich chemicals in the class fail to meet the minimum criteria for safer, then alternatives that do are safer.

In cases of toxicological diversity, where some data rich chemicals in the class meet and others fail to meet the minimum criteria for safer, we relied on two options (described in Appendix C):

1. Using the criteria (minimum or additional) that allows us to identify alternatives that are safer than the data rich priority chemicals potentially found in the priority product.
2. Using the minimum criteria to conservatively identify alternatives that are safer than the data rich hazardous chemicals in the class.

Because there was toxicological diversity within the HFRs class (see hazards of data rich HFRs), we considered the hazards of the HFRs that met the minimum criteria for safer and their relevance to the hazards of the class as a whole. We also considered the chemicals potentially found in the priority products we are evaluating.

We did not identify any HFRs that met our within-class criteria. Using the within-class criteria to identify safer chemicals within the class helps prevent regrettable substitutions. Chemicals within the class are more likely to share hazards (Chen et al., 2016; Cordner et al., 2016; Lioy et al. 2015; NAS, 2019; Vos et al., 2003). Therefore, we need to approach them with added caution (Birnbaum et al., 2021; Blum et al., 2015, DiGangi et al., 2010).

Studies associate many HFRs with carcinogenicity, mutagenicity, reproductive and developmental toxicity, or endocrine disruption (see hazards of data rich HFRs). In order to confirm that each HFR does not share these hazards, the within-class criteria requires evidence that the chemical is not associated with these endpoints. It also does not allow for chemicals that have high or very high persistence according to our criteria for safer (Appendix C).

Chemicals in classes with known, persistent hazards are problematic because it is difficult to reduce exposure if we learn about hazards after contamination. The within-class criteria sets a transparent bar for identifying chemicals within the class that have sufficient data showing they are safer and excluding them. See a full description in Appendix C.

Hazards of the data rich HFRs

We determined that the majority of HFRs do not meet our minimum criteria for safer. In making this determination, we considered available data on 18 hazard endpoints (described in our criteria for safer) for members of the chemical class. To identify chemicals to characterize the class, we utilized the group of 161 HFRs listed in the 2019 National Academies of Sciences (NAS) consensus report. The group of 161 HFRs includes those Ecology previously identified (Ecology, 2015, 2021b; NAS, 2019). To determine hazards associated with the chemical class, we reviewed existing hazard assessments, authoritative listings, and reports from other regulatory bodies for the 161 HFRs the NAS report identified.

The available data on HFRs characterize these chemicals as often sharing similar hazards. The majority of HFRs are also associated with unacceptable environmental fate characteristics. We consider several hazard endpoints as associated with the class because they score high for at least one HFR with an existing hazard assessment. HFRs presence on authoritative lists also informed the determination of hazard endpoints considered associated with the class.

A list of HFRs that are data rich with existing hazard assessments is included in Table 3. Appendix E describes how existing hazard assessment methods meet or fail to meet our minimum criteria for safer. We identified 11 HFRs with existing GreenScreen® hazard assessments and 10 additional HFRs with Scivera GHS+ hazard assessments. This is not an exhaustive list of chemicals included in the HFRs class, rather it is included to illustrate the hazards of 21 well-studied HFRs.

Of the 11 HFRs with existing GreenScreen® assessments, six chemicals scored as BM-1 (Table 3). Further, an additional 10 of the 161 HFRs scored red in verified Scivera GHS+ assessments. Four of 161 HFRs listed were scored as BM-2, and one was scored as BM-U in GreenScreen® assessments; three of those assessments are expired (Table 3).

One of these HFRs, 2,2-bis(chloromethyl)trimethylene bis(bis(2-chloroethyl)phosphate) (V6), had its benchmark score adjusted by Ecology from a BM-2 to a BM-1_{TP} based on the presence of tris(2-chloroethyl) phosphate (TCEP) as an impurity (TCEP scored BM-1) (Ecology, 2015). The subscript "TP" indicates that the Benchmark score was driven by transformation products. Based on this revision, V6 does not meet our minimum criteria for safer.

During public comment on our draft report, we received a new GreenScreen® for decabromodiphenyl ethane (DBDPE),[54] scoring it BM-2 (ToxServices, 2021k). Previously, DBDPE scored BM-1 (NSF Sustainability, 2017). The new assessment included additional information on several endpoints, including developmental toxicity. DBDPE scored as high for developmental toxicity in the previous BM-1 assessment, but scored as moderate in the new GreenScreen®. The previous assessment used data from a structurally similar chemical, decabromodiphenyl ether (DecaBDE) to score this endpoint, while the new assessment referenced data on DBDPE summarized by ECHA and Health Canada. Review of the new assessment indicates that DBDPE does meet our minimum criteria for safer.

The other two BM-2 HFRs, 2-ethylhexyltetrabromobenzoate (TBB) and bis(2-ethylhexyl) tetrabromophthalate (TBPH), may meet our minimum criteria for safer. However, the assessments expired and to our knowledge, no updated assessments are currently available (CPA, 2014a, 2014b).

We also assessed whether DPDBE could meet our within-class criteria for safer based on the updated assessment. Our within-class criteria requires chemicals within the priority chemical class to score low for hazards associated with the class. Carcinogenicity, developmental toxicity, aquatic toxicity, persistence, and bioaccumulation are associated with the HFRs class due to at

[54] https://scs-public.s3-us-gov-west-1.amazonaws.com/env_production/oid100/did200002/pid_202268/assets/merged/9x0vika_document.pdf?v=376V8B5UH

least one member of the class scoring high or very high for these endpoints (see the sections on specific endpoints below for more information).

DPDBE scores moderate for developmental toxicity in the new assessment (ToxServices, 2021k). This score fails our within-class criteria (which requires a low score for this endpoint). Our within-class criteria also does not allow for chemicals with high or very high persistence. DBDPE scores as very high for persistence and therefore fails this requirement as well. Our within-class criteria applies more protective requirements for members of the priority chemical class because the law lists the class due to known association with unacceptable hazards to human health and the environment.

The other two BM-2 HFRs, 2-ethylhexyltetrabromobenzoate (TBB) and bis(2-ethylhexyl) tetrabromophthalate (TBPH), also do not meet our within-class criteria as described in our criteria for safer. Both still score as high for persistence and high for bioaccumulation, and do not score low for several of the human health endpoints associated with the HFRs priority chemical class (CPA, 2014a, 2014b).

Of the remaining HFRs not present on authoritative lists or without hazard assessments, there was insufficient data to demonstrate any do not share similar hazards to other HFRs. This conclusion is consistent with opinions expressed by the scientific community in the San Antonio Statement on Brominated and Chlorinated Flame Retardants*,* which was signed by over 200 scientists from 30 countries with expertise on human health, the environment, and fire safety (Birnbaum & Bergman, 2010). The statement summarizes concerns from scientific experts on the persistent, bioaccumulative, and toxic properties of chlorinated and brominated flame retardants, their use, and resulting exposure in humans and wildlife.

We also considered that HFRs are broadly separated into two groups: additive and reactive (Ecology, 2015). Additive flame retardants are not chemically bound to the materials used in products, but are dispersed in the material matrix. This means additive flame retardants can more easily escape the material matrix and be released into the surrounding environment.

In contrast, reactive flame retardants are chemically reacted with the materials used in products and are chemically bound in the material matrix. This lowers the potential for reactive flame retardants to escape into the surrounding environment compared to additive flame retardants. However, these chemicals can still be released from the matrix due to:

- Material degradation
- Incomplete reaction with the matrix
- Material contamination with unreacted residuals

To our knowledge, the HFRs with existing hazard assessments are examples of additive flame retardants. One notable exception to this is TBBPA, which can be either an additive or reactive flame retardant (Ecology, 2015). TBBPA does not meet our minimum criteria for safer due to its presence on several authoritative lists (Table 3).

We did not identify any other hazard assessments of materials using reactive HFRs that meet our minimum criteria for safer. Additionally, we focus on source reduction across the product lifecycle—products with reactive HFRs can still contribute to environmental contamination upon disposal, and can hinder recycling efforts. Overall, we did not find sufficient reason to separate additive and reactive HFRs in our hazard analysis of the chemical class.

We did not further separate the HFRs into subclasses, as our approach considers the aggregate hazards of chemicals within the class as a whole, and does not attempt to group them by any specific mechanism of action. The majority of the data rich HFRs (e.g., present on authoritative lists or with hazard assessments) do not meet our minimum criteria for safer, and no HFRs used in the priority products identified meet our within-class criteria. Therefore, we consider the entire HFRs class potentially hazardous. This approach follows option one in scenario four for evaluating chemical classes in our criteria for safer—making a conservative decision to classify the class based on the data rich hazardous chemicals, and seeking alternatives that meet the minimum criteria.

As mentioned above, we consider several hazard endpoints associated with the HFRs class. This is due to at least one chemical in the class scoring high or very high for the endpoint in a hazard assessment. The hazard endpoints associated with HFRs include carcinogenicity, developmental toxicity, aquatic toxicity, persistence and bioaccumulation.

Carcinogenicity

Many of the chemicals in the HFRs class are suspected or known carcinogens. Short chain chlorinated paraffins (SCCP) are on the EU – Annex VI CMRs list as suspected human carcinogens (ECHA, 2020a). TBBPA is included on authoritative lists such as California Proposition 65, and International Agency for Research on Cancer (IARC) lists it as a carcinogen (IARC, 2021; OEHHA, 2021). Tris(2-chloroethyl) phosphate (TCEP) and tris(1,3-dichloro-2-propyl) phosphate (TDCPP) also score high for carcinogenicity in GreenScreen® assessments, and are listed under California Proposition 65 as carcinogens (CPA, 2014f, 2014d; OEHHA, 2021). In total, we identified 25 HFRs in the NAS group present on authoritative lists as suspected or known carcinogens (ECHA, 2021a; HBN, 2021; OEHHA, 2021).

Our minimum criteria do not allow for chemicals that score high for carcinogenicity (Appendix C). Thirteen of the 21 HFRs with GreenScreen® or Scivera assessments fail this criteria (Table 3). Three of the 21 HFRs with existing assessments have data gaps for this endpoint. An additional 11 HFRs in the NAS group would fail based on their presence on authoritative lists (ECHA, 2021a; HBN, 2021; OEHHA, 2021). Only one HFR scored low for this endpoint—based on classification as not carcinogenic to humans by U.S. EPA (hexachlorocyclopentadiene).

To meet our within-class criteria, an HFR would need to score low for carcinogenicity, in addition to other criteria. We did not identify any HFRs that meet these requirements.

Developmental toxicity

Multiple chemicals in the HFRs class are associated with developmental toxicity. Sixteen HFRs are present on authoritative lists as developmental toxicants (HBN, 2021). Our minimum criteria requires that chemicals score moderate or lower for developmental toxicity (Appendix C). Sixteen of the HFRs in the NAS group would fail based on their presence on authoritative lists (EHCA, 2020a; HBN, 2021; OEHHA, 2021). Eight additional HFRs are present on screening lists for developmental toxicity (Grandjean & Landrigan, 2006, 2014). Only one HFR scored low for this endpoint in a GreenScreen® assessment: ethylene bis(tetrabromophthalimide) (NSF International, 2017c).

To meet our within-class criteria, an HFR would need to score low for developmental toxicity, in addition to meeting other criteria. We did not identify any HFRs that meet these requirements.

Aquatic toxicity

Several HFRs with existing hazard assessments are highly toxic to aquatic organisms. However, there is some variability within the class for this endpoint. Short chain chlorinated paraffins (SCCP) scored very high for acute and chronic aquatic toxicity in a GreenScreen® assessment and are classified under EU – GHS as very toxic to aquatic life (H400) (ToxServices, 2018a). Tetrabromobisphenol A also scored very high for acute aquatic toxicity and high for chronic aquatic toxicity, and is also classified under EU – GHS as very toxic to aquatic life (H400) (CPA, 2014c). Other HFRs that score as high for aquatic toxicity include:

- Tris(2-chloroethyl) phosphate (TCEP) (CPA, 2014f).
- Tris(1,3-dichloro-2-propyl) phosphate (TDCPP) (CPA, 2014d).
- Tris(2-chloroisopropyl) phosphate (TCPP) (CPA, 2014g).
- 2,2-Bis(chloromethyl)trimethylene bis(bis(2-chloroethyl)phosphate) (V6) (CPA, 2014e).

HFRs do not fail our minimum criteria for safer based on acute or chronic aquatic toxicity alone (Appendix C). If acute or chronic aquatic toxicity score very high, a chemical fails our minimum criteria if either persistence or bioaccumulation also score high. Similarly, if acute or chronic aquatic toxicity score high, a chemical fails if either persistence or bioaccumulation also score very high.

Persistence and bioaccumulation

Due to the chemistry of halogenated organic compounds, many HFRs have very high persistence in the environment. Further, many HFRs also have very high bioaccumulation potential. All of the following HFRs score very high for persistence in GreenScreen® assessments:

- Decabromodiphenyl ethane (NSF International, 2017a; ToxServices, 2021k).
- Short chain chlorinated paraffins (SCCP) (ToxServices, 2018a).
- Tris(2-chloroisopropyl) phosphate (TCPP) (CPA, 2014g).
- 2,2-Bis(chloromethyl)trimethylene bis(bis(2-chloroethyl)phosphate) (V6) (CPA, 2014e).
- 1,3,5-Triazine, 2,4,6-tris(2,4,6-tribromophenoxy)- (TBBP-TAZ) (NSF International, 2017b).
- Tris(1,3-dichloro-2-propyl) (TDCPP) phosphate (CPA, 2014d).

Tetrabromobisphenol A (TBBPA), ethylene bis(tetrabromophthalimide), 2-ethylhexyltetrabromobenzoate, and bis(2-ethylhexyl) tetrabromophthalate all score high for persistence. The authoritative list by the Oslo and Paris Conventions Commission (OSPAR) also includes brominated flame retardants as chemicals for priority action due to their persistence, bioaccumulative, and toxic properties (OSPAR, 2009). The vast majority of the 161 HFRs in the NAS list are brominated flame retardants. Many of these and other HFRs are also present on additional authoritative or screening lists as persistent or bioaccumulative (ECHA, 2020a, 2021a, 2021b; Government of Canada, 2021a, 2021b). As mentioned previously, the San Antonio Statement on Chlorinated and Brominated Flame Retardants also describes persistence and bioaccumulation as properties associated with this class of chemicals (Birnbaum & Bergman, 2010).

To meet our minimum criteria for safer, persistence and bioaccumulation cannot both score very high (Appendix C). This is in addition to the requirements described above for aquatic toxicity when persistence or bioaccumulation score high or very high.

Conclusions

The HFRs class is defined based on chemical structure, physiochemical properties, and functional use, as described above. Although we observed some toxicological diversity within the class, the majority of data rich HFRs with existing hazard assessments do not meet our minimum criteria for safer (16 of 21 HFRs with GreenScreen® or Scivera assessments). The four HFRs that scored BM-2 and one that scored BM-U in expired assessments all fail our within-class criteria. Of the remaining HFRs, none have sufficient data to demonstrate they do not share similar hazards to the data rich HFRs. Based on this information, and the product-specific information described below, we made the conservative decision to classify the class as potentially hazardous based on the data rich chemicals. We will seek alternatives to HFRs that meet our minimum criteria for safer.

Recreational polyurethane foam

HFRs are found in recreational polyurethane foam products including: pentabromodiphenyl ether (PentaBDE), TBPH, TBB, tris(1,3-dichloro-2-propyl)phosphate (TDCPP), and V6 as summarized previously in our report to the Legislature on priority consumer products[55] (Ecology, 2020a). PentaBDE and TDCPP fail to meet our minimum criteria for safer due to presence on authoritative lists. V6, TBB, and TBPH all fail our within-class criteria for safer as they score moderate or higher for hazard endpoints associated with the HFRs class.

For this priority product, we identified alternatives that do not contain HFRs, and, therefore, we consider removing the priority chemical a safer alternative process (see the alternatives are safer, feasible, and available subsection of the recreational polyurethane foam section of this chapter).

Electric and electronic enclosures

HFRs are found in electric and electronic enclosures including DecaBDE, DBDPE, TTBP-TAZ, TBBPA, and 1,2-Bis(2,4,6-tribromophenoxy)ethane (BTBPE), as summarized previously in our report to the Legislature on priority consumer products (Ecology, 2020a). 1,3,5-Triazine,2,4,6-tris(2,4,6-tribromophenoxy) (TTBP-TAZ) and TBBPA fail to meet our minimum criteria due to scoring BM-1 in GreenScreen® assessments. DecaBDE and BTBPE both fail to meet our

[55] https://apps.ecology.wa.gov/publications/summarypages/2004019.html

minimum criteria, as they are present on authoritative lists. DBDPE meets our minimum criteria for safer, but does not meet our additional or within-class criteria.

Based on existing hazard assessments, we found variability within the members of the HFRs class used in electric and electronic enclosures. As outlined in our criteria for safer, when we find variability in the priority chemical class, we rely on members of the class used in the product to set our criteria for identifying safer alternatives. Most HFRs used in electric and electronic enclosures do not meet our minimum criteria. However, a new DBDPE assessment suggests there is some variability in the hazards of HFRs used in the application we are evaluating.

Overall, among the range of HFRs used in electric and electronic enclosures, a majority do not meet our minimum criteria, while a minority do meet our minimum criteria. None of the HFRs meet our additional or within-class criteria for safer. Therefore, alternative chemicals must meet at least our minimum criteria to be considered safer alternatives to using HFRs in electric and electronic enclosures.

Table 3. Organohalogen flame retardants (HFRs) with existing hazard assessments.

Common name, associated CAS(s)	Meets minimum criteria?	Hazard assessment score(s)—GreenScreen®, List Translator, ChemFORWARD or Scivera	Endpoints of concern based on hazard score (high or very high) or Authoritative listings
Short chain chlorinated paraffins (SCCP) 85535-84-8	NO	BM-1 Scivera GHS+ red	**Carcinogenicity:** EU – Annex VI CMRs (Carc 2) MAK Carcinogen (Carc 3B) EU – GHS (H351) **Acute and chronic aquatic toxicity:** EU – GHS (H400) **Persistence:** WA Ecology OSPAR EU – SVHC Candidate List EU – SVHC Prioritisation List **Bioaccumulation:** WA Ecology OSPAR EU – SVHC Candidate List EU – SVHC Prioritisation List
Decabromodiphenyl ethane 84852-53-9	NO	BM-2 (previously BM-1, see above)	Persistence

Common name, associated CAS(s)	Meets minimum criteria?	Hazard assessment score(s)—GreenScreen®, List Translator, ChemFORWARD or Scivera	Endpoints of concern based on hazard score (high or very high) or Authoritative listings
Tetrabromobisphenol A (TBBPA) 79-94-7	NO	BM-1 Scivera GHS+ red ChemFORWARD Hazard Band F	**Carcinogenicity:** CA Prop 65 IARC (2A) **Acute and chronic aquatic toxicity:** EU – GHS (H400) **Persistence:** WA Ecology U.S. EPA – TRI OSPAR **Bioaccumulation:** WA Ecology U.S. EPA – TRI OSPAR
Tris(2-chloroethyl) phosphate (TCEP) 115-96-8	NO	BM-1 Scivera GHS+ red	**Carcinogenicity:** CA Prop 65 **Reproductive toxicity:** EU – GHS (H360F) EU – Annex VI CMRs (Repr 1B) EU – SVHC Candidate List EU – SVHC Prioritisation List Acute aquatic toxicity, neurotoxicity (single-dose), persistence
Tris(1,3-dichloro-2-propyl) phosphate (TDCPP) 13674-87-8	NO	BM-1 Scivera GHS+ red	**Carcinogenicity:** CA Prop 65 Acute and chronic aquatic toxicity, and persistence
1,3,5-Triazine,2,4,6-tris(2,4,6-tribromophenoxy) (TBBP-TAZ) 25713-60-4	NO	BM-1	Persistence, bioaccumulation
Ethylene bis(tetrabromophthalimide) 32588-76-4	NO	BM-1	Persistence, bioaccumulation
Tris(2-chloroisopropyl) phosphate (TCPP) 13674-84-5	NO	BM-U (expired)	Acute aquatic toxicity, persistence

Common name, associated CAS(s)	Meets minimum criteria?	Hazard assessment score(s)—GreenScreen®, List Translator, ChemFORWARD or Scivera	Endpoints of concern based on hazard score (high or very high) or Authoritative listings
2,2-Bis(chloromethyl)trimethylene bis(bis(2-chloroethyl) phosphate) (V6) 38051-10-4	YES	BM-2 (expired)	Chronic aquatic toxicity, persistence
2-Ethylhexyltetrabromobenzoate (TBB) 183658-27-7	YES	BM-2 (expired)	Persistence, bioaccumulation
Bis(2-ethylhexyl) tetrabromophthalate (TBPH) 26040-51-7	YES	BM-2 (expired)	Persistence, bioaccumulation
Tribromophenol 118-79-6	NO	Scivera GHS+ red LT-1	Reproductive toxicity, endocrine activity, dermal sensitization, dermal and eye irritation, acute and chronic aquatic toxicity
Tris(2,3-dibromopropyl) phosphate (TDBPP) 126-72-7	NO	Scivera GHS+ red LT-1	Carcinogenicity, mutagenicity, systemic toxicity, persistence, acute and chronic aquatic toxicity
Octabromodiphenyl ether 32536-52-0	NO	Scivera GHS+ red LT-1	Carcinogenicity, reproductive toxicity, developmental toxicity, endocrine activity, persistence, acute aquatic toxicity
Chlorendic acid 115-28-6	NO	Scivera GHS+ red LT-1	Carcinogenicity, dermal and eye irritation, persistence
Perchloropentacyclodecane 2385-85-5	NO	Scivera GHS+ red LT-1	Carcinogenicity, endocrine activity, acute toxicity, dermal irritation, acute and chronic aquatic toxicity, persistence, and bioaccumulation
Hexabromobiphenyl 36355-01-8	NO	Scivera GHS+ red LT-1	Carcinogenicity, developmental toxicity, endocrine activity, persistence
Decabromobiphenyl 13654-09-6	NO	Scivera GHS+ red LT-1	Carcinogenicity, developmental toxicity, endocrine activity, persistence

Common name, associated CAS(s)	Meets minimum criteria?	Hazard assessment score(s)—GreenScreen®, List Translator, ChemFORWARD or Scivera	Endpoints of concern based on hazard score (high or very high) or Authoritative listings
Chlorinated paraffin 63449-39-8	NO	Scivera GHS+ red	Carcinogenicity, endocrine activity, acute and chronic aquatic toxicity, persistence, and bioaccumulation
2,2-Bis(bromomethyl) propane-1,3-Diol (DBNPG) 3296-90-0	NO	Scivera GHS+ red LT-1	Carcinogenicity, mutagenicity
2,3-Dibromo-1-propanol 96-13-9	NO	Scivera GHS+ red LT-1	Carcinogenicity, acute toxicity, acute aquatic toxicity

Referenced hazard assessments

- The GreenScreen® assessment for short chain chlorinated paraffins (SCCP) (CAS: 85535-84-8) is available from the ToxServices database[56] (ToxServices, 2018a).
- The GreenScreen® assessments for tetrabromobisphenol A (TBBPA), tris(1,3-dichloro-2-propyl) phosphate (TDCPP), tris(2-chloroisopropyl phosphate), bis(2-ethylhexyl) tetrabromophthalate (TBPH), 2-ethylhexyltetrabromobenzoate (TBB), 2,2-bis(chloromethyl)trimethylene bis(bis(2-chloroethyl)phosphate) (V6), and tris (2-chloroethyl) phosphate (TCEP), tris(2-chloro-1-methyl) phosphate (TCPP) (CPA, 2014a, 2014b, 2014c, 2014d, 2014e, 2014f, 2014g) are available from the IC2 Chemical Hazard Assessment Database.[57]
- The GreenScreen® assessments for decabromodiphenyl ethane (DBDPE) (CAS: 84852-53-9), 1,3,5-triazine, 2,4,6-tris(2,4,6-tribromophenoxy)- (CAS:25713-60-4), and ethylene bis(tetrabromophthalimide) (CAS: 32588-76-4) are available on the Pharos website[58] (NSF International, 2017a, 2017b, 2017c).
- The updated GreenScreen® assessment for decabromodiphenyl ethane (DBDPE) (CAS: 84852-53-9) is available in the public comment provided by the ACC North American Flame Retardant Alliance (NAFRA) (ToxServices, 2021k).
- The Scivera GHS+ assessments for alkanes, C10 – 13, chloro (CAS: 85535-84-8), tetrabromobisphenol A (CAS: 79-94-7), tris(2-chloroethyl) phosphate (CAS: 115-96-8), tris(1,3-dichloro-2-propyl) phosphate (CAS: 13674-87-8), tribromophenol (CAS: 118-79-6), tris(2,3-dibromopropyl) phosphate (CAS: 126-72-7), octabromodiphenyl ether (CAS: 32536-52-0), chlorendic acid (CAS: 115-28-6), perchloropentacyclodecane (CAS: 2385-

[56] https://database.toxservices.com
[57] https://theic2.org/hazard-assessment
[58] https://pharosproject.net/

85-5), hexabromobiphenyl (CAS: 36355-01-8), decabromobiphenyl (CAS: 13654-09-6), chlorinated paraffin (CAS: 63449-39-8), 2,2-Bis(bromomethyl) propane-1,3-Diol (CAS: 3296-90-0) and 2,3-Dibromo-1-Propanol (CAS: 96-13-9) are available on the Scivera website[59] (Scivera 2021a, 2021b, 2021c, 2021d, 2021e, 2021f, 2021g, 2021h, 2021i, 2021j, 2021k, 2021l, 2021m, 2021n).

- The ChemFORWARD assessment for tetrabromobisphenol A (TBBPA) is available on the ChemFORWARD website.[60]
- GreenScreen® List Translator (LT) scores were determined using Licensed GreenScreen® List Translator Automators: Toxnot search tool[61] or Pharos website.[62]

Hazards of organophosphate flame retardants (OPFRs)

Organophosphate flame retardants as priority chemicals

We are not evaluating OPFRs as a chemical class, only those specified under RCW 70A.430,[63] consistent with RCW 70A.350.010(12)(d).[64]

Approach for setting the criteria for safer

We approach safer as a spectrum, using minimum or additional criteria to identify safer alternatives. We based both our minimum and additional criteria on 18 hazard endpoints (see more detail in Appendix C). Our evaluation of the hazards of the priority chemical class informs the criteria alternatives need to meet to be considered safer than the existing chemical or process.

In this case, we determined whether the priority chemicals listed in the law met our minimum criteria for safer. Some of the OPFRs listed in the law met our minimum criteria for safer and others did not. Safer alternatives to some OPFRs need to meet the minimum criteria for safer. For other OPFRs, alternatives need to meet the additional criteria for safer. Alternatives without flame retardants are safer than all five of the OPFRs listed in the law.

[59] https://www.scivera.com/ghsplus/
[60] https://www.chemforward.org/
[61] https://toxnot.com/Substances/Search
[62] https://www.greenscreenchemicals.org/learn/greenscreen-list-translator
[63] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.430
[64] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.010

Hazards of data rich OPFRs

There are five OPFRs identified by RCW 70A.430, including two with existing GreenScreen® assessments and one isomeric mixture with an existing GreenScreen® assessment for the ortho-isomer present in the mixture. We described how existing hazard assessments meet or fail to meet our minimum criteria for safer in Appendix E. The OPFRs identified under RCW 70A.430 are listed in Table 4.

Triphenyl phosphate (TPP) scored BM-2 in a GreenScreen® assessment and meets our minimum criteria for safer (CPA, 2014i; TCO Certified, 2022). TPP is scored moderate for carcinogenicity and endocrine activity. TPP scored very high for both acute and chronic aquatic toxicity, but scores as low for persistence and bioaccumulation.

Ethylhexyl diphenyl phosphate (EHDPP) scored yellow overall in a Scivera GHS+ hazard assessment and this meets our minimum criteria for safer (Scivera, 2021o). EHDPP scores as moderate for both carcinogenicity and reproductive toxicity. EHDPP scores as very high for acute and chronic aquatic toxicity, high for persistence, and moderate for bioaccumulation.

Isopropylated triphenyl phosphate (IPTPP) scored BM-2 in an expired GreenScreen® assessment (CPA, 2014h). However, EPA has since designated it as a PBT, and already established a final rule on IPTPP (EPA, 2021a). A more recent ChemFORWARD assessment scored IPTPP as band F which does not meet our minimum criteria for safer (Table 4).

There has not been a GreenScreen® conducted on tricresyl phosphate (TCP, mixed isomers), however triorthocresyl phosphate was assessed and scored as BM-1. We consider this a strong surrogate for the isomeric mixture as the score would likely reflect the presence of the BM-1 ortho-isomer if present in the mixture above 100 ppm (CPA, 2018; ToxServices, 2018b). Triorthocresyl phosphate scored high for reproductive toxicity and moderate for mutagenicity, developmental toxicity, and endocrine activity. Triorthocresyl phosphate also scored very high for acute toxicity, systemic toxicity (single and repeat-dose), neurotoxicity (single-dose), and acute as well as chronic aquatic toxicity. Further, the EPA scored TCP (mixed isomers) as high for reproductive toxicity and systemic toxicity (repeat-dose) using the Design for the Environment Criteria (DfE) in a 2015 report (EPA, 2011a, 2015b). Based on this, TCP also does not meet our minimum criteria for safer.

Tributyl phosphate did not have sufficient data available to determine whether it could meet our minimum criteria.

Based on the available information, TPP and EHDPP are the only OPFRs identified by RCW 70A.430[65] that meet our minimum criteria for safer.

[65] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.430

Recreational polyurethane foam

Several OPFRs are used in recreational polyurethane foam products—including TPP and IPTPP—either individually or in mixtures with HFRs, as summarized previously in our report to the Legislature on priority consumer products[66] (Ecology, 2020a). Some OPFRs that are used in recreational polyurethane foam products meet our minimum criteria for safer (TPP, EHDPP). However, since the priority chemical is not necessary in this product, removing it is considered safer than using those OPFRs if flammability requirements are met. For this priority product, we determined that flame retardants are not necessary to meet flammability standards for most applications and identified alternatives that do not contain any flame retardants.

Electric and electronic enclosures

For this product category, we found HFRs as a priority chemical class do not meet our minimum criteria. We did not evaluate the OPFRs identified under RCW 70A.430[67] for electric and electronic enclosures as priority chemicals. Therefore, OPFRs that meet our minimum criteria are considered safer alternatives to HFRs in these products.

Table 4. Non-organohalogen flame retardants defined in RCW 70A.430.

Common name, associated CAS(s)	Meets minimum criteria?	Hazard assessment score(s)—GreenScreen®, List Translator, or Scivera	Endpoints of concern based on hazard score (high or very high) or authoritative listings
Triphenyl phosphate (TPP) 115-86-6	YES	BM-2 Scivera GHS+ yellow ChemFORWARD Hazard Band C	Acute and chronic aquatic toxicity
Tributyl phosphate (TNBP) 126-73-8	Unknown	LT-P1	**Skin irritation:** EU – GHS (H315)
Tricresyl phosphate (mixed isomers) (TCP) 1330-78-5	NO*	LT-P1	
Triorthocresyl phosphate (TCP) 78-30-8	NO	BM-1 Scivera GHS+ red	**Systemic toxicity (single-dose):** EU – GHS (H370) Acute and chronic aquatic toxicity, acute toxicity, reproductive toxicity, neurotoxicity (single and repeat-dose)
Ethylhexyl diphenyl phosphate (EHDPP) 1241-94-7	YES	LT-P1 Scivera GHS+ yellow	Acute toxicity, acute and chronic aquatic toxicity, bioaccumulation

[66] https://apps.ecology.wa.gov/publications/documents/2004019.pdf
[67] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.430

Common name, associated CAS(s)	Meets minimum criteria?	Hazard assessment score(s)—GreenScreen®, List Translator, or Scivera	Endpoints of concern based on hazard score (high or very high) or authoritative listings
Isopropylated triphenyl phosphate (IPTPP) 68937-41-7	NO	BM-2 (expired) ChemFORWARD Hazard Band F	Acute and chronic aquatic toxicity, bioaccumulation

Note: * = TCP (mixed isomers) (CAS: 1330-78-5) does not meet our minimum criteria for safer due to the BM-1 score for the ortho-isomer (as described previously).

Referenced hazard assessments

- The hazard assessments for triphenyl phosphate (TPP) (CPA, 2014i, 2018), triorthocresyl phosphate (TCP) (ToxServices, 2018b), and isopropylated triphenyl phosphate (IPTPP) (CPA, 2014h) are available from the IC2 Chemical Hazard Assessment Database.[68]
- The Scivera GHS+ assessments for Ethylhexyl diphenyl phosphate (CAS: 1241-94-7), Triphenyl phosphate (CAS: 115-86-6) and Triorthocresyl phosphate (CAS: 78-30-8) are available on the Scivera website[69] (Scivera 2021o, 2021p, 2021q).
- The ChemFORWARD assessments for triphenyl phosphate (TPP) and isopropylated triphenyl phosphate (IPTPP) are available from the ChemFORWARD website.[70]
- GreenScreen® List Translator (LT) scores were determined using Licensed GreenScreen® List Translator Automators: Toxnot search tool[71] or Pharos website.[72]

Priority product: Recreational polyurethane foam

Scope of priority product

Recreational foam products are those that are made from polyurethane foam, and are used as padding in recreational and athletic facilities—such as indoor climbing, gymnastics and athletic gyms, schools, and trampoline parks. Examples of recreational foam products include:

- Foam pit cubes.
- Mats and pads—including crash mats, landing mats, training mats, panel mats, martial arts mats, and wall and post pads.

This priority product does not include outdoor playground equipment, padding designed to be worn, or building insulation materials.

[68] https://theic2.org/hazard-assessment
[69] https://www.scivera.com/ghsplus/
[70] https://www.chemforward.org/
[71] https://toxnot.com/Substances/Search
[72] https://www.greenscreenchemicals.org/learn/greenscreen-list-translator

Function of priority chemical in priority product

To identify potential safer alternatives, we first determine whether the priority chemical is necessary to meet the performance requirements of the priority product at the chemical, material, product, or process level. If the priority chemical is not necessary, the chemical can be removed and there is no need to identify alternatives.

We determined that the function provided by the priority chemical is not necessary for the performance of the priority product in most cases. Flame retardant chemicals are added in products to meet flammability standards. Flammability standards are one way to promote and maintain fire safety. However, for the majority of the recreational polyurethane foam products, there are no required standards. We determined that for those products, flame retardants are not a necessary element in the fire control and response measures used to maintain fire safety in the facilities where they are used. We came to this conclusion after extensive stakeholder engagement with the fire safety community. Because fire safety is important, we supplement our analysis using surrogate standards when relevant.

For those products with a flammability standard, most products can meet requirements without the addition of flame retardants to the foam. However, for wall padding, we were not able to identify that the alternatives can meet the flammability requirements in the relevant building codes, as described below.

Alternatives are safer, feasible, and available

Alternatives are safer

We determined that flame retardants are not necessary for performance of recreational polyurethane foam for most products and uses (see the alternatives are feasible and available section). The alternatives we identified are polyurethane foam products that do not contain flame retardants. Since the alternatives only remove the priority chemical and do not change anything else, no further assessment of safer is needed.

Alternatives are feasible and available

Flame retardant chemicals are intended to slow ignition and progression of fires. They are added to products to meet flammability requirements, developed by authoritative organizations that oversee product or building safety. Given differences in the product types, locations of use, and flammability requirements, when evaluating alternatives, we separated recreational polyurethane foam products into five subcategories:

- **Covered wall padding**—products that are secured to the wall, are covered with fabric, and contain foam padding. They may or may not contain a backboard.
- **Covered floor mats**—products that are covered with fabric and contain foam padding.
- **Covered foam floors**—products that are secured to the floor, are covered with fabric, and contain foam padding.
- **Uncovered foam**—mobile uncovered foam cubes or padding.
- **Outdoor foam**—products that are covered with fabric and contain foam padding.

Flammability standards in the code and local authority

After discussions with stakeholders from the fire protection community, who are experts on building and fire codes and fire safety, our understanding is that the codes establish the minimum requirements for fire prevention and fire protection systems. The building codes specify flammability standards on certain materials attached to the building, for example interior finishes, but do not specify flammability standards for most furnishings (ICC, 2018a, 2018b; Seattle Department of Construction and Inspections, 2021; Washington State Building Code Council, 2020a, 2020b).

There are no flammability standards identified in the building codes for most recreational polyurethane foam products, including covered floor mats, uncovered foam, and outdoor foam. The building code does not address products that are for outdoor use. In addition to fire and building codes, flammability standards can also be required by organizations authorized to ensure the safety of products such as the Consumer Product Safety Commission (CPSC). For recreational foam products, there are no organizations that oversee product safety and require flammability standards for this category (Table 5). The standards required for building codes the subcategories are listed in Table 5.

Table 5. Flammability standard requirements for product subcategories.

Product type	Product examples	Flammability standards required for this product category according to building code	Flammability standard required for this product by CPSC or other state Bureau
Covered wall padding	Protective wall padding	ASTM E-84 (equivalent to UL 723, NFPA 255) or NFPA 286 (Seattle Department of Construction and Inspections, 2021).	None
Covered floor mats	Athletic floor mat	None	None
Covered foam floors	Rock climbing gym attached floors	Exempted if the covering is considered a "traditional type" (Seattle Department of Construction and Inspections, 2021)	None
Uncovered foam	Foam pit blocks	None	None
Outdoor foam	High jump mat, football blocking dummies	N/A	None

State and local fire marshals have the authority to perform inspections and enforce the implementation of fire prevention and protection measures. While the building and fire codes do not specify flammability standards, we learned that in lieu of a specified standard, surrogate standards are sometimes used. A surrogate standard would be a standard that is required for a closely related product. This is subject to the local authority's interpretation.

Products without flammability requirements in the code

Flammability standards are one way to promote and maintain fire safety. If there are no relevant flammability standards for a product, we conclude that flame retardants in those products are not a necessary element in the fire control and response measures used to maintain fire safety in the facilities where they are used. This conclusion is based on engagement with the fire safety community. As described in Table 5, we did not identify any required flammability standards for covered floor mats, uncovered foam, or outdoor foam in the code. As such, flame retardants are not necessary for these product categories.

However, because fire safety is of paramount importance, we supplemented our analysis using surrogate standards when relevant. For foam pits, marketing material indicates that manufacturers sometimes use the California Technical Bulletin 117 (TB-117) or Technical Bulletin 117-2013 (TB-117-2013) as surrogate standards. California TB-117 is an outdated standard, replaced by California TB-117-2013. TB-117-2013 is intended for regulation of flammability of upholstered furniture, which by definition does not include 'furniture used exclusively for the purpose of physical fitness and exercise' (State of California, 1996). In June 2021, it was also adopted by the CPSC for upholstered furniture, but not for recreational products (CPSC, 2021).

TB-117-2013 can be met without the addition of flame retardants, so if a local authority requires this standard as a surrogate for recreational polyurethane foam, flame retardants are not necessary. An example of foam pit cubes meeting this standard without the use of flame retardants is in the marketing materials of DGS (DGS, 2019). A product manufacturer of wall padding and floor mats also shared documentation that the foam they use meets TB-117-2013 without the use of flame retardants (AK Athletics, 2021). They also disclosed that the cover material used in these products passes ASTM E-84 class A and NFPA 701 tests (AK Athletics, 2021).

In addition, a study conducted by the Worcester Polytechnic Institute (WPI) Fire Protection Engineering Department in collaboration with the Toxics Use Reduction Institute (TURI) at University of Massachusetts, Lowell compared the fire resistance of polyurethane foam cubes containing flame retardants to cubes without added flame retardants. This study demonstrated that both foams met a smolder standard, which was similar to the test described in TB-117-2013 (Dembsey et al., 2019). The study also demonstrated that pits containing foam blocks, with or without flame retardants, can produce severe fires when exposed to small, open flame ignition sources.

The feasibility of flame retardant free foam is further supported by gyms that practice fire safety without the use of flame retardants. An example of this is a gym in Massachusetts—Gymnastics and More. Staff replaced all of their facilities' loose pit foam with flame retardant free foam with the approval of their local fire department (TURI, 2018).

Products with flammability requirements in the code

In the building code, there are requirements for interior finishes so that they "do not significantly add to or create fire hazards in buildings" (Seattle Department of Construction and Inspections, 2021). These requirements vary based on factors like location, occupancy, and use of active fire protection methods (e.g., building sprinklers). These include requirements for interior wall and floor finishes.

While there are some requirements for some types of interior floor finishes, there are exceptions in the code. If the floor finish or covering is a traditional type such as wood, vinyl, linoleum, terrazzo, or resilient floor covering materials that are not composed of fibers, they are exempted from the required sections on floor finishes (Seattle Department of Construction and Inspections, 2021). Consultation with a floor system installer revealed that they do not specify foam with any level of flame retardancy. However, if a jurisdiction requires fire resistance from the flooring, the carpeting or vinyl coated fabric used to cover the foam has met the need without the addition of flame retardants in the foam (Cascade Specialty, 2021). This approach aligns with the exemption in the code for traditional floor finishes (e.g., vinyl).

For wall padding, the code references products meeting flammability standard ASTM E-84 or NFPA 286 for interior finishes. For ASTM E-84, the fire rating class that the wall padding needs to meet varies. We have not found any wall padding products that contained polyurethane foam that meet ASTM E-84 Class A, therefore we did not assess this category. Class A is required in some interior stairways, ramps and corridors for exits but does not appear to be required in rooms and enclosed spaces where wall padding could be used for recreational purposes (Seattle Department of Construction and Inspections, Table 803.3, 2021).

We also did not find any wall padding products that provided information on meeting ASTM E-84 Class B or C. When asked about products that were not Class A, one manufacturer shared that the only flame retardant component of their wall pads, if they are not Class A, is the cover. The foam used in these products is polyester foam (with 60% recycled content) and the cover material is an 18 oz. vinyl, which meets NFPA 701, test method 2 (CoverSports, 2021). This appears to align with other polyurethane wall padding products that are not Class A—where the textile cover used on the wall padding meets the ASTM E-84 Class A rating and NFPA 701. We received confirmation from one manufacturer that flame retardants were not used in the foam of these products (AK Athletics, 2021). An installer also communicated to us that foam and backboards in these products are not fire rated, and only the cover material is fire rated in these products (Wall Padding Solutions, 2021).

Availability of alternatives

We identified several manufacturers and retailers that offer polyurethane foam products without flame retardants (Table 6). This includes examples of both covered and uncovered polyurethane foam products including foam pit cubes, landing mats, flooring systems, and replacement foam. A study researchers at Duke University conducted further supports the finding that recreational foam without flame retardants is available. In the study, flame retardants were not detected in 6 of 39 of the gymnastics pit cubes at over 1% by weight (Cooper et al., 2016). Follow-up communication from Duke University researchers described only 64% of gym equipment tested as containing flame retardants at greater than 1% by weight (Duke University Foam Project, 2021). The database containing this information does not specify the product type in all instances. However, it was noted that out of 110 samples tested, 67 were pit cubes and 20 were landing mats. This further supports the determination that flame retardant free recreational polyurethane foam products are available.

Table 6. Availability of flame retardant free polyurethane foam products by type, manufacturer, or retailer, and additional product information.

Product type	Manufacturer or retailer*	Product information*
Uncovered foam	Envirolite	Foam Pit Cubes and Mat replacement foam (Envirolite, 2021a)
Uncovered foam	DGS	Foam Pit Cubes (DGS, 2019)
Uncovered foam	BFF Foam Corporation	Foam Pit Cubes (Gymnast Collaborative, 2021)
Uncovered foam	Future Foam	Foam Pit Cubes (AK Athletic, 2021b; Gymnast Collaborative, 2021)
Covered floor mats	Envirolite	Landing mats (Envirolite, 2021a)
Covered floor mats	Carolina Supply	Soft Landing Mats, Above Ground Resi Mats (Carolina Gym, 2021)
Covered floor mats	AK Athletic	Polyurethane foam products (AK Athletic, 2021b)
Covered foam floors	Cascade Specialty	Impact Floor Systems (Cascade Specialty, 2021)
Covered wall padding	AK Athletic	Class A rated vinyl covered wall padding (AK Athletic, 2021a, 2021b)

Note: * = Any reference in this publication to persons, organizations, services, products, or activities does not constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

In summary, we determined that flame retardants in recreational polyurethane foam are not necessary to meet fire safety requirements, and that flame retardant free foam is both feasible and available for use in recreational applications.

Additional fire safety considerations

While flame retardants are not needed to meet fire codes for the majority of these products, fire safety is of utmost importance. It can be maintained with a combination of appropriate fire control and response measures. Examples of recommendations to ensure fire safety include, but are not limited to (TURI, 2018):

- A fire evacuation plan for the facility approved by the local fire department.
- An appropriate sprinkler system that transmits an alarm to a monitoring system.
- Egress from all points in the building compliant with the requirements of the existing Washington state building code.
- Adherence to all state and local requirements for fire system impairments.
- Hot works and general fire safety in facilities that contain recreational polyurethane foam products.

To help address this concern, we sought additional information through engaging the Washington fire protection community. The information gathered further supports the determination that flame retardants are not necessary in these products to meet flammability standards, and that other approaches, including proper fire detection and suppression systems, are being used to meet fire safety requirements.

Conclusions

We determined that safer alternatives to HFRs and OPFRs in recreational polyurethane foam are feasible and available for four of the five product categories (uncovered foam, covered floor mats, covered foam floors, and outdoor foam) (Table 7 and Table 8). The safer alternatives in these cases are products that use polyurethane foam without added flame retardants.

For wall padding, we were able to demonstrate safer alternatives are available, but we could not demonstrate they are feasible alternatives. We were able to find products without added flame retardants that are available on the market, but did not have sufficient information to determine whether they can meet flammability requirements in the fire code.

Restricting the use of flame retardants in recreational foam would reduce a significant source of exposure to people and the environment.

Table 7. Feasibility and availability of alternative(s) for recreational foam products.

Product category	Available	Feasible
Uncovered foam	Yes. On the commercial market and available by request.	Yes. No specific standard, meet surrogate standard (TB-117-2013).
Covered floor mats	Yes. On the commercial market.	Yes. No specific standard, meet surrogate standard (TB-117-2013).
Covered foam floors	Yes. Installer does not specify flame retardants in foam. Vinyl cover used to meet flammability requirements.	Yes. Exempted from interior finish standard with vinyl cover.
Outdoor foam	Yes.	Yes. No specific standard.
Wall padding	Yes.	Could not be determined.

Table 8. Questions from IC2 Guide for evaluating feasibility and availability of alternative(s).

IC2 Guide feasibility and availability metrics	Determination
Is the alternative used for the same or a similar function?	Yes. Recreational polyurethane foam products without flame retardants are currently used.
Is the alternative used in similar products on the commercial market?	Yes. Polyurethane foam without added flame retardants is available on the commercial market.
Is the alternative marketed in promotional materials for application of interest?	Yes. Recreational polyurethane foam products without flame retardants are marketed for the same uses.

IC2 Guide feasibility and availability metrics	Determination
Is this a favorable alternative based on answers to the above questions?	Yes. Recreational polyurethane foam products (uncovered foam, covered floor mats and foam floors, and outdoor foam products) without added flame retardants are a favorable alternative. We did not identify feasible and available flame retardant free wall padding.

Reducing a significant source or use

In order to restrict or prohibit priority chemicals in priority products, RCW 70A.350.040[73] requires Ecology and Health to determine that either:

- The restriction will reduce a significant source or use of a priority chemical, or
- The restriction is necessary to protect the health of sensitive populations or sensitive species.

We identified recreational polyurethane foam products as a significant source or use of organohalogen and specific organophosphate flame retardants in our 2020 report to the Legislature.[74] That report became effective at the end of the 2021 legislative session on April 25, 2021. Based on that report, we determined that restricting any of the chemical-product combinations in that report would reduce a significant source or use of a priority chemical class. With this determination, further evaluating whether a restriction would reduce a significant source or use (RCW 70A.350.040(3)(b)(ii)) is not required by statute.

As described in our report to the Legislature on priority consumer products (Ecology, 2020a), several flame retardants are used in recreational polyurethane foam products at concentrations above 1% of the total product mass, and in one study the range was estimated between 2 and 6.5% (Carignan et al., 2013; Ecology, 2020a). Based on the number of facilities in Washington that contain or may contain foam pits, we estimated over 500,000 foam pit blocks could be present in the state. Additionally, we estimated that approximately 800,000 square feet of mats that may contain flame retardants are used in gym facilities in Washington. As the thickness of these mats will vary from a few inches to many feet, it is difficult to determine how much foam this represents.

Flame retardants in recreational foam accumulate in dust where they can be inhaled, ingested, and come in contact with skin. There is widespread exposure to flame retardants in the U.S. population (Ospina et al., 2018). Gymnastic studios have higher levels of flame retardants in dust compared to homes (Carignan et al., 2013, La Guardia & Hale, 2015). In addition, gymnasts and gym employees have higher exposures (Carignan et al., 2013, 2016; Ceballos et al., 2018). Intervention studies where foam was replaced with flame retardant free foam showed reduced exposures (Ceballos et al., 2018; Dembsey et al., 2019). Foam products are also used in other recreational facilities including school auditoriums, climbing gyms and recreational centers.

[73] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.040

[74] https://apps.ecology.wa.gov/publications/summarypages/2004019.html

In addition to athletes such as gymnasts, this reduction in exposure could be especially important for sensitive populations such as workers, children, and people of childbearing age. Gymnastic coaches and facilities staff are exposed to flame retardants regularly at work. Children sometimes begin participating in activities in recreational facilities at an early age, and facilities such as gymnasiums offer parent-child classes for babies and toddlers. Training can involve even more time in the gym as these athletes grow older, and at the collegiate level, they are of childbearing age, which brings additional considerations and concerns for exposure.

Ecology determined that restricting flame retardants in recreational polyurethane foam products would reduce a significant use of these chemicals and reduce the potential for human exposure to protect sensitive populations.

Priority product: Electric and electronic products (device casings)

Scope of priority product

Device casings or enclosures of electric and electronic products include the exterior material of the electric or electronic product that serves as a barrier to surround "inaccessible electric component(s)." This includes the product stand. RCW 70A.350.010[75] defines "inaccessible electric component" as "a part or component of an electronic product that is located inside and entirely enclosed within another material and is not capable of coming out of the product or being accessed during any reasonably foreseeable use or abuse of the product." The scope includes the enclosures of electric and electronic products intended for indoor and outdoor use.

Examples of items included in the scope of device casings or enclosures are: the external housing material of personal computers, laptops, monitors, televisions, mobile phones, adaptors, kitchen appliances, washing machines, irons, and hair dryers, to name a few (not an exhaustive list).

Examples of items not included in the scope of electric and electronic enclosures are printed circuit boards, internal fans, wires, cords, cables, switches, light bulbs, connectors, and screens (however, the plastic enclosure surrounding the screen is in scope).

The scope also does not include wiring devices, control devices, electrical distribution equipment, and lighting equipment—which are hardwired into and become part of the fixed electrical wiring installation of a building. Further, components of electric and electronic products that are removable and replaceable, but not accessible once the product is in its assembled functional form, are not included in scope. Finally, products FDA regulates as medical devices are not included in the scope.

[75] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.010

Function of priority chemical in priority product

To identify potential safer alternatives, we first determine whether the priority chemical is necessary to meet the performance requirements of the priority product at the chemical, material, product, or process level. If the priority chemical is not necessary, the chemical can be removed and there is no need to identify alternatives.

We determined that the function provided by HFRs is sometimes necessary for the performance of plastic enclosures in electric and electronic products. Manufacturers incorporate flame retardant chemicals in plastic resins used in electric and electronic enclosures to meet certain flammability standards. As such, the application of interest is the plastic resin used in electric and electronic enclosures.

For some flammability standards, using flame retardants in plastic resins is not necessary to meet the standard. For others, the standard cannot be met without using flame retardants. Therefore, to be considered feasible for those applications, chemical alternatives will need to provide the flame retardant function of HFRs in plastic resins. We also identified alternative processes to meet flammability requirements without using chemical alternatives as flame retardants.

Alternatives are safer, feasible, and available

Alternatives are safer

Alternative chemicals

The majority of HFRs used in electric and electronic enclosures do not meet our minimum criteria for safer. While DBDPE does meet our minimum criteria, it does not meet our additional or within-class criteria for safer. We found that to meet flammability requirements for plastic electric and electronic enclosures, use of flame retardants is necessary in some applications. We identified several OPFRs that meet our minimum criteria for safer, and we consider these safer alternatives relative to using HFRs in these products. Several of the OPFRs also meet our more protective additional criteria for safer. This means that they are safer than DPDPE, which meets the minimum criteria but not the additional criteria. To identify safer alternatives, we used:

- Existing alternative assessments
- Reports on flame retardants
- TCO Certified Accepted Substance List

The TCO Certified Accepted Substance list contains non-organohalogen flame retardants that score BM-2 or better in GreenScreen® assessments. These flame retardants meet at least our minimum criteria for safer, and several are already used broadly in electric and electronic enclosures. Find a description of how GreenScreen®, Scivera GHS+, and ChemFORWARD hazard assessments meet or fail to meet our criteria in Appendix E. The OPFRs that meet our minimum or additional criteria for safer are described below and summarized in Table 9.

Triphenyl phosphate (TPP) (CAS: 115-86-6): TPP scored yellow overall in a verified Scivera GHS+ hazard assessment, and this meets our minimum criteria for safer (Scivera, 2021p). The assessment noted a data gap for sensory irritation. Sensory irritation does not align to an endpoint in our criteria, and we do not require data for this endpoint.

TPP scored as hazard band C in a ChemFORWARD assessment, and this meets our minimum criteria for safer. The assessment noted a data gap for carcinogenicity based on limited studies, but the available data was negative for carcinogenicity. The assessment flagged acute and chronic aquatic toxicity hazards that correspond to a score of very high in our criteria.

TPP scored BM-2 in a GreenScreen® assessment, and TCO Certified reviewed the assessment. This meets our minimum criteria for safer and our data requirements (CPA, 2014i; TCO Certified, 2022).

TPP as well as three HFRs (HBCD, TBBPA, TCEP) were identified as high priority chemicals under TSCA (EPA, 2019b). EPA is currently conducting risk evaluations on these flame retardants. If EPA finds unreasonable risk associated with TPP, it may restrict use. Based on the information in this report, we find that HFRs would be regrettable substitutions for TPP. Therefore, if there are future restrictions on TPP in electric and electronic enclosures, the other safer flame retardants identified in this section should be considered as possible replacements to TPP.

Resorcinol bis(diphenyl phosphate) (RDP) (CAS: 57583-54-7):

RDP scored hazard band C in a ChemFORWARD assessment and meets our minimum criteria for safer. The assessment noted one study that reported evidence of endocrine activity based on effects on thyroid and adrenal weights. However, other studies do not report endocrine-related effects. This resulted in a moderate score for endocrine activity with low confidence. The assessment also noted that chronic aquatic toxicity was observed in crustaceans at doses that correspond to a score of very high, but these effects have not been observed in vertebrates or algae.

RDP scored BM-2 in a GreenScreen® assessment, and the assessment was reviewed by TCO Certified. This meets our minimum criteria for safer (TCO Certified, 2022).

Bisphenol A bis(diphenyl phosphate) (BDP) (CAS: 181028-79-5, 5945-33-5):

BDP scored hazard band B in a ChemFORWARD assessment and meets our minimum and additional criteria for safer. The assessment notes a data gap for experimental data on carcinogenicity, but also indicates a low potential for carcinogenicity based on lack of structural alerts. Our data requirements can be met using structural alerts.

BDP scored BM-3 in a GreenScreen® assessment, and the assessment was reviewed by TCO Certified. This meets our minimum and additional criteria for safer (TCO Certified, 2022).

Together, the hazard band B score in the ChemFORWARD assessment and the BM-3 score in the GreenScreen® assessment demonstrate BDP meets both our minimum and additional criteria for safer.

Tetrakis(2,6-dimethylphenyl) 1,3-phenylenebisphosphate (CAS: 139189-30-3):

Tetrakis(2,6-dimethylphenyl) 1,3-phenylenebisphosphate scored hazard band B in a ChemFORWARD assessment and meets our minimum criteria for safer. The assessment notes moderate systemic toxicity (repeat-dose) and neurotoxicity (repeat-dose) for the inhalation route of exposure with low confidence. It also notes modeling data corresponding to a very high persistence score, but indicates low confidence due to a lack of supporting experimental data.

Tetrakis(2,6-dimethylphenyl) 1,3-phenylenebisphosphate scored as yellow overall in a verified Scivera GHS+ hazard assessment and meets our minimum criteria for safer (Scivera, 2021r). The assessment noted data gaps for endocrine activity, acute toxicity (inhalation only), respiratory sensitization, and sensory irritation. Data for endocrine activity is not required in our criteria and the assessment did not identify any data for this endpoint. Our criteria does not require data for acute toxicity for all routes of exposure, and the assessment scores acute toxicity for dermal and oral exposure as green, so this meets our data requirements. A data gap for respiratory sensitization is allowed, given that skin (dermal) sensitization scored yellow. Sensory irritation does not align to a specific endpoint in our criteria and we do not require data for this endpoint.

Tetrakis(2,6-dimethylphenyl) 1,3-phenylenebisphosphate scored BM-3 in a GreenScreen® assessment and the assessment was reviewed by TCO Certified. This meets our minimum and additional criteria for safer (TCO Certified, 2022).

Together, the hazard band B score in the ChemFORWARD assessment, yellow in the Scivera assessment, and BM-3 in the GreenScreen® assessment indicate that tetrakis(2,6-dimethylphenyl) 1,3-phenylenebisphosphate meets both our minimum and additional criteria for safer.

Polyphosphonate (CAS: 68664-06-2): Polyphosphonate scored BM-3 in a GreenScreen® assessment, and the assessment was reviewed by TCO Certified. This meets our minimum and additional criteria for safer (TCO Certified, 2022).

Diethylphosphinate, aluminum salt (CAS: 225789-38-8): Diethylphosphinate, aluminum salt scored hazard band B in a ChemFORWARD assessment. The assessment noted a data gap for carcinogenicity and neurotoxicity (single-dose). It also noted high persistence of the compound. However, bioaccumulation scored low (ChemFORWARD, 2020h).

Diethylphosphinate, aluminum salt scored BM-3 in a GreenScreen® assessment (ToxServices, 2019). The assessment scored carcinogenicity low based on an EPA assessment of analogous metal salts and negative modeling studies. Persistence scored very high, but bioaccumulation scored very low. This meets our minimum and additional criteria for safer.

Diethylphosphinate, aluminum salt scored yellow/green overall in a verified Scivera GHS+ hazard assessment (Scivera, 2021ag). The assessment notes a very high score for persistence, but bioaccumulation scored low. This meets our minimum and additional criteria for safer.

Diethylphosphinate, aluminum salt is included on the TCO Certified Accepted Substance List as a BM-3 chemical (TCO Certified, 2022). This further demonstrates it meets our minimum and additional criteria for safer.

Together, the hazard band B score in the ChemFORWARD assessment, yellow/green in the Scivera assessment, and BM-3 in the GreenScreen® assessment indicate that diethylphosphinate, aluminum salt meets our minimum and additional criteria for safer.

Poly(phosphonate-co-carbonate) (CAS: 77226-90-5):

Poly(phosphonate-co-carbonate) scored BM-3 in a GreenScreen® assessment (ToxServices, 2019, 2022a). The assessment scored all endpoints low except persistence, which scored very high, and bioaccumulation, which scored very low. The assessment noted that no catalyst is present in the polymer substance and residual monomers are present below 100 ppm. This meets our minimum and additional criteria for safer.

Poly(phosphonate-co-carbonate) is included on the TCO Certified Accepted Substance List as a BM-3 chemical (TCO Certified, 2022). This also meets our minimum criteria for safer.

Other flame retardants on TCO Certified Accepted Substance List

In addition to the safer alternatives above, other alternatives listed on the TCO Certified Accepted Substance List also meet our criteria for safer. Flame retardants on the TCO Certified Accepted Substance List scoring BM-2 meet our minimum criteria. Those scoring BM-3 meet our additional criteria (see Appendix E for more information). These offer manufacturers more options for non-organohalogen flame retardants to consider when designing products.

Table 9. Hazard assessment scores of identified alternatives.

CAS(s)	Common Name	Meets minimum criteria?	Meets additional criteria?	Hazard Assessment score(s)—GreenScreen®, ChemFORWARD, orScivera GHS+
115-86-6	Triphenyl phosphate (TPP)	YES	NO	BM-2 Scivera yellow ChemFORWARD Hazard Band C
57583-54-7	Resorcinol bis(diphenyl phosphate) (RDP)	YES	NO	BM-2 ChemFORWARD Hazard Band C
181028-79-5 5945-33-5	Bisphenol A bis(diphenyl phosphate) (BDP)	YES	YES	BM-3 ChemFORWARD Hazard Band B
139189-30-3	Tetrakis(2,6-dimethylphenyl) 1,3-phenylenebisphosphate	YES	YES	BM-3 Scivera yellow ChemFORWARD Hazard Band B
68664-06-2	Polyphosphonate	YES	YES	BM-3
225789-38-8	Diethylphosphinate, aluminum salt	YES	YES	BM-3 Scivera yellow/green ChemFORWARD Hazard Band B
77226-90-5	Poly(phosphonate-co-carbonate)	YES	YES	BM-3

We also found that to meet flammability standards for some applications, the identified OPFRs need to be combined with additives that provide an anti-drip function. This is commonly achieved by addition of fluoroorganic additives (e.g., polytetrafluoroethylene (PTFE)) to the enclosure material at low concentrations (up to 0.5%) to provide the necessary anti-drip function (for additional details on this requirement, see alternatives are feasible and available section below) (Pinfa, 2017; TCO Certified, 2019). PTFE does not meet our minimum criteria for safer. Therefore, in addition to our analysis of OPFRs, we also considered the relative exposure potential for a maximum of 0.5% PTFE in these products compared to using HFRs to meet flammability standards.

We consider the combination of the identified BM-2 or BM-3 OPFRs, or those listed on the TCO Certified Accepted Substance List, with a maximum of 0.5% PTFE to be a safer alternative to using HFRs in applications where the anti-drip function is required to meet flammability standards. Our rationale for this is based on data showing HFRs used in products at up to 25% by weight, and the relatively lower concentration of PTFE (up to 0.5%) required to provide the anti-drip function. Using the alternative BM-2 or BM-3 in combination with a maximum of 0.5% PTFE, when required, will reduce a significant use of HFRs and reduce the concentration of chemicals that fail to meet our minimum criteria for safer in products.

We identified electric and electronic enclosures as priority products for HFRs, not PFAS chemicals serving alternative functions to flame retardants. PFAS acting as anti-drip agents are not considered HFRs. Therefore, we did not evaluate whether safer alternatives to PFAS as anti-drip agents in electric and electronic products are feasible and available. We are not considering restricting PFAS used as anti-drip agents in this cycle of Safer Products for Washington.

There are, however, other efforts to restrict PFAS broadly in products. In 2021, Maine adopted a law that prohibits the sale of products with intentionally added PFAS after 2030 (Maine, 2021). The law also authorizes the Maine Department of Environmental Protection to identify and exempt currently unavoidable uses by rule (Maine, 2021). We did not determine whether there are alternatives to PFAS as anti-drip agents in this report. However, based on the analysis in this report, we can conclude that using HFRs at concentrations up to 25% by weight would be a regrettable substitution for PFAS used at concentrations less than 0.5% by weight as an anti-drip agent in these products. As manufacturers move away from PFAS, they should move toward safer alternatives.

Alternative processes

Another alternative for meeting flammability requirements is using an internal enclosure made of an inherently flame resistant material (e.g., metal) to serve the function of a fire enclosure—thereby reducing the flammability rating required for the exterior electronic enclosure (see alternatives are feasible and available section for more information) (UL, 2018). In addition, the external enclosure could itself be made of an inherently flame resistant material, such as steel, aluminum, or magnesium alloys, that can meet flammability requirements without the use of chemical flame retardants. These approaches do not require chemicals to replace priority chemicals, and we consider them safer alternative processes.

Alternatives are feasible and available

We determined that chemical alternatives identified in Table 9 are also feasible and available for use broadly in electric and electronic enclosures of products used indoors. We were unable to confirm that these alternatives were feasible and available in products intended for use in outdoor applications, because they may require additional considerations given the impacts of prolonged exposure to outdoor conditions.

Electric and electronic enclosures are commonly made of plastics or plastic blends that incorporate flame retardants to meet flammability standards. Flame retardant chemicals are marketed as compatible with specific plastics or plastic blends. Plastics or plastic blends containing additional chemistries and compatible flame retardants are sold as resins for use in enclosures of electric and electronic products.

To demonstrate the chemical alternatives we identified are feasible, we provide evidence that the alternatives are compatible with plastics and plastic blends commonly used in electric and electronic enclosures. We then provide examples of plastic resins that use safer alternatives and can meet the relevant flammability standards for electric and electronic enclosures.

To demonstrate the alternatives we identified are available, we focused on the application of interest. In this case, it is the plastic resins used in the enclosures of electric or electronic products. We show that the identified safer alternatives are available and used in plastics commonly found in electric and electronic enclosures. Further, we provide examples of plastic resins that are available and used in electric and electronic enclosures for broad range of products.

To further demonstrate how the alternatives we identified are feasible and available, we provide examples of existing electric and electronic products that are available on the market and that already use safer alternative chemicals and alternative processes.

Feasibility of alternatives

We demonstrate the feasibility of the safer alternatives we identified by showing:

- Safer alternative flame retardants are compatible with a variety of plastic blends commonly used in electric and electronic enclosures.
- Resins made using those plastic blends and safer alternative flame retardants can meet flammability requirements in the relevant standards.
- Alternative processes can also be employed to meet flammability requirements.
- Existing products already use the plastic blends, safer alternative flame retardants, and alternative processes we identified.

Common plastics and plastic blends used in electric and electronic enclosures

We identified several plastics and plastic blends that are commonly used in electric and electronic enclosures. The most common plastics used in electric and electronic enclosures include acrylonitrile butadiene styrene copolymers (ABS), polycarbonate (PC), PC/ABS blends, high impact polystyrene (HIPS), and polyphenylene oxide (PPO)/HIPS blends (A&C Plastics, 2022; Pinfa, 2017; Sofies, 2022).

Flammability requirements

The primary flammability requirements that apply broadly to polymeric (plastic) electric and electronic enclosures are listed in the UL 746C standard (UL, 2018). The UL 746C standard applies to polymeric (plastic) enclosures and refers to the UL 94 flammability ratings in its criteria (Table 10). The applicable UL 94 rating depends on the resistance to flammability required for the product category. The rating can be met through use of inherently fire resistant materials, design change, or chemical flame retardant additives (UL, 2013).

For the lowest rating, UL 94 HB, frequently no flame retardants are necessary to meet the standard (CPSC, 2018). For higher ratings, flame retardants are often necessary to meet the standard. Some UL 94 ratings (such as V-0, 5VB, and 5VA) specify that the plastic material used for the enclosure may not form flaming drips during the prescribed burn tests (Table 10). This is commonly achieved by adding fluoroorganic additives (such as polytetrafluoroethylene or PTFE) to the enclosure material at low concentrations (up to 0.5%) to provide the necessary anti-drip function (Lowell Center for Sustainable Production, 2005; Pinfa, 2017).

Table 10. UL746C flammability requirements by product category.

Product category	Examples	UL 94 Standard (minimum flammability rating)	Additional notes
Portable attended household equipment	Blender, hand-held dryer	HB	Frequently no flame retardant necessary
Other portable equipment	TV, laptop	V-2, V-1, V-0	May require anti-drip function
All other equipment	Hardwired wall heater	5VB, 5VA	Requires anti-drip function

Resin compatibility and meeting flammability requirements

Electric and electronic enclosures can be comprised of a variety of different plastics or plastic blends. We identified safer alternative flame retardants that are compatible with common plastics and plastic blends used in electronic enclosures including HIPS, PC, PC/ABS, and PPO/HIPS as well as additional plastics and plastic blends (summarized in Table 11).

Table 11. Resin compatibility, example manufacturers, and trade names of identified alternative flame retardants.

CAS(s)	Common name	Compatible plastics or blends	Example manufacturers*	Trade names*
115-86-6	Triphenyl phosphate (TPP)	PC/ABS, PPO/HIPS (Pinfa, 2017)	Lanxess, GreenChemicals	Disflamoll® TP (Lanxess, 2020a)
57583-54-7	Resorcinol bis(diphenyl phosphate) (RDP)	PC/ABS, PPO/HIPS, PC, polyamide (PA), polybutylene terephthalate, PET (Pinfa, 2017, 2021)	Adeka Polymer Additives Europe, Thor, ICL-IP, GreenChemicals	ADK STAB PFR, AFLAMMIT® PLF 280, Fyroflex RDP Fyroflex RDP-HP (Pinfa, 2021)

CAS(s)	Common name	Compatible plastics or blends	Example manufacturers*	Trade names*
181028-79-5 5945-33-5	Bisphenol A bis(diphenyl phosphate) (BDP)	PC/ABS, PPO/HIPS, PC, PET (Adeka, 2016; GreenChemicals, 2019; Pinfa, 2017, 2019)	Adeka Polymer Additives Europe, GreenChemicals	ADK STAB FP-600, ADK STAB FP-700 (Pinfa, 2019), GC BDP (GreenChemicals, 2019)
139189-30-3	Tetrakis(2,6-dimethylphenyl) 1,3-phenylenebisphosphate	PC/ABS, PPO/HIPS, PC (GYC Group, 2021; Novista, 2021; Pinfa, 2017)	Novista Group, GYC Group	PX-200 (Novista, 2021), GY-FR-PX200 (GYC Group, 2021)
68664-06-2	Polyphosphonate	PC/ABS, PC/ASA (acrylic-styrene-acrylonitrile), PC, PET, polybutylene terephthalate, PC/PET, PC/ polybutylene terephthalate (FRX Polymers, 2021)	FRX Polymers	HM1100, HM5000, HM7000, HM9000 (FRX Polymers, 2021)
225789-38-8	Diethylphosphinate, aluminum salt	PET, polybutylene terephthalate, PA (Pinfa, 2021)	Clariant	Exolit OP 1230, Exolit OP 1240 (Clariant, 2019, 2022)
77226-90-5	Poly(phosphonate-co-carbonate)	PC, PC Blends	FRX Polymers	CO3000, CO4000, CO6000 (FRX Polymers, 2021)

Note: * = Any reference in this publication to persons, organizations, services, products, or activities does not constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

To determine whether the relevant flammability standards could be met with the identified alternatives, we referred to a report by the Phosphorus, Inorganic, and Nitrogen Flame Retardants Association (Pinfa, 2017). The report provides examples of the use of several OPFRs in PC/ABS plastic blends—including the thickness and loading of the OPFR required to meet the UL 94 V-0 standard—which we summarized in Table 12.

We focused on V-0 as an example because it is the most stringent standard relevant for most products in the scope of the priority product category. For these examples, the report also notes that a co-additive, usually PTFE, is commonly used at concentrations up to 0.5% by weight to provide the anti-drip function required (as previously described). Based on this information, we determined that flammability requirements can be met using the safer alternatives we identified in plastic blends used in electric and electronic enclosures.

Table 12. Examples of meeting flammability requirements in PC/ABS blends (4:1) with OPFRs (adapted from Pinfa, 2017).

OPFR alternative (BM-2 or BM-3)	Required OPFR (% by weight)	Thickness for UL 94 V0 (mm)
Triphenyl phosphate (TPP)	14	1.7
Resorcinol bis(diphenyl phosphate) (RDP)	9	1.5
Bisphenol A diphosphate (BDP)	12.3	1.5
Tetrakis(2,6-dimethylphenyl) 1,3-phenylene bisphosphate	11.5	1.5
Poly(phosphonate-co-carbonate)	15 – 20	1.5

Alternative processes and meeting flammability requirements

Another way to meet the UL 746C standard is to employ a change in process or design that reduces flammability requirements for the exterior electric or electronic enclosure. This can be done by using an internal fire barrier made of a non-polymeric, inherently fire resistant material, such as metal. If there is an internal enclosure that serves as a fire barrier, then the external enclosure only needs to meet the UL 94 HB standard. This standard does not require the anti-drip property, and can often be met with resin grades that do not contain added flame retardants (CPSC, 2018; UL, 2018).

A resin manufacturer described this approach as achievable to allow the use of plastics rated UL 94 HB without flame retardant additives (which includes common plastics such as ABS, HIPS, MABS, PA, polybutylene terephthalate, etc.) (BASF, 2000). Covestro also lists several grades of Bayblend that can meet the UL 94 HB rating without using flame retardants (Covestro, 2016).

As an additional alternative, the external enclosure can be made using a non-polymeric, inherently flame resistant material, such as metal. In this case—since the UL 746C standard is only intended for enclosures made of polymeric materials—flame retardants are not necessary to meet flammability requirements.

We recognize these alternative processes may not be feasible in some applications. However, they provide additional options manufacturers should consider when designing electric and electronic products.

Availability of alternatives

We demonstrate that the safer alternatives we identified are available for use in the application of interest by showing:

- Safer alternative flame retardants are available.
- Resins made using common plastic blends and safer flame retardants are available.
- Existing products that use safer alternative flame retardants and the plastic blends we identified are available.

Safer chemical alternatives are available

We determined that safer chemical alternatives are available. Several are produced and sold by multiple manufacturers and are marketed for use in common plastics and plastic blends used in electric and electronic enclosures. We summarize a non-exhaustive list of manufacturers, along with tradenames for the alternatives we identified, in Table 11.

Resins using safer chemical alternatives are available

We also identified several examples of commercially available resins that manufacturers advertise for use in electric and electronic enclosure applications, and that meet our minimum criteria for safer (Table 13).

In general, there is a lack of transparency around the specific flame retardants used in resin formulations. Rather than disclose the flame retardant used, some manufacturers communicate that their resins do not contain intentionally added HFRs. An example of this communication is through programs like the UL Non-Halogenated or Non-Chlorine and Non-Bromine programs (UL, 2016). Using information from the UL Prospector and UL Yellow Card, we found examples of available resins described as halogen-free and confirmed they met current TCO requirements regarding their halogens criteria (Table 13).

For the resins listed in Table 13 that did not state they fulfill the requirements for materials used in the manufacture of TCO Certified products, we confirmed that they:

- Only use flame retardants that are on the TCO Certified Accepted Substance list
- Use less than 0.5% PTFE in applications that require the anti-drip function

The flame retardants on the TCO Certified Accepted Substance list score BM-2 or higher, and meet our minimum criteria for safer (TCO Certified, 2022).

Table 13. Examples of commercially available resins that use flame retardants and meet our minimum criteria for safer, with advertised flammability ratings.

Resin^	Manufacturer^	Available applications	Achievable flammability ratings
Bayblend FR grades (PC/ABS)* (Covestro, 2016, 2021)	Covestro	Computers, monitors, printers, photocopiers, laptops, televisions, DVD players, mobile phones, panels for dishwashers, washing machines, housing for kitchen appliances, and medical applications	V-0/5VA
Cycoloy C6600 (PC/ABS) (SABIC, 2008, 2021a)	SABIC	Electrical and electronic applications, electronic displays	V-0/5VB
Cycoloy CM6240 (PC/ABS) (SABIC, 2021b)	SABIC	Electrical parts, electronic displays	V-0/5VB

Resin^	Manufacturer^	Available applications	Achievable flammability ratings
DuraPET FR™ (PET) (PolyVisions, 2017, 2022)	Polyvisions	Consumer electronic devices, medical instrumentation housings, transportation, building and construction	V-0
Notoxicom® S6000 (PC/ASA) (Polymer Compounders Limited, 2021a, 2022a, 2022b)	Polymer Compounders Limited	Medical devices, battery casings	V-0
Notoxicom® B6000, B6303 (PC/ABS) (Polymer Compounders Limited, 2021b, 2021c)	Polymer Compounders Limited	Medical devices, battery casings	V-0
Notoxicom® A6000 (PC) (Polymer Compounders Limited, 2021d)	Polymer Compounders Limited	Medical devices, battery casings	V-0

Notes:

- * = Bayblend also has resin grades without flame retardants that meet the HB flammability rating.
- ^ = Any reference in this publication to persons, organizations, services, products, or activities does not constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

Existing products using safer alternatives are available

To establish further the feasibility and availability of alternatives, we identified relevant products listed in the TCO Certified Product Finder (TCO Certified, 2020). Products that are TCO Certified do not use HFRs, and if they use a polymeric enclosure, they can only:

- Use flame retardants listed on the TCO Certified Accepted Substance List
- Contain fluoroorganic additives at a maximum of 0.5%

Flame retardants listed on the TCO Certified Accepted Substance List must achieve a BM-2 rating or better in a GreenScreen® assessment reviewed by TCO Certified. As such, flame retardants used in products that are TCO Certified also meet our minimum criteria for safer.

The TCO Certified Product Finder contains thousands of individual products in several product categories, and one to eighteen brands for each category (TCO Certified, 2020). Product categories covered include displays, notebooks, tablets, smartphones, headsets, desktops, all-in-one PCs, projectors, and servers. A number of products listed in the TCO Certified Product finder already use safer flame retardants as well as the plastics and plastic blends we identified above (in the section common plastics and plastic blends used in enclosures).

As an example, the HP EliteBook 835 G8 is a notebook listed in the TCO Certified Product Finder. The Eco Declaration lists the housing material as a PC/ABS plastic blend that uses an organophosphate flame retardant (HP, 2015). That means the finished product uses an enclosure made of PC/ABS, and an organophosphate flame retardant listed on the TCO

Certified Accepted Substance List. This meets our minimum criteria for safer, and shows that safer alternative flame retardants are feasible and available—they are used in existing products.

We also identified several products that use metal enclosures as examples of alternative processes. Examples where metal enclosures were feasible include laptops, desktops, tablets, smart watches , cameras, cell phones, portable media, electric ranges, and washers and dryers (Apple, 2019, 2021a, 2021b, 2021c, 2021d; Frigidaire, 2022; LG, 2022a, 2022b, 2022c). This further supports the finding that safer alternative processes are feasible and available for use in these products.

Conclusions

We determined that safer alternatives to HFRs in electric and electronic enclosures are feasible and available (Table 14).

To establish the feasibility and availability of alternatives, we provided evidence that:

- Safer flame retardants are sold and compatible with plastic and plastic blends used broadly in electric and electronic enclosures
- Plastic blends containing safer flame retardants are sold as resins for use in enclosures of a broad range of products and can meet relevant flammability requirements
- Alternative processes can also be used to meet flammability requirements without the use of flame retardants
- Existing products are already available that use safer alternative flame retardants in plastic enclosures or the identified alternative processes

Our analysis builds on and is supplemented by past alternative assessments and reports on HFRs in products conducted over many years (DEPA, 1999, 2006; Ecology, 2015; EPA, 2014).

We clarified the scope of the priority product category based on input received (see the scope of the priority product section). With that clarification taken into consideration, we found that the safer alternatives identified are feasible and available for use in electric and electronic enclosures of indoor products. We only found limited evidence of resins using safer alternatives for outdoor applications. We were unable to confirm these alternatives were broadly feasible and available in products intended for outdoor use. Outdoor products may require additional considerations due to the impact of prolonged exposure to outdoor conditions.

In summary, we conclude that safer alternatives to HFRs are feasible and available for use broadly in the electric and electronic enclosures of products for indoor use. We did not find alternatives were feasible and available in products intended for outdoor use.

Restricting HFRs in electric and electronic enclosures would reduce a significant source of potential exposure for people and the environment.

Table 14. Questions from IC2 Guide for evaluating feasibility and availability of alternative(s).

IC2 Guide feasibility and availability metrics	Determination
Is the alternative used for the same or a similar function?	Yes. The identified safer flame retardants replace the intended function of HFRs to meet flammability standards.
Is the alternative used in similar products on the commercial market?	Yes. The safer flame retardants are already used in electric and electronic enclosures available on the market, with the exception of outdoor products.
Is the alternative marketed in promotional materials for application of interest?	Yes. The safer flame retardants are marketed in promotional materials for use in electric and electronic enclosures to meet flammability standards.
Is this a favorable alternative based on answers to the above questions?	Yes. The safer flame retardants identified are favorable for use in electric and electronic enclosures. The only application we did not identify safer flame retardants as favorable was in the enclosures of outdoor products.

Reducing a significant source or use

In order to restrict or prohibit priority chemicals in priority products, RCW 70A.350.040[76] requires Ecology and Health to determine that either:

- The restriction will reduce a significant source or use of a priority chemical, or
- The restriction is necessary to protect the health of sensitive populations or sensitive species.

We identified electric and electronic products as a significant source or use of organohalogen flame retardants in our 2020 report to the Legislature.[77] That report became effective at the end of the 2021 legislative session on April 25, 2021. Based on that report, we determined that restricting any of the chemical-product combinations in that report would reduce a significant source or use of a priority chemical class. With this determination, further evaluating whether a restriction would reduce a significant source or use (RCW 70A.350.040(3)(b)(ii)) is not required by statute.

As outlined in our report to the Legislature on priority consumer products (Ecology, 2020a), flame retardants are used in electric and electronic enclosures to meet flammability standards. Common flame retardants found in these products are decaBDE (used in the past), DBDPE, TTAP-TAZ, TBBA, and RDP—at concentrations up to 25% by weight. We have not estimated the weight of flame retardants in electric and electronic products in Washington, but most households contain multiple electric and electronic products (Nielson, 2019; U.S. Census Bureau, 2018).

Flame retardants are often additive, meaning the flame retardants are not covalently bound to the other materials and more easily escape from consumer products and expose people. Flame

[76] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.040
[77] https://apps.ecology.wa.gov/publications/summarypages/2004019.html

retardants are widely found in house dust (Ecology, 2020a) and people in the U.S. (Ospina et al., 2018). Children are more highly exposed than adults, due to their greater breathing rates, proximity to the floor, and hand-to-mouth behaviors. The concentration of specific flame retardants in house dust has been associated with proximity to electronics (Allen et al., 2008; Brandsma et al., 2014; Harrad et al., 2009; Muenhor & Harrad 2012).

Workers in certain occupations have higher exposure to flame retardants. These occupations include office workers, firefighters, and electronics recyclers (Jakobsson et al., 2002; Park et al., 2015; Qu et al., 2007; Sjodin et al., 1999). Most of these studies are on older flame retardants (PBDEs), but there is no evidence that there would be different exposures from other flame retardants.

Several HFRs have been detected in environmental media and in aquatic species in Washington state (Ecology, 2020a). Some HFRs are persistent in the environment, can be transported across long distances, bioaccumulate in organisms, and concentrate in the environment. An example are PBDEs, which the Southern Resident Orca Task Force identified as a primary contaminant of concern for this species (Ecology, 2020a).

Ecology determined that restricting flame retardants in electric and electronic products would reduce a significant use of these chemicals, reduce the potential for human exposure, protect sensitive populations, and protect sensitive species.

Chapter 2: Polychlorinated Biphenyls (PCBs)

Chapter overview

The Washington State Legislature identified polychlorinated biphenyls (PCBs) as a priority chemical class. Ecology and Health (jointly "we") identified paints and printing inks containing PCBs as a priority products (separate sections follow, corresponding to priority chemical-product combinations). The most prevalent source of PCB release into the environment is from "legacy" sources such as lamp ballasts (Ecology, 2020a, Ecology & Health, 2015). However, Safer Products for Washington is focused on releases from products currently being manufactured. Paints and inks remain an important source, since they are ongoing releases. PCBs are inadvertent contaminants in paints and inks. Although the initial source of PCBs in these products is due to the pigment that is added to them, because the amount of pigments sold in Washington is likely much lower than the amount of paints and inks, we did not identify pigments as a priority product.

Ecology considered the hazards associated with PCBs and determined they do not meet our minimum criteria for safer, as outlined in our criteria for safer and described in the hazards of PCBs section of this chapter. Paints and inks that avoid or reduce the inadvertent generation of PCBs are considered safer alternatives in this case, because they are less hazardous. Reducing inadvertent PCBs represents a step toward eliminating them. We identified paints and inks with lower PCB concentrations that are feasible and available (see the alternatives are safer, feasible, and available section(s) of this chapter).

We also considered the presence of PCBs in paints and printing inks and determined that they are a significant source of PCBs to the environment and have the potential to expose people and wildlife to PCBs (see the reducing a significant source or use section of this chapter). A restriction on the presence of PCBs in paints and inks would reduce a significant current source of PCBs.

Scope of priority chemical class

Chapter 70A.350[78] RCW defines polychlorinated biphenyls, or PCBs, as chemical forms that consist of two benzene rings joined together and containing one to ten chlorine atoms attached to the benzene rings. The class of PCBs can be described in a single CAS number, 1336-36-3. There are 209 PCB congeners with different numbers and positions of chlorines. They are often identified by their congener number, PCB-1 to PCB-209, rather than by IUPAC nomenclature, and are also sometimes categorized into homologue groups based on the number of chlorines. There are separate CAS numbers for all PCBs, each homologue group, and each congener.

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

Hazards of polychlorinated biphenyls (PCBs)

PCBs as a priority chemical class

We approach PCBs as a class because RCW 70A.350.010 defines PCBs collectively as a priority chemical. The statute's directive is reasonable and well supported for several reasons:

- Multiple authoritative sources identify PCBs as a class as persistent, bioaccumulative, and toxic chemicals by (OSPAR, 2008; UNEP, 2019b; U.S. EPA, 2021a).
- People and wildlife are exposed to mixtures of PCBs, which can have cumulative effects on health.
- PCBs are often regulated as a class.

PCBs are persistent, bioaccumulative, and toxic chemicals (OSPAR, 2008; UNEP, 2019b; U.S. EPA, 2021a). The U.S. National Toxicology Program and the International Agency for Research on Cancer consider PCBs as a class to be carcinogens. Under Proposition 65, California classifies all PCBs as developmental toxicants.

Eight PCBs are listed on Washington State's Persistent, Bioaccumulative, and Toxic (PBT) list (WAC 173-333[79]), but our Chemical Action Plan evaluated the class as a whole. Because PCBs are often found in mixtures, people (and wildlife) are exposed to them as mixtures, and PCBs are often regulated as a class. The scientific basis for managing chemicals based on a class approach was recently published for per- and polyfluoroalkyl substances (PFAS) (Kwiatkowski et al., 2020). Because PCB congeners have arguably greater structure and activity (SAR) similarity than diverse PFAS chemicals, regulating PCBs as a chemical class has an even stronger basis.

In 1979, most uses of PCBs were banned in the U.S. (Nestler et al., 2019). However, inadvertent generation of PCBs continued. EPA limits inadvertent PCBs in products to annual average concentration of 25 ppm for adjusted total PCBs (40 CFR section 761.3[80]). The adjusted total PCB concentration allows for higher concentrations of monochlorinated and dichlorinated biphenyls relative to polychlorinated biphenyls.

Approach for identifying safer alternatives to inadvertent contaminants

Typically, we approach safer as a spectrum, using minimum or additional criteria to identify safer alternatives. We based both our minimum and additional criteria on 18 hazard endpoints, which we describe in detail in Appendix C.

However, our evaluation of safer is slightly different in the case of PCBs. The products we evaluate in this report contain inadvertently generated PCBs. Therefore, we concluded that products with lower concentrations of PCBs are safer than those with higher concentrations of PCBs. In this case, safer alternatives avoid or reduce the inadvertent generation of PCBs.

[79] https://apps.leg.wa.gov/wac/default.aspx?dispo=true&cite=173-333

[80] https://www.govinfo.gov/content/pkg/CFR-2011-title40-vol31/pdf/CFR-2011-title40-vol31-sec761-3.pdf

Hazards of the data rich PCBs

PCBs are associated with many hazards that do not meet our minimum criteria for safer. For this reason, alternatives that reduce or avoid the inadvertent generation of PCBs are considered safer. This finding is based on hazard assessments by authoritative sources and consideration of available data for hazard endpoints in our criteria. There are not adequate data available for any individual PCBs that would suggest otherwise.

Authoritative sources have classified the entire class as:

- Carcinogenic (CA, 2021; IARC, 2016; NTP, 2016a).
- A developmental toxicant (OEHHA, n.d.).
- Toxic to aquatic organisms (ECHA, 2020a).
- Persistent and bioaccumulative (EPA, 2021a; OSPAR, 2008; UNEP, 2019b).

Using the scoring system described in our criteria for safer, all PCBs would be considered high for carcinogenicity. The 14th Report on Carcinogens (RoC) concluded that PCBs are reasonably anticipated to be human carcinogens, based on sufficient evidence of carcinogenicity from studies in experimental animals (NTP, 2016a). The International Agency for Research on Cancer (IARC) classified PCBs as Group 1 (carcinogenic to humans), reporting sufficient evidence in humans and animals for carcinogenicity (IARC, 2016). PCBs would be considered high for developmental toxicity, per California EPA listing all PCBs as carcinogens and developmental toxicants under Proposition 65 (OEHHA, n.d.). PCBs would score very high for acute aquatic toxicity, according to EU – GHS classifications on acute and chronic aquatic toxicity (H400, H410) (ECHA, 2020a). There are also concerns relating to potential endocrine disruption (DEPA, n.d.).

Many authoritative sources rate PCBs as very high for persistence and bioaccumulation. For example, PCBs are on several authoritative PBT lists, including:

- OSPAR list of PBTs for priority action (OSPAR, 2008).
- PBTs for reporting in the Toxics Release Inventory (TRI) (U.S. EPA, 2021a).
- Persistent Organic Pollutants (POPs) in the Stockholm Convention (UNEP, 2019b).

In Washington state, eight PCBs are on our PBT list (WAC 173-333[81]). Twelve PCB congeners display dioxin-like toxicity, act via a common mechanism (binding the aryl hydrocarbon receptor [AHR] as an initial step), and are typically expressed in toxic equivalents (TEQ) of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) (Van den Berg et al., 1998, 2006).

PCBs as a class have a GreenScreen® list translator score of LT-1 (CPA, 2018), due to their presence on authoritative lists for carcinogenicity, developmental toxicity, aquatic toxicity, and persistence and bioaccumulation. Chemicals present on authoritative lists consistent with LT-1 do not meet our minimum criteria for safer.

[81] https://apps.leg.wa.gov/wac/default.aspx?dispo=true&cite=173-333

PCBs do not meet our minimum criteria for several endpoints. First, our minimum criteria do not allow for PBT chemicals. Second, our minimum criteria do not allow for chemicals that score high for carcinogenicity or developmental toxicity. Third, our criteria do not allow for very persistent and very bioaccumulative chemicals. Table 15 shows the endpoints of high (H) or very high (vH) concern associated with PCBs as a class, based on authoritative lists. Since the class as a whole is listed, no chemicals within the class meet our minimum criteria for safer.

Table 15. Authoritative lists and endpoints of concern for PCBs as a class.

Common name, associated CAS	Meets minimum criteria?	List Translator score	Authoritative Lists for endpoints associated with priority chemical class
Polychlorinated biphenyls (PCBs) 1336-36-3	No	LT-1	**Carcinogenicity:** U.S. NIH – RoC IARC CA Prop 65 **Developmental toxicity:** CA Prop 65 **Acute aquatic toxicity:** EU – GHS (H400) **Persistence and bioaccumulation:** U.S. EPA – TRI PBTs UNEP – POPs OSPAR – Priority PBTs

Referenced hazard assessments

- GreenScreen® List Translator (LT) scores were determined using Licensed GreenScreen® List Translator Automators: Toxnot search tool[82] or Pharos website.[83]

Conclusions

PCBs are defined as a class based on chemical structure, physiochemical properties, and toxicity endpoints, as described above. PCBs (as a class) are found on authoritative lists that do not meet our minimum criteria for safer. As PCBs are often inadvertently generated, alternative products and processes will be considered safer if they contain lower concentrations of PCBs, or avoid or reduce the generation of PCBs.

[82] https://toxnot.com/Substances/Search
[83] https://www.greenscreenchemicals.org/learn/greenscreen-list-translator

Priority product: Paints

Scope of priority product

Paints are pigmented coatings used to protect or decorate. Paints sold in any form or packaging for personal, commercial, or industrial use are included. This does not include painted products.

Function of priority chemical in priority product

To identify potential safer alternatives, we first determine whether the function provided by the priority chemical is necessary to meet the performance requirements of the priority product at the chemical, material, product, or process level. If the priority chemical does not provide a necessary function, the chemical can be removed and there is no need to identify alternatives.

PCBs do not perform a function in paints, but inadvertent PCBs (iPCBs) are widespread in paints. Due to non-specific chlorination processes in many reactions where carbon, chlorine, and heat are involved, PCBs can contaminate pigments and other compounds. Manufacturers add pigments to paints to provide color. Pigments affected include (but may not be limited to) diarylide yellows, phthalocyanines, and titanium dioxide. Pigments added to paints can contain PCBs.

Alternatives are safer, feasible, and available

Since PCBs do not perform a function in paints, paints with lower (or no) PCB contamination would be considered safer than paints with higher concentrations of PCBs.

An examination of PCB testing of paints as well as colorants used in paints can be used to determine if paints with lower PCB concentrations are feasible and available. The colorants data we used represented liquid dispersions of pigment that are added to paints to provide color. The maximum concentration of colorants in paints is 14% (ACA, 2022).

We identified five peer-reviewed journal articles and government testing that examined PCB levels in paints and paint colorants available in the U.S. From these studies, we found data on 50 paint samples and 55 colorant samples (N = 105). Using testing data from these reports, we created a histogram showing the number of samples binned into discrete PCB concentration intervals (Figure 1).

Results from these studies can be sorted into four categories:

- Building paint for indoor and outdoor use (building paints and colorants).
- Spray paints.
- Children's paints
- Road paints.

All four categories had approximately the same range and median PCB concentrations (Table 16). There is some variation in both minimum, maximum, and median/mean between paint types. However, when comparing paint types, all of these values were within about one order of magnitude of each other, and all were much lower than the TSCA limit of 25 ppm (adjusted total). Experts assume that pigments are the primary source of PCBs detected in these paints (Hu & Hornbuckle, 2010). There is no evidence that the pigments used in the four categories are substantially different—in chemistry or concentration—with respect to PCB contamination (Table 16).

A list of studies is included in Supplement 1, and a summary histogram is included in Figure 1. Additional histograms showing testing for green and yellow paints are presented in Supplement 2. We did not identify testing data for other categories of paint, so our determination of safer, feasible, and available is limited to these four paint categories.

Table 16. Summary of PCB testing by paint type from studies in Supplement 1.

	Building paint	Colorants	Spray paint	Children's paint	Road paint
Number of samples	10	55	15	8	17
Minimum (ppb)	0**	0**	0.0032	0**	0**
Maximum (ppb)	14	47*	35	21	100
Median (ppb)	0.31	0.29*	3.3	1.3	0.58
Mean (ppb)	2.7	4.5*	9.1	5.8	13.8
75% Under (ppb)	1.5	1.7*	13	2.8	2.7

Notes:

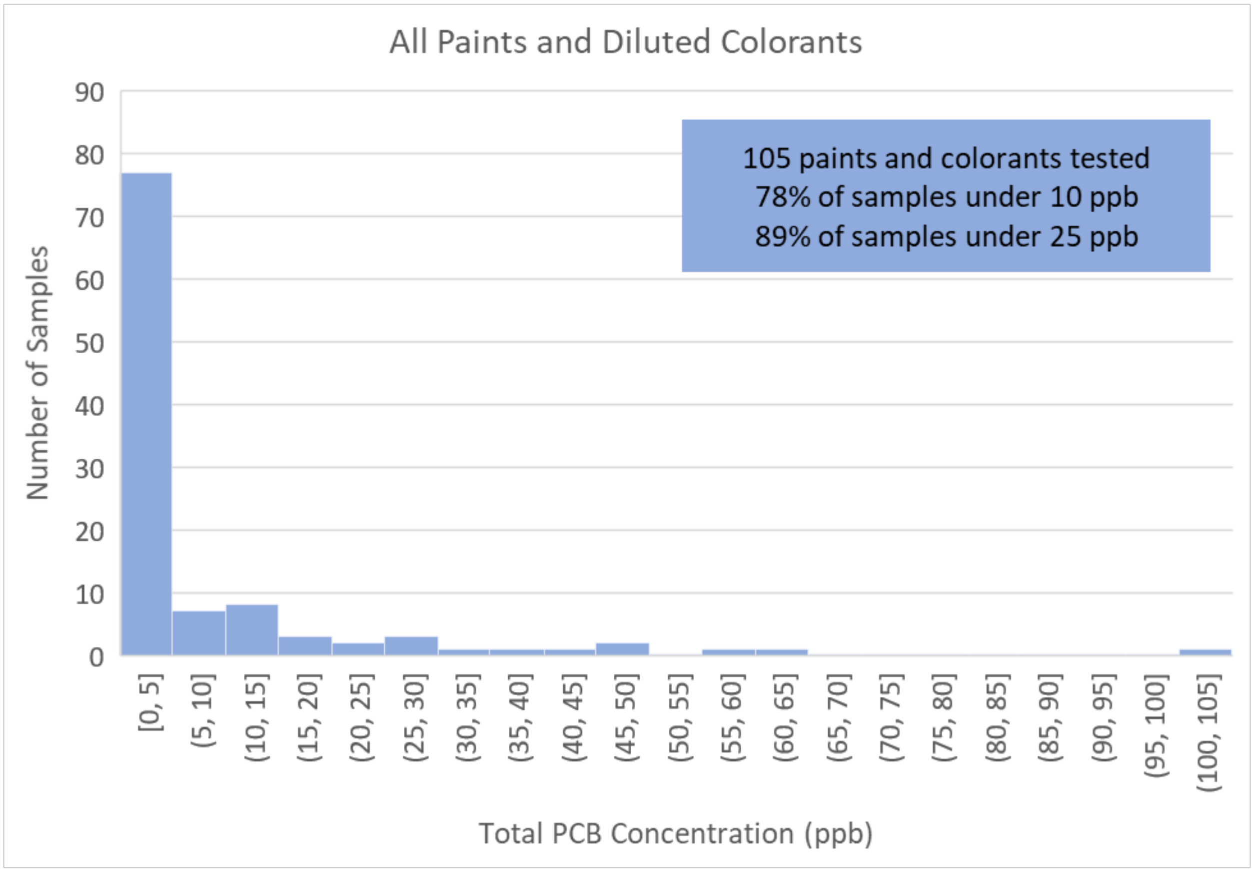
- * = 14% of reported values to reflect highest concentration used in standard paint formulations.
- ** = For this table and the histogram in Figure 1, we used values as reported by the cited papers. If they reported a value as less than the Limit of Detection, Limit of Quantitation, or the Method Reporting Limit, we used a value of zero for our statistical analysis. The LOD, LOQ, and MRL depend on the study cited and the individual sample, but were less than 1 ppb in all cases.

Two of the cited studies tested paint colorants rather than the paints themselves. Paint colorants are used in hardware and paint stores, where colorant is added to a base paint to achieve the desired color. The American Coatings Association reports that the maximum percentage of colorants used in standard paints is 14% (American Coatings Association, 2021). For this reason, when looking at PCB concentrations in paint, we calculated 14% of the reported PCB concentrations for paint colorants, and used this number for our analysis. This likely overestimates PCB concentrations in paint, since lighter tone paints will use less than 14% colorant in their formulations. However, it demonstrates that deeper tone paints with 14% colorant concentrations can have lower PCB concentrations.

Inadvertent PCBs are more often associated with green and yellow pigments, and testing data of paints and paint colorants support this—with green and yellow paints and paint colorants having more samples containing PCB concentrations greater than 10 ppb (Supplement 2). However, even in these colors, over half of the samples had less than 10 ppb detected.

The Ecological and Toxicological Association of Dyes and Organic Pigment Manufacturers (ETAD) published PCB concentration ranges detected in pigments produced in Europe. This information is not peer reviewed, but is useful to compare against the paint and colorant data used in our assessment. All but one yellow pigment and all green pigments included in the ETAD publication could produce paints with PCB concentrations under 100 ppb—even assuming the maximum concentration of pigment in a standard paint (ETAD, 2020). This maximum concentration of pigment in standard paint is 30% pigment in the colorant and 14% colorant in the paint (ACA, 2022).

Figure 1. Histogram of total PCB concentration in paints and diluted colorants. Data from references in Supplement 1.



Data from the histogram in Figure 1 show that PCB concentrations in children's paint, spray paint, road paint, and building paint range generally from zero (below the limit of detection) to 100 ppb. Of the 105 paint samples tested in the identified studies, 89% had concentrations under 25 ppb, and 78% had concentrations under 10 ppb. When looking between paint types, all types of paint had more than 75% of samples reported at less than 13 ppb (Table 16). Paints with lower concentrations of PCBs are considered safer than paints with higher concentrations of PCBs. In addition, since all of the samples were purchased at stores and marketed as paints, the samples with lower PCB concentrations are also feasible and available.

Conclusion

We determined that for the product categories of building paint for indoor and outdoor use, spray paint, children's paint, and road paint, safer alternatives to PCBs in paint are feasible and available (Table 17). We identified insufficient data for other types of paint, so at this time, we are limiting our determination to the above paint types.

Restricting PCBs in paints would reduce a significant source of PCBs to people and the environment. However, because we believe we are preempted by federal Toxic Substances Control Act (TSCA) regulations, our regulatory determination on PCBs in printing inks is no action.

Table 17. Questions from IC2 Guide for evaluating feasibility and availability of alternative(s) (IC2, 2017) in the categories of building paint for indoor and outdoor use, spray paint, children's paint, and road paint.

IC2 Guide feasibility and availability metrics	Determination
Is the alternative used for the same or a similar function?	Yes. Building paints for indoor and outdoor use, spray paints, children's paints, and road paints with lower PCB concentrations were purchased at the same location or advertised for a similar purpose.
Is the alternative used in similar products on the commercial market?	Yes. For the product categories tested, paints with lower concentrations of PCBs were found in similar products.
Is the alternative marketed in promotional materials for application of interest?	Yes. Paints with lower concentrations of PCBs are advertised in the same way as paints with higher concentrations of PCBs.
Is this a favorable alternative based on answers to the above questions?	Yes. Paints with lower concentrations of PCBs are favorable compared to paints with higher concentrations of PCBs.

Reducing a significant source or use

In order to restrict or prohibit priority chemicals in priority products, RCW 70A.350.040[84] requires Ecology and Health to determine that either:

- The restriction will reduce a significant source or use of a priority chemical, or
- The restriction is necessary to protect the health of sensitive populations or sensitive species.

We identified paints as a significant source of PCBs in our 2020 report to the Legislature.[85] That report became effective at the end of the 2021 legislative session on April 25, 2021. Based on that report, we determined that restricting any of the chemical-product combinations in that report would reduce a significant source or use of a priority chemical class. With this

[84] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.040
[85] https://apps.ecology.wa.gov/publications/summarypages/2004019.html

determination, further evaluating whether a restriction would reduce a significant source or use (RCW 70A.350.040(3)(b)(ii)) is not required by statute.

In our report on priority consumer products (Ecology, 2020a), we estimated that 30 million gallons of paint and coatings are used in Washington per year. The American Coatings Association reported 2017 production of paints and coatings at 1.28 billion gallons in the U.S., while other sources reported 1.5 billion gallons in 2016, and a projected 1.4 billion gallons in 2020 (Freedonia Group, 2017; Pilcher, 2018; Wells, 2017). Taking Washington's share of the U.S. population would give around 30 million gallons of paints in all of these cases, however, not all paints and coatings contain PCBs. Figure 1 shows the variability in concentrations of PCBs in paints.

There is the potential for sensitive populations and sensitive species to be exposed to PCBs from paints. While many PCB congeners can be inadvertently generated, PCB 11 is considered a hallmark of iPCB contamination, specifically from pigments and dyes. It is known to be present in many painted and printed materials, and it is not found in legacy PCB products (Heine & Trebilcock, 2018). Humans and wildlife can be exposed to PCBs from paint as it chips off or degrades over time, during use, and if it is improperly disposed of. This is supported by the detection of PCBs in residential environments from indoor air and house dust (Ampleman et al., 2015). PCBs have been shown to leach from painted materials (EPA, 2015a; George et al., 2006). This supports the conclusion that pigments found in paints are likely sources of PCBs detected in the environment (Andersson et al., 2004; Hu et al., 2011; Jartun et al., 2009a, 2009b; Johnston et al., 2006; Ruus et al., 2006).

Some leftover paints may be recycled. In 2019, the Washington State Legislature enacted the Architectural Paint Stewardship Program (RCW 70A.515[86]) to manage the estimated 10% of paints that are leftover. The Legislature found that leftover architectural paints present environmental risks, as well as health and safety risks for workers in the solid waste industry. Ecology worked with the American Coatings Association to establish PaintCare, aiming to reduce the health and environmental impact of leftover paint. However, we are still concerned about the 90% of paints that are used and degrade over time, contaminating our homes and environment. Further, not all paints meet the requirements for this recycling program, and not all eligible paints will be recycled. Lowering the PCB concentrations in new paints means that over time, less PCBs will be brought into the recycled paint.

Therefore, as described in our report on priority consumer products[87] (Ecology, 2020a), we conclude that the volume of paints used each year in Washington, plus the potential for paints to contribute to PCB exposure for sensitive populations and species, make paints a significant source of exposure to PCBs. Therefore, restricting the presence of PCBs in paints will reduce a significant source of PCBs to people and the environment.

[86] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.515

[87] https://apps.ecology.wa.gov/publications/summarypages/2004019.html

Priority product: Printing inks

Scope of priority product

Inks containing pigment sold in any form or packaging for personal, commercial, or industrial use. This does not include toner powder or liquid toner.

Function of priority chemical in priority product

To identify potential safer alternatives, we first determine whether the function provided by the priority chemical is necessary to meet the performance requirements of the priority product at the chemical, material, product, or process level. If the priority chemical does not provide a necessary function, the chemical can be removed and there is no need to identify alternatives.

PCBs do not perform a function in inks, but inadvertent PCBs (iPCBs) are widespread in inks. Due to non-specific chlorination processes in many reactions where carbon, chlorine, and heat are involved, PCBs can contaminate pigments and other compounds. Pigments affected include (but may not be limited to) diarylide yellows, phthalocyanines, and titanium dioxide (Heine & Trebilcock 2018, Nestler et al., 2019). Thus, pigments added to inks can contain PCBs.

Alternatives are safer, feasible, and available

Since PCBs do not perform a function in inks, inks with lower (or no) PCB contamination would be considered safer than inks with higher concentrations of PCBs.

A literature review of studies testing inks for PCBs could be used to determine if inks with lower PCB concentrations are feasible and available. However, we found limited publicly available testing results that directly tested inks for PCB concentration. When we identified inks as a significant source of PCBs, we relied primarily on the presence of PCBs in printed material (Ecology, 2020a).

There are several different types of inks, which can have different formulations depending on the printing process. Examples include inks for offset lithography, flexography, rotogravuere, silkscreen, and digital ink jet. Manufacturers formulate inks for specific printing processes and often cannot use them with a different printing process (Kipphan, 2014).

However, in all cases, the main source of PCBs in inks is likely from the pigment (Rodenburg et al., 2015). Example ink formulations provided by the National Association of Printing Ink Manufacturers (NAPIM) show that different types of ink contain similar pigment concentrations (15 – 25%) and may use the same pigment (NAPIM, 2019). This suggests that while inks intended for different printing processes may have substantially different formulations, the pigment type and concentration can be the same between ink types. However, pigments must be processed to make them compatible with different ink types, and we do not know the degree to which a processed pigment can be used in inks intended for different printing processes. For this reason, in our analysis, we group inks by their intended printing process.

Printing inks also have a range of colors, which may use different pigments, and thus have a different range of possible PCB concentrations. However, manufacturers can reproduce most colors using four inks: cyan (C), magenta (M), yellow (Y), and black (K). Known as CMYK inks or process inks, these are the colors most commonly used in printing where producing a very specific hue is not necessary. Other colors, known as spot colors, are often used for specific applications such as brand recognition. Due to the unlimited number of spot colors that could be produced—it is estimated that humans can visually distinguish about 1 million different colors (Hadhazy, 2015)—and because each color may have different PCB concentration, at this time, we are limiting our analysis to CMYK inks.

To demonstrate that printing inks with PCB concentrations below the TSCA limit of 25 ppm PCBs (adjusted total) are feasible and available, we reviewed PCB concentrations in CMYK inks used for a specific printing process. Given that PCBs are not an intentionally added ingredient in inks, we expect some variability in the PCB concentration within batches of the same pigment. To confirm that lower PCB concentrations are feasible, we identified at least one manufacturer that produces a full set of CMYK inks for a specific type of printing process. The full set of CMYK inks had total PCB concentrations below 25 ppm.

Figure 2 summarizes results of PCB testing in CMYK inks. We only identified two samples of ink that were tested for PCB concentration prior to 2021, both from the Ecology 2016 Product Testing Study (Ecology, 2016). These samples were taken from digital inkjet inks. In 2021, we conducted another PCB testing study focused on CMYK ink. The Quality Assurance Project Plan[88] describes the sampling and analytical methods. The results of that study, which provided data from 18 additional ink samples, are available in the Ecology Product Testing Database.[89] We also summarized in an overview, available on our stakeholder webpage.[90]

Overall, we obtained data for 20 samples of ink, including five cyan inks, five magenta inks, seven yellow inks, and three black inks.

- Five samples (one cyan, one magenta, and three yellow) are intended for use in digital inkjet printing.
- Four samples (cyan, magenta, yellow, and black) are UV-cured inks intended for offset lithography printing.
- The remaining 11 samples are oil-based or petroleum-based inks intended for offset lithography printing.

We group UV-cured and oil-based inks intended for offset lithography printing separately because they:

- Use substantially different ingredients
- Are used to print on different materials
- Have different ink curing methods

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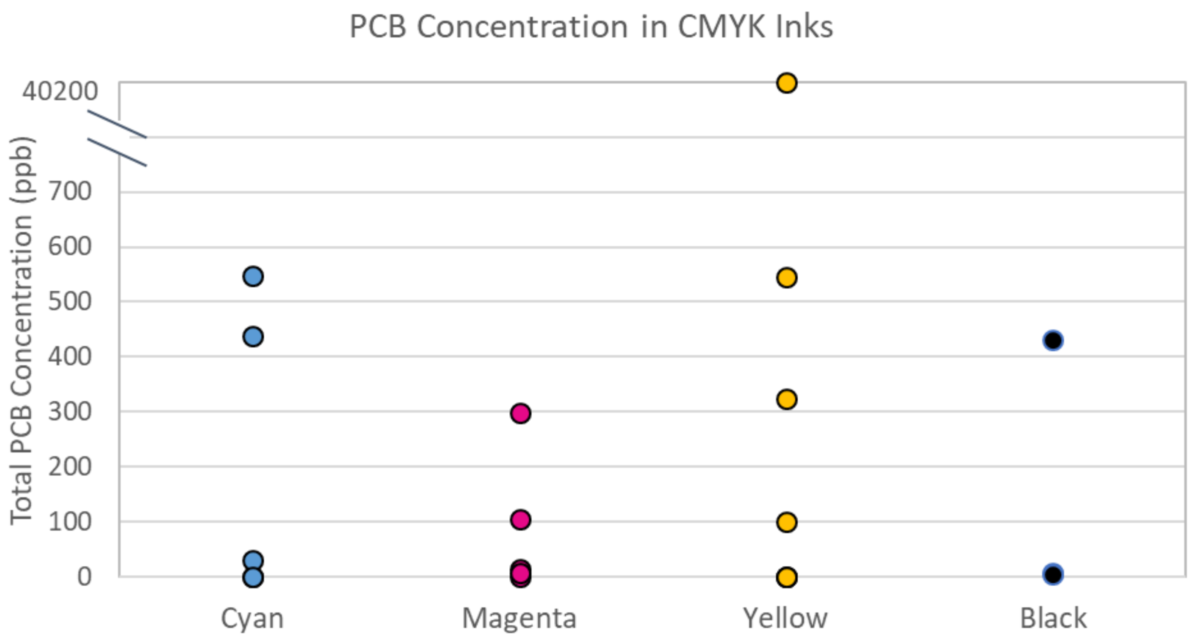
88 https://apps.ecology.wa.gov/publications/SummaryPages/2103121.html
89 https://apps.ecology.wa.gov/ptdbreporting/Default.aspx
90 https://www.ezview.wa.gov/Portals/_1962/Documents/saferproducts/PrintingInks_ManufacturerData.pdf

Figure 2. PCB concentrations in CMYK inks identified from product testing studies.



For each color, there was a range of PCB concentrations available. The minimum and maximum total PCB concentrations were also sorted by ink type.

- Digital inkjet inks (five samples—cyan, magenta, yellow): 0.00959 to 0.650 ppb
- UV-cured inks (four samples—cyan, magenta, yellow, black): 31.5 to 40,200 ppb
- Oil- or petroleum-based offset lithography inks (11 samples—cyan, magenta, yellow, black): 0.881 to 547 ppb

All samples, except for one polymerizable ink, contained PCBs well below the TSCA limit of 25 ppm PCBs (adjusted total). Besides that one sample, the highest level identified was 547 ppb in a cyan ink (Figure 2). We purchased all the samples in stores or online, and they were all marketed as inks. Therefore, the samples with lower PCB concentrations are also feasible and available.

The ETAD published PCB concentration ranges detected in pigments produced by European manufacturers. This information is not peer reviewed, but is useful to compare against the printing ink data we collected for cyan, magenta, and yellow process inks during the product testing study.

The ETAD publication reports PCB concentrations for pigments. We used a pigment concentration of 25% in printing inks to calculate expected maximum PCB concentrations in ink formulations, and then compare these concentrations to the printing inks tested in our study. Stakeholders reported this concentration to us as the maximum concentration of pigment used in a formulation (NAPIM, 2022).

We expect yellow printing inks to have PCB concentrations ranging from 125 to 8,750 ppb based on the PCB concentrations reported for yellow pigments (ETAD, 2020). We expect most magenta printing inks to have similar PCB concentrations, ranging from 125 to 6,250 ppb. Notably, ETAD reported one magenta pigment with a PCB concentration below the limit of detection. Based on the concentrations for blue pigments, cyan printing inks would have PCB concentrations under 125 ppb (ETAD, 2020).

Conclusion

Inks with lower concentrations of PCBs are considered safer than inks with higher concentrations of PCBs. Given that PCBs are inadvertent contaminants, we expect there to be some variability in PCB concentration for the same pigment. This is due to both manufacturing differences and potential batch-to-batch variability.

To confirm that lower PCB concentrations are feasible, we identified at least one manufacturer that produces a full set of CMYK inks for a specific printing process. We identified multiple oil-based offset lithography ink manufacturers making all four process colors with reduced PCB concentrations. Therefore, we determined that for oil-based CMYK offset lithography inks, lower PCB concentrations are safer, feasible, and available (Table 18). Oil-based includes mineral and vegetable oils as well as petroleum distillates. We did not identify sufficient data for other ink colors, so at this time, we are limiting our determination to CMYK inks.

We do not have enough samples to determine that lower PCB concentrations are safer, feasible, and available in other types of ink. We did not obtain ink data for all four process colors used in digital inkjet printing. Additionally, although we obtained ink data for all four process colors used in UV-cured ink from one manufacturer, one of the samples was well above 25 ppm, and therefore we do not consider it safer.

We determined that for oil-based CMYK offset lithography inks, lower PCB concentrations are safer, feasible and available alternatives to PCBs (Table 18). We have not collected data for all oil-based CMYK offset lithography inks offered for sale. Based on PCB concentration data for different pigments, it is possible to generate inks with PCB concentrations that are higher than those measured in our product testing study.

Reducing PCBs in these inks to a level closer to what we identified in this report would reduce a significant source of PCBs to people and the environment. However, because we believe we are preempted by federal Toxic Substances Control Act (TSCA) regulations, our regulatory determination on PCBs in printing inks is no action.

Table 18. Questions from IC2 Guide for evaluating feasibility and availability of alternative(s) (IC2, 2017).

IC2 Guide feasibility and availability metrics	Determination
Is the alternative used for the same or a similar function?	Yes for oil-based offset lithography process inks. Inks made with lower PCB concentration pigments were purchased at the same location or advertised for a similar purpose.
Is the alternative used in similar products on the commercial market?	Yes. For the product categories tested, inks with lower concentrations of PCBs were found in similar products.

IC2 Guide feasibility and availability metrics	Determination
Is the alternative marketed in promotional materials for application of interest?	Yes. Inks with lower concentrations of PCBs are advertised in the same way as inks with higher concentrations of PCBs.
Is this a favorable alternative based on answers to the above questions?	Yes. Inks with lower concentrations of PCBs are favorable compared to inks with higher concentrations of PCBs.

Reducing a significant source or use

In order to restrict or prohibit priority chemicals in priority products, RCW 70A.350.040[91] requires Ecology and Health to determine that either:

- The restriction will reduce a significant source or use of a priority chemical, or
- The restriction is necessary to protect the health of sensitive populations or sensitive species.

We identified printing inks as a significant source of PCBs in our 2020 Priority Consumer Products Report to the Legislature.[92] That report became effective at the end of the 2021 legislative session on April 25, 2021. Based on that report, we determined that restricting any of the chemical-product combinations in that report would reduce a significant source or use of a priority chemical class. With this determination, further evaluating whether a restriction would reduce a significant source or use (RCW 70A.350.040(3)(b)(ii)) is not required by statute.

Printing inks often contain inadvertently generated PCBs. In our 2020 report (Ecology, 2020a), we estimated that 56 million pounds of printing inks are used in Washington per year. This is supported by data from the Color Pigments Manufacturers Association (CPMA), which estimates that the total amount of phthalocyanine and diarylide pigments imported or manufactured in the U.S. is about 90 million pounds per year (Ecology & Health, 2015). This would mean Washington's share (by population) is around two million pounds of these pigments. Printing inks contain 5 – 30% pigment by weight (PCC Group, 2018), so if we only consider these two types of pigments, that would amount to approximately 7 – 40 million pounds of printing ink used (Ecology, 2020a).

Levels of PCBs in people have declined since the 1980s, but PCBs are still widespread in humans. They are detected in nearly all people in the U.S., including women and children (CDC-NHANES, 2019; Ecology & Health, 2015). People are generally exposed to a mixture of PCBs, rather than a single PCB compound. People, including sensitive populations, and the environment can be exposed to PCBs from printing inks in printed materials (including during their recycling).

While many PCB congeners can be inadvertently generated, PCB 11 is considered a hallmark of iPCB contamination, specifically from pigments and dyes (Guo et al., 2014). PCB 11 is known to be present in many painted and printed materials, and it is not found in legacy PCB products (Heine & Trebilcock, 2018). A biomonitoring study for PCB 11 showed 65% of 85 women in the

[91] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.040
[92] https://apps.ecology.wa.gov/publications/summarypages/2004019.html

Midwest had trace levels of PCB 11 in their blood (Marek et al., 2014). In 2013, studies reported the presence of PCB 11 in air samples and in the blood of children and mothers (Marek et al., 2013; Zhu et al., 2013). A 2015 study reported PCB congeners 11, 14, 35, 133, and 209 as the most frequently detected non-Aroclor congeners in the blood of study participants (Koh et al., 2015).

Pigments found in inks can contribute to environmental concentrations of PCBs. They were directly linked to wastewater discharges with PCB levels above water quality criteria in the City of Spokane (Grossman, 2013). Limited data are available, but it was estimated that two paper recycling facilities in Washington discharge 28 g of PCBs per year, with 3.8 g being PCB 11, and that the Spokane River Wastewater Treatment Plant was discharging 71 g of PCBs per year (Ecology & Health, 2015). Product testing results suggest that pigments may account for the majority of PCB 11 detected in the environment (Guo et al., 2014), and thus almost certainly contribute other congeners as well.

We determined that restricting the levels of PCBs in printing inks would reduce a significant source of PCBs to the environment and reduce the potential for human exposure.

Supplement 1. Studies used to create histogram of PCB in paint concentrations

- Hu, D., and Hornbuckle, K. (2010). Inadvertent Polychlorinated Biphenyls in Commercial Paint Pigments. *Environmental Science and Technology, 44*, 2822 – 2827. doi:10.1021/es902413k
- Jahnke, J., and Hornbuckle, K. (2019). PCB Emissions from Paint Colorants. *Environmental Science and Technology, 53*, 5187 – 5194. doi:10.1021/acs.est.9b01087
- Washington Department of Ecology (Ecology). (2016). Polychlorinated Biphenyls (PCBs) in Consumer Products. Stone, A. https://apps.ecology.wa.gov/publications/SummaryPages/1604014.html
- Washington Department of Ecology (Ecology). (2014). Polychlorinated Biphenyls (PCBs) in General Consumer Products. Stone, A. https://apps.ecology.wa.gov/publications/summarypages/1404035.html
- Spokane. (2015). PCBs in Municipal Products. *City of Spokane Wastewater Management Department.*

Supplement 2. Histogram of PCB in paint concentrations by selected colors

Figure 3. Histogram of total PCB concentration in green paints and diluted colorants. Data from references in Supplement 1.

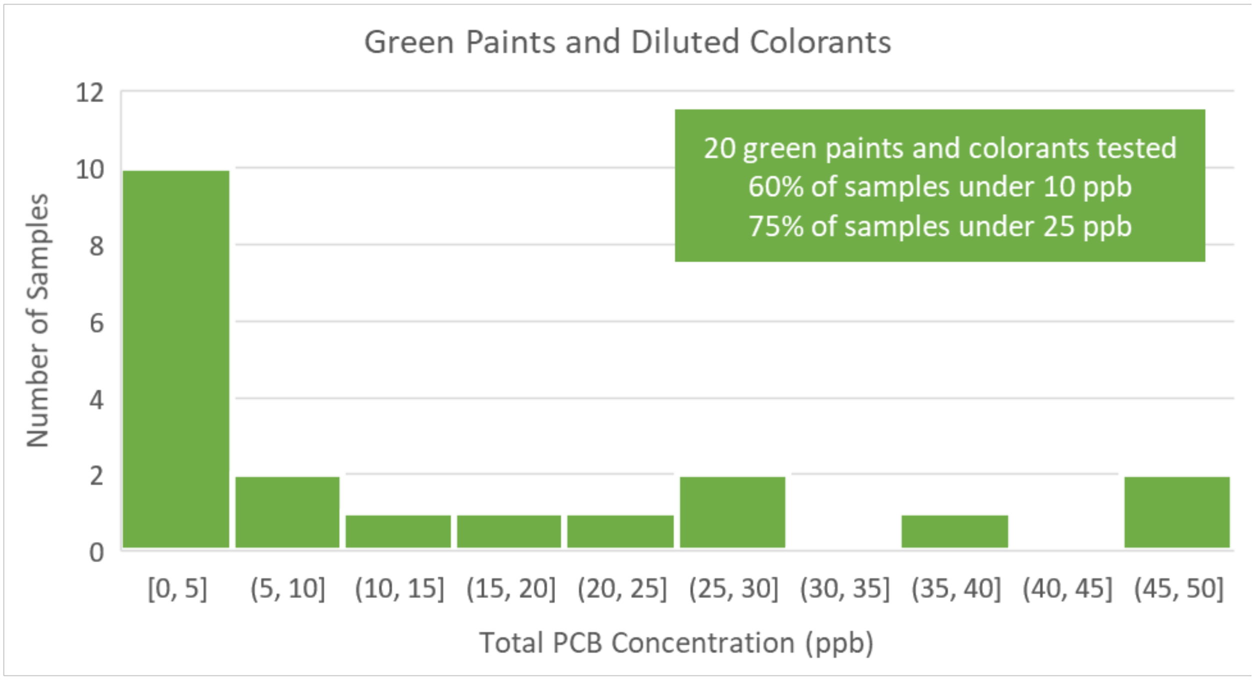
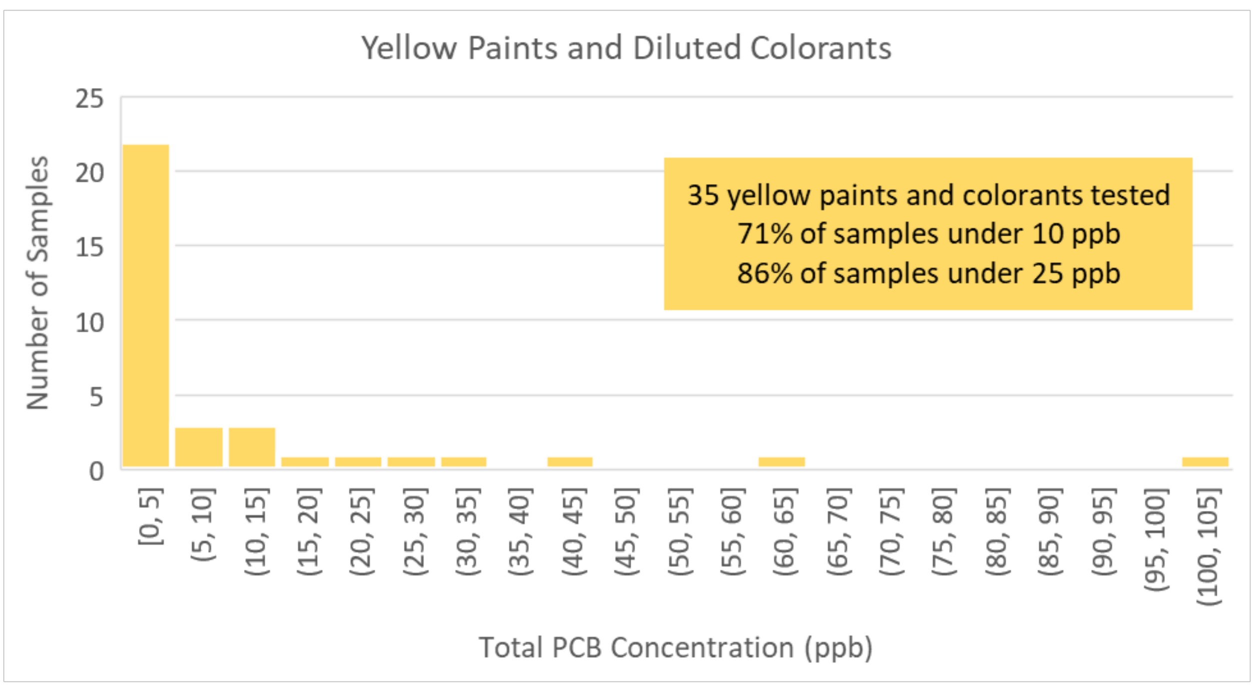


Figure 4. Histogram of total PCB concentration in yellow paints and diluted colorants. Data from references in Supplement 1.



Chapter 3: Per- and Polyfluoroalkyl Substances (PFAS)

Chapter overview

The Washington State Legislature identified perfluoroalkyl and polyfluoroalkyl substances, or PFAS, as a priority chemical class. Ecology and Health (jointly "we") identified the following priority products that contain PFAS:

- Leather and textile furniture and furnishings.
- Carpets and rugs.
- Aftermarket stain- and water-resistance treatments.

PFAS are applied topically to these products to repel aqueous liquids and oils. We considered the hazards associated with PFAS in the hazards of PFAS section of this chapter, and determined they do not meet our minimum criteria, as outlined in our criteria for safer.

Leather and textile furniture and furnishings

We identified alternative processes that avoid the use of premarket topical chemical treatments on indoor leather and textile furnishings. Premarket topical chemical treatments are those that are applied to products during the manufacturing process to make surfaces easier to clean. Some products also use topical chemical treatments to protect items under the surface (such as mattresses) from contact with liquids. The alternative processes we identified replace the use of any topical chemical, meaning they meet our criteria for safer and are feasible and available (see the alternatives are safer, feasible, and available subsection of the furniture and furnishings section of this chapter).

We did not identify alternative process that could completely replace outdoor leather and textile furnishings with topical chemical treatments that protect them from weathering, such as untreated leather or textile furniture or furnishings marketed for outdoor use. This lack of use may mean these untreated materials are not feasible alternatives for outdoor furniture and furnishings. Other alternative processes are not one-to-one substitutes for outdoor furniture and furnishings made using leather or textiles.

In support of our priority product determination, we considered both the volume of PFAS used in furniture and furnishings, and the contribution of these products as a source PFAS to the environment. We also considered the potential for exposure to PFAS in humans, including in sensitive populations (see the reducing a significant source or use subsection of the furniture and furnishings section of this chapter).

Carpets and rugs

We identified safer alternative premarket topical chemical treatments that can be used on carpets and rugs and alternative processes that avoid the use of premarket topical chemical treatments. Premarket topical chemical treatments are applied to carpets and rugs during the manufacturing process to make carpets and rugs easier to clean. The alternative chemical treatments and processes we identify meet our minimum criteria for safer and are feasible and available (see the alternatives are safer, feasible, and available subsection of the carpets and rugs section of this chapter).

In support of our priority product determination, we considered both the volume of PFAS used in carpets and rugs, and the contribution of these products as a source of PFAS to the environment. We also considered the potential for exposure to PFAS in humans, including in sensitive populations (see the reducing a significant source or use subsection of the carpets and rugs section of this chapter).

Aftermarket stain- and water-resistance treatments

Finally, we identified alternative chemicals that can be used in aftermarket stain- and water-resistance treatments, as well as alternative products and processes that can be used instead of stain- and water-resistance treatments. These products are applied to an already purchased product to create a more cleanable surface. They may also protect items under the surface from contact with liquids. The alternative chemicals, products, and processes we identify meet our minimum criteria for safer and are feasible and available (see the alternatives are safer, feasible, and available subsection of the stain- and water-resistance treatments section of this chapter).

In support of our priority product determination, we considered both the volume of PFAS used in aftermarket stain- and water-resistance treatments, and the contribution of these products as a source of PFAS to the environment. We also considered the potential for exposure to PFAS in humans, including in sensitive populations (see the reducing a significant source or use subsection of the aftermarket stain- and water-resistance treatments section of this chapter).

Scope of priority chemical class

RCW 70A.350.010[93] defines "perfluoroalkyl and polyfluoroalkyl substances" or "PFAS chemicals" as a class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom.

Hazards of per- and polyfluoroalkyl substances (PFAS)

PFAS as a priority chemical class

We approach PFAS as a class because RCW 70A.350.010 identifies PFAS collectively as a priority chemical. The statute's directive is reasonable and well supported for several reasons:

- All PFAS are persistent or break down to persistent PFAS.
- The most well-characterized PFAS are associated with human and environmental hazards.
- While some PFAS have been phased out by U.S. manufacturers, they have been replaced with other PFAS.

[93] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.010

- Manufacturing PFAS compounds generates PFAS impurities or wastes that are associated with human and environmental hazards.

PFAS are a large class of chemicals defined by the presence of multiple carbon-fluorine bonds. These bonds are hard to break, causing PFAS to either be extremely persistent or to break down into other PFAS that are extremely persistent (Ecology, 2021a; Ellis et al., 2001; Schlummer et al., 2015). Persistent chemicals are problematic because they do not break down in the environment. That means that as releases continue, exposures increase. Persistent chemicals are difficult to clean up, particularly if we learn about hazards after widespread contamination has occurred.

Many PFAS also bioaccumulate, and are associated with human health and environmental toxicity. PFOA and PFOS are the most well characterized PFAS. They are associated with systemic and developmental toxicity, persistence, and bioaccumulation (Table 19). Other chemicals in the PFAS class have similar toxic properties of concern, such as reproductive and developmental toxicity and systemic toxicity (including immunotoxicity, neurotoxicity, and thyroid) (Table 19) (Ecology, 2021a; Fenton et al., 2020). Some PFAS are also toxic to aquatic organisms (Ecology, 2021a; Lee et al., 2020).

Many PFAS currently used were brought to market to replace other PFAS manufacturers phased out due to toxicity concerns (EPA, 2021e). Addressing PFAS as a class avoids replacing current PFAS with other, similarly toxic PFAS.

Finally, the manufacture of PFAS compounds results in the creation of perfluoroalkyl acids (PFAAs). PFAAs are used in the production of other PFAS chemicals but can also be created as other PFAS chemicals break down (Balan, 2021). Toxicity research has identified several PFAAs that have demonstrated human and environmental health hazards in addition to extreme persistence (Kwiatkowski et al., 2020).

Based on these concerns, PFAS are already regulated under numerous Washington state laws. Recent Washington state actions restricted PFAS as a class in some food packaging applications (RCW 70A.222.070[94]) and firefighting foam (RCW 70A.400[95]). Previous actions on PFAS include listing PFOS and its salts as persistent, bioaccumulative, toxic chemicals under WAC 173-333-310[96] and as chemicals of high concern to children under WAC 173-334-130.[97] Because PFAS are halogenated organic compounds, they can be regulated under the Washington State Dangerous Waste Regulations (Chapter 173-303 WAC).

Recent laws (RCW 70A.222.070 and RCW 70A.400) regulate PFAS as a class, instead of by individual PFAS chemicals. Multiple publications identify the need to manage PFAS as a class (Bălan et al., 2021; Cousins et al., 2020; Kwiakowski et al., 2020; Lohmann et al., 2020). This is because the class as a whole is persistent, and many PFAS share hazard traits such as systemic toxicity, reproductive and developmental toxicity, and aquatic toxicity. Historically, voluntary

[94] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070
[95] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.400
[96] https://apps.leg.wa.gov/wac/default.aspx?dispo=true&cite=173-333-310
[97] https://app.leg.wa.gov/WAC/default.aspx?cite=173-334-130

agreements to phase out certain PFAS or restrictions on the use of some PFAS led to substitutions using other members of the class—which are considered regrettable (Ahearn, 2019).

Approach for setting the criteria for safer

We approach safer as a spectrum, using minimum or additional criteria to identify safer alternatives. We based both our minimum and additional criteria on 18 hazard endpoints, which we describe in detail in Appendix C. Our evaluation of the hazards of the priority chemical class informs the criteria alternatives need to meet to be considered safer than the existing chemical or process.

We applied elements of the hazard assessment scoping plan from the National Academies of Sciences' Class Based Approach to Organohalogen Flame Retardants (NAS, 2019) to assess the hazards of PFAS as a class.

We first determined whether the class as defined in the law is unified by "structure, physiochemical properties, biology, or some combination thereof." We concluded that PFAS can be defined by structure based on the RCW 70A.350.010[98] definition: "a class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom."

We then reviewed the data rich chemicals within the class. Data rich chemicals either:

- Were evaluated by authoritative sources.
- Have third-party reviewed or publicly available hazard assessments that we can compare against our criteria for safer.

We determined whether each data rich chemical met or failed to meet our minimum criteria for safer. This approach assumes that data poor chemicals within the class are potentially hazardous. It helps us avoid the pitfalls of assuming chemicals with limited hazard data or data gaps are not hazardous. If the data rich chemicals in the class fail to meet the minimum criteria for safer, then alternatives that do are safer.

In cases of toxicological diversity, where some data rich chemicals in the class meet and others fail to meet the minimum criteria for safer, we relied on two options (described in Appendix C):

1. Using the criteria (minimum or additional) that allows us to identify alternatives that are safer than the data rich priority chemicals potentially found in the priority product.
2. Using the minimum criteria to conservatively identify alternatives that are safer than the data rich hazardous chemicals in the class.

We also looked for any data rich PFAS that would meet our within-class criteria. The within-class criteria sets a transparent bar to identify chemicals within the class that have sufficient data showing they are safer and exclude them. Using the within-class criteria to identify safer chemicals within the class helps prevent regrettable substitutions. Chemicals within the class are more likely to share hazards (Chen et al., 2016; Cordner et al., 2016; Lioy et al., 2015; NAS,

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[98] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.010

2019; Vos et al., 2003). That means we need to approach them with added caution (Birnbaum et al., 2021; Blum et al., 2015; DiGangi et al., 2010). See a full description in Appendix C.

Many PFAS are associated with systemic and developmental toxicity (see hazards of data rich PFAS below). In order to confirm that a PFAS does not share these hazards, the within-class criteria requires evidence of the lack of both reproductive and developmental toxicity (among other criteria). It also does not allow for chemicals that have high or very high persistence, according to our criteria for safer (Appendix C). Chemicals in classes with known hazards that are persistent are concerning—it is difficult to reduce exposure if we learn about hazards after contamination has occurred.

Hazards of the data rich PFAS

We identified data rich PFAS as those with authoritative listings or existing third-party reviewed or publicly available hazard assessments. We found seven GreenScreen® hazard assessments in the ToxServices GreenScreen® Library[99] and one listed on TCO's Accepted Substances list (TCO Certified, 2022). Each GreenScreen® assessment was conducted by a Licensed GreenScreen® Profiler and is either publicly available (ToxServices, 2021a) or found on the TCO list (TCO Certified, 2022). The GreenScreen® methodology scored seven of the PFAS as Benchmark-1 (BM-1) chemicals (Table 19), so they do not meet our minimum criteria for safer. Find an explanation of how Benchmark scores compare to our minimum criteria for safer in Appendix E.

The PFAS listed on TCO's Accepted Substances list scored BM-2 using the GreenScreen® method, indicating that it meets our minimum criteria for safer but not our additional criteria. Information on specific hazards associated with the chemical are not publicly available through the listing. We discuss this PFAS later in the conclusion of this section.

We identified an additional seven PFAS that are included on authoritative lists and are classified as LT-1 using the GreenScreen® List Translator methodology (Table 19). A score of LT-1 indicates the chemical is associated with hazards that do not meet our minimum criteria for safer.

The majority of the data rich PFAS identified in Table 19 are PFAAs and PFAA precursors. Perfluorobutanesulfonate, perflurorohexanoic acid, perfluorononanoic acid, PFOA, and PFOS are some examples of PFAAs in Table 19. 3-ethoxyperfluoro(2-methylhexane), 2-perfluorohexylethanol, and 1,1,2,2-tetrahydroperfluorodecyl acrylate are examples of PFAA precursors in Table 19. Teflon is an example fluoropolymer in Table 19.

We received a submission of a GreenScreen® assessment for a partially fluorinated polymer that meets our definition of a PFAS. The submitter reported this polymer has been used as a treatment to make paper resistant to oil and grease. A licensed profiler conducted the assessment, but used redacted toxicity test data and has not been reviewed by a third party or Ecology. Therefore, we did not include it in Table 19. Based on studies of similar partially

[99] https://database.toxservices.com/Home/Home/Index

fluorinated polymers, we expect this polymer to potentially act as a PFAA precursor (Li et al., 2017; Washington et al., 2009; Washington & Jenkins, 2015).

The vast majority of the data rich PFAS in Table 19 show a range of hazards that do not meet our minimum criteria for safer. Of those PFAS listed in Table 19 that have information for specific hazard endpoints, all score high or very high for persistence. Seven also score high or very high for bioaccumulation. Eight of the data rich chemicals in the class score high or very high for carcinogenicity, reproductive toxicity, or developmental toxicity (Table 19). Other endpoints of concern include systemic toxicity and aquatic toxicity (Table 19). We discuss concerns around persistence, bioaccumulation, carcinogenicity, reproductive and developmental toxicity, and systemic toxicity below.

Persistence and bioaccumulation

Chemicals that are very persistent and very bioaccumulative do not meet our minimum criteria for safer. Seven PFAS in Table 19 score high or very high for persistence and bioaccumulation. Very persistent and very bioaccumulative chemicals stay in the environment for a long time and build up in our bodies and the food chain. These chemicals are problematic because if we learn about hazards later, it is difficult to reduce exposures. They are difficult to clean up in the environment. PFAS in our bodies can expose developing fetuses and breastfeeding infants.

Perfluorooctanoic acid, perfluorononanoic acid, perfluorooctanesulfonic acid, potassium perfluorooctanesulfonate, and ammonium perfluorooctanesulfonate are all listed as persistent, bioaccumulative, toxic chemicals by authoritative sources (Table 19). An existing GreenScreen® assessment scored 3-Ethoxyperfluoro(2-methylhexane) very high for both persistence and bioaccumulation (ToxServices, 2020a). All PFAS with existing hazard assessments score high or very high for persistence (Table 19).

Carcinogenicity

Tetrafluoroethylene is considered “probably carcinogenic to humans” by the International Agency for Research on Cancer (IARC, 2018). California Prop 65 also lists tetrafluoroethylene for carcinogenicity (OEHHA, 2021). The U.S. National Toxicology Program reviewed the carcinogenicity of tetrafluoroethylene and concluded that tetrafluoroethylene is “reasonably anticipated to be a human carcinogen” based on evidence from experimental animals (NTP, 2016b). A GreenScreen® assessment scored hexafluoropropylene high for carcinogenicity based on its structural similarity to tetrafluoroethylene (ToxServices, 2018c, CAS: 116-15-4).

Reproductive and developmental toxicity

Perfluorononanoic acid, PFOA, PFOS, and their salts (ammonium perfluorooctanoate, potassium perfluorooctanesulfonate, and ammonium perfluorooctanesulfonate) are all found on authoritative lists that indicate a high score for reproductive or developmental toxicity (Table 19). California Prop 65 lists PFOA and PFOS as developmental toxicants (OEHHA, 2021). The European Union Classification for the Labeling and Packaging of hazardous chemicals attaches the codes H360 and H362 to PFOA and PFOS, indicating that they may damage fertility or the unborn child and may cause harm to breast-fed children (ECHA, 2020a).

Perfluorononanoic acid is also flagged by the European Union Classification for the Labeling and Packaging of hazardous chemicals with H362 and H360f, indicating that it may cause harm to breast-fed children and may damage fertility (ECHA, 2020a). It is also listed under the European Union Annex VI CMR as a Category 1B, indicating that it is a presumed reproductive toxicant based on animal studies (ECHA, 2020a).

Systemic toxicity

The European Union Classification for the Labeling and Packaging of hazardous chemicals attaches the H372 code to PFOA, indicating that it causes damage to organs through prolonged or repeated exposure (ECHA, 2020a). Existing hazard assessments for 1,1,2,2-Tetrahydroperfluorodecyl acrylate, Teflon, perflurorohexanoic acid, and 2-Perfluorohexylethanol have also found high systemic toxicity (Table 19).

These assessments are based on the use of:

- Surrogates (1H,1H,2H-Perfluorodecanol-1-ol (CAS: 678-39-7) was used as a surrogate for 1,1,2,2-Tetrahydroperfluorodecyl acrylate) (ToxServices, 2016a).
- Human exposure data (Teflon) (ToxServices, 2019a).
- High quality animal studies (perflurorohexanoic acid and 2- perfluorohexylethanol) (ToxServices, 2016b, 2019b).

Breakdown and transformation products

The majority of the data rich PFAS identified are PFAAs. The hazards of PFAAs are relevant because all PFAS are PFAAs, break down into PFAAs, or require PFAAs as part of the manufacturing process (Dinglasan-Panlilio & Mabury, 2006; Lohmann et al., 2020; Wang et al., 2020; Washington & Jenkins, 2015).

Conclusion

Because we only identified one PFAS that met our minimum criteria for safer, we concluded that the majority of PFAS do not meet our minimum criteria for safer and alternatives that do are safer (see hazards of data rich PFAS). The single PFAS that meets our minimum criteria for safer is a solvent (Table 19) that is not used in the priority products we are evaluating. Find a list of data rich PFAS with existing hazard assessments in Table 19. This is not a complete list of PFAS that are regulated. Rather, it summarizes findings from existing hazard assessments of data rich chemicals that meet the RCW 70A.350[100] definition of PFAS.

There is some toxicological diversity within the PFAS class. The vast majority of data rich PFAS did not meet our minimum criteria for safer. 1,1,2,2-Tetrafluoro-1-(2,2,2-trifluoroethoxy)ethane (CAS 406-78-0) scored BM-2 and meets our minimum criteria for safer. Although we could not access information on the specific hazards identified for this chemical, we do not expect this to meet our within-class criteria due to high persistence. When there is

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

toxicological diversity within the class, we consider the hazards of chemicals that are potentially found in the product.

Of the data rich PFAS we identified, most are expected to be present in textiles that have been treated with PFAS. Most are PFAAs, related salts of PFAAs, or PFAA precursors that have been identified in textiles treated with PFAS (Bečanová et al., 2016; Borg & Ivarsson, 2017; Glüge et al., 2020; Guo, Liu, & Krebs, 2009; Janousek, Lebertz, & Knepper, 2019; KEMI, 2015). Polytetrafluoroethylene (CAS 9002-84-0) is a fully fluorinated polymer that is used in textiles (Glüge et al., 2020). None of these data rich chemicals meet our minimum criteria for safer. Therefore, alternatives to PFAS in the products we are considering must meet our minimum criteria to be considered safer alternatives.

There are four data rich PFAS that we do not anticipate would be present in textiles that have been treated with PFAS. Therefore, these PFAS did not impact our decision to use the minimum criteria to identify safer alternatives to PFAS for use in the priority products we are considering. The majority of these chemicals do not meet our minimum criteria for safer. Hexafluoropropylene (CAS 116-15-4) and tetrafluoroethylene (CAS 116-14-3) are both chemical inputs used to make fluorinated polymers that can be used in textile treatments (Glüge et al., 2020). However, both chemicals are reasonably expected to be gases under normal conditions of use or manufacture, and are unlikely to be present in treated textiles or leather (NTP, 1992; ToxServices, 2018c).

The two remaining data rich PFAS we identified—1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)ethane and 3-ethoxyperfluoro(2-methylhexane) (CAS 297730-93-9)—are both primarily used as solvents. There is some evidence 3-ethoxyperfluoro(2-methylhexane) may be used as a solvent in the process of making PFAS-containing textile or leather treatments, but it is more commonly found in electronics and electric component manufacturing (Glüge et al., 2020; Jing et al., 2021a, 2021b).

1,1,2,2-Tetrafluoro-1-(2,2,2-trifluoroethoxy)ethane was the only data rich PFAS we identified that met our minimum criteria for safer. It is used as a solvent in cleaners for electronics and metals (Glüge et al., 2020; TCO Certified, 2022). Although manufacturers may use this solvent alongside PFAS treatments, we did not identify any evidence it was involved in treating leather, textiles, or related materials. Therefore, although this PFAS met our minimum criteria for safer, it is not relevant for us to evaluate the hazards of the class and identify safer alternatives for our product categories.

We determined that the data rich PFAS present in priority products do not meet our minimum criteria for safer. We use these data rich PFAS to characterize the hazards of PFAS present in textiles and leather products, and assume that data poor PFAS in these products are potentially hazardous. Alternatives used to replace PFAS must meet the minimum criteria for safer to be considered safer alternatives.

Table 19. Data rich PFAS, common hazards, and presence on authoritative and screening lists.

Common name, associated CAS(s)	Meets minimum criteria?	GreenScreen® assessment or List Translator score(s)	Endpoints of concern based on GreenScreen® score (high or very high) or authoritative listings
1,1,2,2-Tetrafluoro-1-(2,2,2-trifluoroethoxy)ethane	Yes	BM-2	Unknown
Hexafluoropropylene 116-15-4	No	BM-1	Carcinogenicity, neurotoxicity (single), systemic toxicity (single and repeat), skin and eye irritation, and persistence
3-Ethoxyperfluoro(2-methylhexane) 297730-93-9	No	BM-1	Persistence, bioaccumulation, and chronic aquatic toxicity
Perfluorobutanesulfonate, potassium salt 29420-49-3	No	BM-1	Persistence, eye irritation
1,1,2,2-Tetrahydroperfluorodecyl acrylate 27905-45-9	No	BM-1	Persistence, bioaccumulation, neurotoxicity (repeat), and systemic toxicity (repeat)
Polytetrafluoroethylene 9002-84-0	No	BM-1	Persistence, systemic toxicity
Perflurorohexanoic acid 307-24-4	No	BM-1	Persistence, skin and eye irritation, and systemic toxicity (single)
2- Perfluorohexylethanol 647-42-7	No	BM-1	Acute toxicity, systemic toxicity (single and repeat), aquatic toxicity (acute and chronic), and persistence
Perfluorooctanoic acid (PFOA, C8) 335-67-1	No	LT-1	**Developmental toxicity:** CA Prop 65, H360D, H362 (EU GHS) **Systemic toxicity:** EU GHS statement H372 **Eye irritation:** EU GHS 318 **Persistence and Bioaccumulation:** PBT (UNEP Stockholm Convention Persistent Organic Pollutants)

Common name, associated CAS(s)	Meets minimum criteria?	GreenScreen® assessment or List Translator score(s)	Endpoints of concern based on GreenScreen® score (high or very high) or authoritative listings
Perfluorononanoic acid (PFNA, C9) 375-95-1	No	LT-1	**Reproductive and developmental toxicity:** EU Annex VI CMRs Category 1B, EU REACH Annex XVII CMRs Category 2, EU SVHC Authorisation List (toxic to reproduction candidate list), EU GHS H362, H360Df **Systemic toxicity:** EU GHS H372 **Eye irritation:** EU GHS H318 **Persistence and bioaccumulation:** PBT (EU SVHC Authorisation List PBT Candidate)
Perfluorooctanesulfonic acid (PFOS, C8) 1763-23-1	No	LT-1	**Reproductive and developmental toxicity:** EU Annex VI CMRs Category 1B, EU REACH Annex XVII CMRs Category 2 **Developmental toxicity:** CA Prop 65, EU GHS H360D and H362 **Systemic toxicity:** EU GHS 372 **Persistence and bioaccumulation:** Priority PBT (UNEP Stockholm Convention Persistent Organic Pollutant)
Ammonium perfluorooctanoate 3825-26-1	No	LT-1	**Reproductive and developmental toxicity:** EU Annex V1 CMRs Category 1B, EU Annex XVII CMRs Category 2, EU SVHC Authorisation List (toxic to reproduction candidate list), EU GHS H360D, H362 **Systemic toxicity:** EU GHS H372 **Eye irritation:** EU GHS H318 **Persistence and bioaccumulation:** PBT (UNEP Stockholm Convention Persistent Organic Pollutants)

Common name, associated CAS(s)	Meets minimum criteria?	GreenScreen® assessment or List Translator score(s)	Endpoints of concern based on GreenScreen® score (high or very high) or authoritative listings
Potassium perfluorooctanesulfonate 2795-39-3	No	LT-1	**Reproductive toxicity:** EU Annex V1 CMRs Category 1B, EU Annex XVII CMRs Category 2 **Developmental toxicity:** EU GHS H360D, H362 **Systemic toxicity:** EU GHS H372 **Persistence and bioaccumulation:** PBT (UNEP Stockholm Convention Persistent Organic Pollutant)
Ammonium perfluorooctanesulfonate 29081-56-9	No	LT-1	**Reproductive toxicity:** EU Annex VI CMRs Category 1B, EU Annex XVII CMRs Category 2 **Developmental toxicity:** EU GHS H360D, H362 **Systemic toxicity:** EU EHS H372 **Persistence and bioaccumulation**: PBT (UNEP Stockholm Convention Persistent Organic Pollutant)
Tetrafluoroethylene 116-14-3	No	LT-1	**Carcinogenicity:** CA Prop 65, IARC Group 2A, MAK Group 2, U.S. NIH Report on Carcinogens

Referenced hazard assessments

- GreenScreen® hazard assessments of 1,1,2,2-Tetrahydroperfluorodecyl acrylate (ToxServices, 2016a), perflurorohexanoic acid (ToxServices, 2016b), hexafluoropropylene (ToxServices, 2018c), 2- Perfluorohexylethanol (ToxServices, 2019b), Teflon (ToxServices, 2019a), 3-Ethoxyperfluoro(2-methylhexane (ToxServices, 2020a), and perfluorobutanesulfonate, potassium salt (ToxServices, 2020b) are available from the ToxServices database.[101]

[101] https://database.toxservices.com

- GreenScreen® List Translator (LT) scores were determined using Licensed GreenScreen® List Translator Automators: Toxnot search tool[102] or Pharos website.[103]
- A GreenScreen® hazard assessment summary score for 1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)ethane can be found on the TCO Accepted Substances List.[104]

Priority product: Leather and textile furniture and furnishings

Scope of priority product

Indoor and outdoor leather and textile furnishings used in residential and commercial settings including indoor and outdoor furniture, mattress pillow tops and protectors, and other textiles. Examples of other textiles include:

- Table linens.
- Bedding.
- Cushions and pillows.
- Curtains, drapes, and awnings.
- Towels.

Carpet is not considered a furnishing in this report and is discussed in the carpet and rugs section.

Function of priority chemical in priority product

To identify potential safer alternatives, we first determine whether the function provided by the priority chemical is necessary to meet the performance requirements of the priority product at the chemical, material, product, or process level. If the priority chemical does not provide a necessary function, the chemical can be removed and there is no need to identify alternatives.

We determined that PFAS are used in leather and textile furnishings to increase the cleanability of the product and provide water resistance. Water resistance is not required for most products designed for indoor use. Therefore, the function of PFAS at the product and process level varies by product category.

At the chemical level, PFAS repel aqueous and oily liquids. At the material level, PFAS-coated materials help limit the seepage of liquids into the textile. However, at the product and process level, the necessary functions of PFAS will vary slightly across different kinds of products within this category (see Table 20).

[102] https://toxnot.com/Substances/Search
[103] https://www.greenscreenchemicals.org/learn/greenscreen-list-translator
[104] https://tcocertified.com/industry/accepted-substance-list/

Table 20. Function provided by PFAS at the material, product, and process level in different types of leather and textile furniture and furnishings.

Product types	Product function	Process function(s)
Indoor furniture (residential and commercial)	Furniture and furnishing surfaces are easy to clean because leather and textile surfaces are topically treated with PFAS.	Enhances cleanability of the treated surface
Outdoor furniture and furnishings (residential and commercial)	Furniture and furnishing surfaces are easy to clean because material surfaces are topically treated with PFAS. In outdoor furniture and furnishings (such as awnings or furniture covers) the items under the furnishing (such as cushion foam or furniture) are protected from weathering.	• Enhances cleanability of the treated surface • Provides water resistance (including rain resistance)
Mattress and pillow protectors	Mattresses and pillow protectors made from textiles topically treated with PFAS are water resistant and easy to clean. The mattress or pillow is protected from liquid.	• Provides water resistance • Enhances cleanability of the treated surface
Other indoor textiles (examples: sheets, pillowcases, tablecloths, napkins, towels)	Other indoor textile surfaces are easy to clean because the surfaces are topically treated with PFAS.	Enhances cleanability of the treated surface

Alternatives are safer, feasible, and available

Alternatives are safer

Chemical alternatives used to replace PFAS must meet the minimum criteria for safer in order to be considered safer alternatives.

Alternative products or processes where no chemical treatments are used to repel aqueous liquids or oils are not evaluated against our minimum criteria for safer. Instead, they cannot contain chemicals known to be in products during use at concentrations greater than 100 ppm that have known hazards of concern (such as known carcinogens, mutagens, or reproductive or developmental toxicants). We do not evaluate chemicals found in both the priority product and the alternatives for known hazards of concern. For example, a toxic chemical found in both untreated and PFAS-treated upholstery would not be considered because it's found in both the priority product and the alternative product or process.

Our evaluation of the hazards of leather and textile furniture and furnishings was limited to PFAS associated with premarket topical treatments and not the product as a whole. Comparing the hazards of one component of a product or process (such as the topical treatment) to the hazards of an entire product or process is uneven. If a topical treatment can be avoided by using an alternative material, product, or process, then the alternative is safer—provided there are no known chemical hazards that would be considered regrettable substitutions.

Alternative processes: Using untreated fibers to make products

Furniture may be made from materials that do not require topical chemical treatments to increase the cleanability or provide water resistance. Many of these materials are inherently stain- or water-resistant. Inherently stain-resistant materials include polyolefins (such as polypropylene and polyethylene), wool, polyester, and thermoplastic polyurethane.

Polypropylene (PP) is the most common polyolefin used in textiles. PP fabrics are inherently stain resistant and do not require additional topical treatments (Burrow, 2017). We did not identify any known regrettable substitutions in PP. The Minnesota Office of Environmental Assistance ranked six plastics by estimated environmental risk, and found that PP has the lowest environmental risk (Minnesota, 1998). Similarly, Clean Production Action's plastics scorecard scores polypropylene with an A-, the highest score achieved in version 1.4 (CPA, 2011).

PP is a polyolefin plastic formed by the polymerization of propylene. PP (CAS: 9003-29-6) is listed on the EPA Safer Chemicals Ingredient List as a green circle, indicating that at least certain PP can be made that is not a regrettable substitute (EPA, 2021b). Textiles made from PP may include additional additives that could impact its potential toxicity. We do not know the specific additives used in PP fabric used in furniture and furnishings. However, we do know that Burrow manufactures furniture and furnishings using PP fabric that does not contain ortho-phthalates, phenols, heavy metals, formaldehyde, or flame retardants, which have known hazards (Burrow, 2017).

Polyethylene (PE) is another polyolefin that can be used to make fabrics that do not require or use topical stain treatments or have any known regrettable substitutions. One example is, Carnegie Xorel® (Carnegie Fabrics INC, 2020a) which makes wall coverings, upholstery, and panel fabrics from PE. Xorel fabrics do not have any topical treatments to provide stain resistance. These fabrics are Cradle to Cradle Certified® (C2CC®) with a Platinum Material Health Certificate™ (C2CC®, 2021a). (Cradle to Cradle Certified® is a registered trademark of the Cradle to Cradle Products Innovation Institute. The Cradle to Cradle Certified® Material Health Certificate™ is a trademark of the Cradle to Cradle Products Innovation Institute.) This certification demonstrates that Xorel fabrics do not contain known regrettable substitutions and are considered a safer alternative. Find more information about C2CC® in Appendix E, on safer certifications.

High density polyethylene (HDPE) is a specific type of PE that can be used to make water-resistant products. HDPE does not require topical stain treatments and can be made without known regrettable substitutions. One example is recycled HDPE outdoor furniture made by Loll Designs (Loll Designs, 2021) which is C2CC® with a Silver Material Health Certificate™ (C2CC®, 2021b). Silver Material Health Certificates™ do not alone meet our minimum criteria for safer, but do demonstrate that there are no known regrettable substitutions. Find more information about C2CC® in Appendix E, on safer certifications.

Wool is an inherently stain-resistant fabric made from fibers obtained from sheep or other animals. We identified one furniture manufacturer using a wool blend with a C2CC® Material Health Certificate™ of Silver (C2CC®, 2021c). We confirmed that this product contains no chemical topical stain treatments (Steelcase, 2021). We did not identify any known regrettable substitutions associated with wool.

Polyester can be used to make a synthetic fabric that has inherently stain-resistant properties (Levity, 2021a). One known concern about polyester fabrics is the potential for antimony to be present (Bivar, 2021). Antimony is "reasonably anticipated to be a human carcinogen" according to the U.S. National Toxicology Program (NTP, 2018a) and a Chemical of High Concern to Children (Washington state, 2018).

We did not consider polyester a regrettable substitution because:

- Antimony is not found in all polyester products. Antimony-free polyester is available as an upholstery fabric (Herman Miller, 2021). A recent study of polyester clothing and upholstery only detected antimony in 14 out of 76 samples. Of the 14 samples where antimony was detected, over half also contained bromine, suggesting the antimony was added as a flame retardant synergist (Turner & Filella, 2017). The use of antimony as a flame retardant synergist is outside the scope of this analysis because both polyester and non-polyester fabrics may contain flame retardants and antimony.
- PFAS topical treatments are used on some polyester upholstery fabrics, but are not used on others (Herman Miller, 2021). Untreated polyester is a safer alternative to PFAS treated polyester.

Thermoplastic polyurethane (TPU) is a plastic material that is water- and stain-resistant. It can be used as the primary material in applications such as artificial leather. Polyurethane (CAS 9009-54-5) has been evaluated as yellow in a verified Scivera assessment (Scivera, 2021s), indicating it does not contain known carcinogens, mutagens, or reproductive or developmental toxicants. However, because different monomers can be used to make polyurethane, it is unclear how applicable this hazard assessment is to leather and textile furnishings. We identified diisocyanate as a chemical of concern used in the manufacturing of TPU (EPA, 2011b). Diisocyanates are anticipated to be carcinogenic according to the National Toxicology Program (NTP, 2016c).

However, we determined that polyurethane is not a regrettable substitution based on two factors.

- The scope of our hazard assessment focuses on chemicals found in products during the use phase. EPA and others predict low residual concentrations and exposure potential for diisocyanates in cured poluyurethane products (such as TPU) (Donchenko et al., 2020; EPA, 2011b).
- Topical treatments (which may contain PFAS) are used on some polyurethane upholstery fabrics, but are not on others (Herman Miller, 2021). Untreated TPU is a safer alternative to PFAS-treated TPU.

Ethylene vinyl acetate (EVA) is a plastic material that is water and stain resistant. It can be used as the primary material in applications like shower curtains. EVA is copolymer that is manufactured using ethylene and vinyl acetate, which may remain in products made with EVA as residual monomers. There are no known hazards associated with EVA itself.

There are some concerning hazards associated with vinyl acetate, which may be present as a residual monomer. IARC previously identified vinyl acetate as a suspected carcinogen (IARC, 1995). Vinyl acetate is listed as a suspected mutagen by GHS Japan and Australia, and a known or presumed mutagen by GHS New Zealand (NITE, 2019; New Zealand, 2021; Safe Work Australia, 2016). We did not identify EVA as a known regrettable substitution because:

- It is unclear if, or at what concentration, vinyl acetate is present in EVA products.
- Suspected carcinogens or mutagens are not necessarily regrettable substitutions (see our criteria for safer for more details)
- It is unclear whether vinyl acetate would be considered a suspected or known mutagen in a hazard assessment. The GHS classifications from Japan, New Zealand, and Australia are considered screening lists and not authoritative lists (see criteria for safer). Therefore, mutagenicity is not identified as a known hazard.

Untreated leather can be used to make furniture and furnishing products instead of applying a topical treatment. Because the base material is not expected to change, untreated products are considered safer alternatives to those that are treated with PFAS.

Other untreated textile products may be manufactured without using any topical chemical treatments or stain-resistant fabric. The comparison would be between a fabric treated with PFAS and a fabric without PFAS or any other treatment, for example. Because the base material is not expected to change, untreated products are considered safer alternatives.

Alternative processes: Designing products to make fabrics easier to clean

Products can be designed to be easier to clean using readily available appliances (such as a laundry machine). Untreated fabrics like those described above can then be used in these products. Since the same materials are used in this alternative process as if they are treated with PFAS, we conclude that these alternatives are safer than PFAS.

This alternative also requires the use of laundry detergents. A list of EPA Safer Choice laundry detergent can be found in Chapter 5 (EPA Safer Choice, 2021c). Safer Choice products contain only ingredients that meet the Safer Chemical Ingredients List (SCIL) master criteria or are considered “best in class.” Products that have EPA’s Safer Choice Label would not contain any known regrettable substitutes and are considered safer.

Alternative processes: Using cleaning products and stain removers

Instead of applying topical chemical treatments for stain-resistance, cleaning products can be used to remove stains after they have occurred. These products include laundry detergent (for machine washable products), upholstery cleaners (for non-washable products), and stain removers (for after stains occur). EPA’s Safer Choice program recognizes a number of cleaning products. These products are evaluated against the Safer Choice criteria and do not contain regrettable substitutions. Find a non-exhaustive list of Safer Choice cleaning products in Table 21.

Alternatives are feasible and available

The safer alternatives identified are all alternative processes. We identified them as alternative processes because instead of treating furniture and furnishings during the manufacturing process, product cleanability is increased in other ways. At the process level, PFAS:

- Increase the cleanability of products, which maintains the appearance of products.
- In some cases, provide water-resistance when used in leather and textile furniture and furnishings.

Table 20 shows the performance requirements for each product category. When evaluating alternatives, we first determine whether safer alternative chemicals can also serve the functions relevant to each product category. We then use modules from the IC2 guide to address the performance requirements, and to determine whether these safer alternatives are feasible and available.

Indoor furniture and furnishings (residential and commercial)

PFAS are used in indoor furniture to increase the cleanability and maintain the appearance of products. The alternative processes described below offer safer, feasible, and available ways to increase the cleanability of furniture.

Using untreated leather, textiles, or other materials to make products: There are a number of ways untreated leather and textiles can be used to make products that are easier to clean, including using inherently stain-resistant upholstery and designing textiles to be machine washable.

Untreated fabric or leather can be used for some applications to meet the performance needs of consumers, regardless of the stain-resistant properties of the material. Ikea makes furniture using untreated fabrics, and found that it generally meets the performance needs of consumers (Lilliebladh, 2021). Maharam is a textile company that designs and develops textiles for commercial and residential interior environments. They reported that in their experience, PFAS did not provide effective stain-resistance, and that stains were easier to clean on surfaces that did not have any topical stain treatments. In many cases, Maharam has moved away from topical stain-resistance treatments all together, and has not seen an increase in claims relating to staining (Phillips, 2021). Humanscale designs and manufactures commercial office furniture. They reported that their internal product studies show untreated products can meet performance needs of consumers (Zhou, 2021). They also reported that they have observed that the benefits of PFAS are relatively short-lived (Zhou, 2021). The experiences of these three companies demonstrate the feasibility of untreated furniture and furnishings for meeting the performance needs of consumers.

Inherently stain-resistant materials such as PP, PE, polyester, wool, and TPU can be used instead of fabrics or leather treated with PFAS for furniture where staining is a concern. The fibers used in synthetic, inherently stain-resistant fabrics (PP, PE, and polyester) are all solution-dyed, which significantly reduces the ability of staining liquid to bind to the fiber. Wool fibers are covered in an outside cuticle that makes it difficult for stains to penetrate into the fiber. TPU is a plastic material that is water- and oil-repellent. In all cases, these stain-resistant fibers are easier to clean than non-stain-resistant fibers.

We identified five examples of companies already using these safer alternatives in furniture and furnishings. They are Burrow, Levity, Sabai Design, Carnegie Xorel® Fabrics, and Herman Miller.

- **Burrow** uses polypropylene fabrics called Nomad and Range (Burrow, 2021a) that are inherently stain resistant (Burrow, 2021b). They offer a wide variety of fabric furniture using this material (Burrow, 2021c).
- In addition to using an inherently stain-resistant fabric (polyester), **Levity** also designs products to have removable, washable covers (2021b). Levity uses this alternative process to make many different types of furniture (Levity, 2021b).
- **Sabai Design** also uses a polyolefin-based fabric to make furniture. Their woven upcycled poly is made from 100% upcycled polyolefin (Sabai Design, 2021a). This fabric is inherently stain resistant (Sabai Design, 2021b) and used to make a wide variety of furniture (Sabai Design, 2021c).
- **Carnegie** offers Xorel® fabrics, which use polyethylene based yarn for wall coverings and other upholstery applications (Carnegie Fabrics INC, 2020a). Xorel® upholstery is inherently stain resistant (Carnegie Fabrics INC, 2020b).
- **Herman Miller** offers a number of untreated wool, polyester, and polyester blend fabrics for use in a variety of furniture and furnishing products for residential and commercial use (Herman Miller, 2021).

TPU is used in residential and commercial furniture to provide an easy-to-clean surface without topical treatments. Herman Miller makes polyurethane furniture for commercial applications (Herman Miller, 2021). Ikea makes polyurethane furniture for residential and commercial applications (Ikea, 2021b, 2021c). This material and other wipeable surfaces are used as an alternative to PFAS by Kaiser Permanente in high-traffic areas (Franklin, 2016). Cleanability is an important attribute of hospital furniture. Kaiser Permanente's implementation of this alternative process further demonstrates the feasibility and availability of wipeable alternatives, including TPU.

Designing products to make fabrics easier to clean: Furniture and furnishing products can also be designed to be easier to clean using conventional equipment. We identified several products that are designed with removable upholstery than can be washed using a laundry machine, enhancing their cleanability. Covers that are removeable can be washed to clean any spills or stains after they occur. Three examples of companies using removeable, washable covers to increase the cleanability of furniture are Sabai Designs, Levity, and Ikea.

- **Sabai Designs** offers slipcovers made with inherently stain-resistant fabrics (polyolefin) that are removeable and machine washable (Sabai Designs, 2021d).
- **Levity** makes furniture using removeable, machine washable covers (Levity, 2021a). The covers are made from inherently stain-resistant polyester fabric and have a thermoplastic polyurethane barrier to protect the foam cushions (Levity, 2021a). The

covers can be purchased separately from the furniture, but are designed specifically for Levity products (Levity, 2021c).

- **Ikea** offers untreated fabric furniture with removeable, washable covers (Ikea, 2021a). Ikea prohibited the use of PFAS in textile materials in 2016 (Ikea, 2016) and did not replace PFAS with any other chemical treatment for indoor furniture (Lilliebladh, 2021).

Find a non-exhaustive list of safer laundry detergents in Chapter 5.

Using cleaning products and stain removers: When untreated fabrics are used in furniture and furnishings, cleaning products can be used to provide increased cleanability in the absence of topical treatments. A non-exhaustive list of safer stain treatments can be found in Table 21. These products have the Safer Choice label, indicating that they have been evaluated against the safer choice standard. These cleaners are currently offered for sale, meeting our criteria for being feasible and available.

Table 21. A non-exhaustive list of Safer Choice cleaning products that can be used to increase the cleanability of untreated leather and textile furniture and furnishing products.

EPA Safer Choice product name*	Product manufacturer*	Relevant products	Qualifying language
Bissell Advanced Clean + Protect	BISSELL Homecare, Inc.	Home upholstery and carpets	StainProtect™ Technology to keep carpets cleaner longer
Bissell Clean + Protect	BISSELL Homecare, Inc.	Home upholstery and carpets	StainProtect™ Technology to keep carpets cleaner longer
Fabric and rug cleaner maximum strength	Guardian Protection Products	Upholstery or carpet	Water based oxidizer cleaner. Works on all washable fabrics and rugs with cleaning codes W or WS.
Upholstery Stain Remover – Gold & Upholstery Stain Remover – Purple	Crypton, Inc.	Upholstery	Professional strength, ready-to-use cleaner is built to remove tough stains. Use [Crypton Gold] in combination with Crypton Purple for stains like mayo and salad dressing.
Revitalize Miracle Spotter	Ecolab, Inc.	Upholstery	An excellent multi-purpose spotter ideal for both common and the "unknown" spots and stains.
Crypton leather/vinyl treatment	Crypton, Inc.	Home and business leather/vinyl cleaner for furniture	Removes dirt, crayon, dye transfer. Our chemically balanced cleaner is specially formulated to safely clean treated leather and vinyl.
Fabric and rug cleaner maximum strength	Guardian Protection Products	Home washable fabrics	Cleans ink, newspaper transfer, highlighter, grape juice, red soda, lipstick, cosmetics, iodine, blood, sun block, wine, mustard, and much more.

EPA Safer Choice product name*	Product manufacturer*	Relevant products	Qualifying language
Fabric and rug cleaner stain spotter	Guardian Protection Products	Home washable fabrics	Cleans food, beverage, liquor, protein, chocolate, tea, ketchup, coffee, blood, milk, butter, vomit, jelly, oil, and much more.
Emergency Stain Rescue	Emergency Stain Rescue LLC	Home and business fabric and upholstery	This on-the-spot stain solution quickly & safely rescues your clothes, carpets, and upholstery from life's inevitable accidents.
Krud Kutter	Rust-Oleum Corporation	Indoor, outdoor, automotive, marine surfaces.	The most effective and safe all purpose remover available. Excellent laundry stain remover—it's color fast and fabric safe.
CLR Outdoor Furniture Cleaner	CLR	Outdoor products (including fabrics)	Specially formulated to remove outdoor dirt and grime quickly and easily.
Outdoor surface cleaner	EcoCompounds, Inc.	Outdoor furniture, awnings	Strips away mold and mildew. Get the yuck off an outdoor surface.

Note: * = Any reference in this publication to persons, organizations, services, products, or activities does not constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

Find a summary of safer, feasible, and available alternatives to PFAS in indoor residential and commercial furniture in Table 22. We found that untreated materials, products designed specifically for increased cleanability, and the use of safer stain treatments and cleaning products can increase the cleanability of leather and textile furniture for indoor uses.

Table 22. Summary of safer, feasible, and available alternatives for indoor residential and commercial furniture.

Alternative process	Safer, feasible, available alternatives*
Use untreated materials	• Polyolefin (polypropylene)—Sabai, Burrow • Polyester—Levity • Polyethylene—Carnegie Xorel Fabrics • Polyurethane (Ikea, Herman Miller)
Design product so textile is easier to clean	• Removeable and washable covers—Ikea • Removeable and washable covers—Sabai • Removeable and washable covers—Levity • Safer Choice laundry detergent

Alternative process	Safer, feasible, available alternatives*
Untreated fabrics with stain treatments	• Ikea • Maharam • Herman Miller • Safer Choice stain removers

Note: * = Any reference in this publication to persons, organizations, services, products, or activities does not constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

Other indoor textiles

PFAS are used in other textiles to increase the cleanability and maintain their appearance. In some cases, such as for mattress and pillow protectors and shower liners, water-resistant barriers may also be required. We describe alternative processes for serving these functions below.

Using untreated leather, textiles, or other materials to make products: TPU or EVA barriers can be added to home textiles when water or liquid resistance is necessary. Naturepedic and Ikea make mattress protectors using polyurethane barriers to protect the foam products beneath and increase the cleanability of the product (Ikea, 2021d; Naturepedic 2021a, 2021b). EVA can be used to make water-resistant shower curtains (Ikea, 2021e).

Designing products to make fabrics easier to clean: Untreated textiles can meet the performance needs for washable products. Sheets, towels, napkins, tablecloths, curtains, and many other home textiles can be washed. Find examples of Safer Choice cleaning products in Table 21. Ikea sells many washable home textiles that do not have topical stain treatments and are designed to be washed using a home laundry machine (Lilliebladh, 2021).

Outdoor furniture and furnishings (residential and commercial)

PFAS are used on outdoor furniture and furnishings to increase their cleanability. PFAS also provide water-resistance to textiles. In outdoor furniture and furnishings, PFAS-treated textiles may help protect fabric, as well as objects below it (like cushion foam) from rain or liquid damage. PFAS-treated textiles are used to keep items placed underneath dry, such as people or furniture items.

The alternative processes described below offer safer, feasible, and available ways to increase the cleanability and protect untreated outdoor furniture. However, we did not identify untreated textiles that are used to make outdoor furniture and furnishings. Absent this information, we could not identify that safer alternative process as feasible and available for this product type.

Using untreated materials other than textiles to make products: High density polyethylene is an untreated material that is water resistant and can be used to make uncushioned outdoor furniture. Loll Designs makes a recycled high density polyethylene outdoor furniture for residential and commercial applications (Loll Designs, 2021). Other companies also make furniture out of high density polyethylene, including Tailwind (Tailwind, 2021a, 2021b).

Storing untreated furniture under cover: Outdoor furniture is most often damaged through weathering, which occurs through prolonged exposure to outdoor conditions. By storing furniture inside or under cover when not in use, damage due to exposure can be reduced, making it easier to keep the furniture clean and maintain its appearance. One way to store furniture under cover is through the use of deck boxes. Deck boxes can be made out of high density polyethylene (Lifetime, 2021; Tailwind, 2021a, 2021b). However, because we did not identify any untreated outdoor furniture on the market, we determined this option did not meet our criteria for feasible and available.

Using cleaning untreated products and stain removers: Another way to reduce the damage caused by exposure to outdoor conditions is by using cleaning products to provide increased cleanability. Find a non-exhaustive list of safer cleaning products and stain treatments in Table 21. These products have the Safer Choice label and are currently used for the application of interest. They meet our criteria for being feasible and available. However, because we did not identify any untreated outdoor furniture on the market, we determined this option did not meet our criteria for feasible and available.

Conclusions

We identified several safer alternatives to PFAS that can be used in leather and textile furniture and furnishings. To demonstrate that they are feasible and available, we looked for evidence that these safer alternatives are already used to increase the cleanability of leather and textile furniture and furnishings. Based on the available evidence, we determined that the feasibility of these alternatives depends on whether the product is intended for indoor or outdoor use.

We determined that safer alternatives to PFAS in indoor leather and textile furniture and furnishings are feasible and available (Table 23). We did not identify any indoor leather and textile furniture and furnishings that could not be made or used with the alternative processes discussed above. Restricting the use of PFAS in leather and textile indoor furniture and furnishings would reduce a significant source of exposure for people and the environment.

Several of the untreated materials identified for use indoors could be used in outdoor furniture and furnishings. However, we did not identify examples of untreated leather or textile furniture or furnishings for use in outdoor furniture or furnishings. This lack of use may mean these untreated materials are not feasible for outdoor furniture and furnishings.

In addition to untreated textiles, we identified safer alternative processes to eliminate PFAS in outdoor leather and textile furniture and furnishings, but could not confirm they were feasible at this time.

The first safer alternative is to replace textiles in furniture and furnishings with a hard, impermeable barrier, such as a hard plastic. However, we did not find evidence manufacturers use this alternative in products like outdoor cushions and umbrellas. While this is an available alternative, we do not think these alternatives can completely replace all types of outdoor leather and textile furniture and furnishings.

The second alternative is to store furniture and furnishings when not in use and to clean furniture as needed. Storing furniture can minimize weathering caused by rain exposure and eliminate the need for water-resistant textiles. In the absence of untreated leather and textiles that are used outside, this alternative can only extend the lifetime of treated outdoor furniture and furnishings, not help to replace it.

Based on our findings, we determined that safer alternatives to PFAS in outdoor leather and textile furniture and furnishings are not feasible and available at this time (Table 23).

Table 23. Questions from IC2 Guide for evaluating feasibility and availability of alternative(s).

IC2 Guide feasibility and availability metrics	Determination
Is the alternative used for the same or a similar function?	**Indoor leather and textile furniture and furnishings:** Yes, we identified a wide variety of alternative processes for increasing the cleanability and maintaining the product appearance. We also identified alternative processes for water resistance, when needed. **Outdoor leather and textile furniture and furnishings:** We identified alternative processes for increasing the cleanability and maintaining the product appearance and providing water resistance. However, we do not think these alternatives can completely replace leather and textile furniture and furnishings.
Is the alternative used in similar products on the commercial market?	**Indoor leather and textile furniture and furnishings:** Yes, the alternative processes are being used by a number of manufacturers and retailers. We found one example of a hospital putting the alternatives into practice. **Outdoor leather and textile furniture and furnishings:** No, the alternative processes are not currently used for leather or textile furniture or furnishing products marketed for outdoor environments.
Is the alternative marketed in promotional materials for application of interest?	**Indoor leather and textile furniture and furnishings:** Yes, the alternative processes are marketed as providing stain resistance, cleaning fabric and upholstery, providing water resistance (when needed) and/or increasing the cleanability of products. **Outdoor leather and textile furniture and furnishings:** Yes, the alternative processes are marketed as cleaning fabric and upholstery, providing water resistance or increasing the cleanability of products.
Is this a favorable alternative based on answers to the above questions?	**Indoor leather and textile furniture and furnishings:** Yes, we determined that the alternatives are feasible and available for all reported uses of PFAS. **Outdoor leather and textile furniture and furnishings:** No, we determined that the alternatives are not feasible and available for all reported uses of PFAS in leather and textiles intended for use outdoors.

Reducing a significant source or use

In order to restrict or prohibit priority chemicals in priority products, RCW 70A.350.040[105] requires Ecology and Health to determine that either:

- The restriction will reduce a significant source or use of a priority chemical, or
- The restriction is necessary to protect the health of sensitive populations or sensitive species.

We identified leather and textile furniture and furnishings as as a significant source or use of PFAS in our 2020 report to the Legislature.[106] That report became effective at the end of the 2021 legislative session on April 25, 2021. Based on that report, we determined that restricting any of the chemical-product combinations in that report would reduce a significant source or use of a priority chemical class. With this determination, further evaluating whether a restriction would reduce a significant source or use (RCW 70A.350.040(3)(b)(ii)) is not required by statute.

As outlined in our report to the Legislature on priority consumer products (Ecology, 2020a), leather and textile furnishings that have been treated during the manufacturing process with PFAS are a significant source and use of PFAS (Ecology, 2020a). These products contribute to the amounts of PFAS in our homes, workplaces, and environment, and have the potential to expose infants, young children, and women of childbearing age.

People are exposed to PFAS, with children often being more exposed than adults. A wide range of PFAS are frequently detected in nearly all people, including women of childbearing age, infants, and young children (CDC-NHANES, 2015, 2017). Concentrations of PFAS in dust are important because children, including infants, spend more time on or near the floor, and have relatively high respiration rates and frequent hand-to-mouth activity. As such, they are exposed to more contaminated air, carpet, and house dust compared to their body weight than older people. Karaskova et al. (2016), Shoeib et al. (2011), Tian et al. (2016), and Trudel et al. (2008) found that house dust is an important PFAS exposure route for toddlers.

PFAS from textiles can be released into indoor air and accumulate in dust (Morales-McDevitt et al., 2021; Schlummer et al., 2013; Yao et al., 2018). Human exposure to PFAS occurs when people inhale and ingest the contaminated air and dust. The presence of PFAS in dust from buildings without carpet shows the contribution from other products (Zeng et al., 2020). Babies and children under age three, who often put objects in their mouths, can ingest PFAS when mouthing textile furnishings, such as tablecloths or upholstered furniture. In a 2013 study by the Danish Ministry of the Environment, PFCAs were found to migrate from textiles into artificial saliva, with the saliva collecting 1% of the concentration found in the textile (DEPA, 2014).

Recently a number of the PFAS used in furniture and furnishings have been detected in breastmilk (Zheng et al., 2021). Of the 12 PFAS assessed, PFOA, PFOS, and PFHxA were detected

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[105] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.040

[106] https://apps.ecology.wa.gov/publications/summarypages/2004019.html

at the highest concentrations (Zheng et al., 2021). This is noteworthy because a recent intervention study found that replacing PFAS-containing carpet and furniture decreased PFAS concentrations in dust by 78%, and that PFHxA had the biggest reduction (Young et al., 2021). This is in line with other studies showing women living in homes with treated carpet or upholstery had higher exposure to PFNA and PFDeA (Boronow et al., 2019). Reducing the use of PFAS in carpets and furniture significantly reduces PFAS in dust (Young et al., 2021), and may eventually lead to reductions in the PFAS found in breastmilk at the highest concentrations (PFHxA).

Side-chain fluorinated polymers are the most common PFAS used in leather and textile furnishings (Ecology, 2020a). These side-chain fluorinated polymers degrade under normal wear and tear, releasing fluorinated side-chains (e.g., FTOHs) which degrade to PFCAs (Winkens et al., 2018). While concentrations of PFAS in textiles vary, multiple studies have found PFCAs and FTOHs in leather and textile furnishings (Ecology, 2020a). We estimate that a total of 15,500 metric tons (approximately 34 million pounds) of treated textiles are in Washington homes—containing 310 – 465 metric tons of side-chain fluorinated polymers, 0.1 – 16 kg total PFCA (C5 – C12), and 6 – 665 kg FTOHs (Ecology, 2020a). We also estimate that up to 1,800 metric tons of PFAS-treated furniture and 5,000 metric tons of PFAS-treated textiles are disposed in Washington landfills each year (Ecology, 2020a).

As outlined in our report on priority consumer products, the use of PFAS in leather and textile furnishings is a significant source of PFAS to humans and the environment. Therefore, restricting the use of PFAS in leather and textile furnishings will reduce a significant source of PFAS exposure to people and the environment.

Priority product: Carpets and rugs

Scope of priority product

Carpets and rugs sold for residential and commercial settings.

Function of priority chemical in priority product

To identify potential safer alternatives, we first determine whether the function provided by the priority chemical is necessary to meet the performance requirements of the priority product at the chemical, material, product, or process level. If the priority chemical does not provide a necessary function, the chemical can be removed and there is no need to identify alternatives.

PFAS are applied to carpets and rugs to confer stain and soil resistance. This function increases the cleanability of carpets and rugs, which helps to maintain their appearance over time. Table 24 shows the function of PFAS in carpets and rugs at the chemical, material, product, and process levels.

Table 24. Function of PFAS in carpets at the chemical, material, product, and process levels.

Level	Function
Chemical	PFAS repel aqueous and oily liquids
Material	PFAS-coated material is better able to repel dirt and may reduce liquid absorption
Product	PFAS are applied as a topical treatment to carpet/rug fibers to prevent soiling (uptake of dirt by residue on carpet); may prevent staining of the fiber
Process	PFAS-treated surface has increased cleanability, which maintains appearance of the carpet

Alternatives are safer, feasible, and available

Alternatives are safer

The scope of this assessment is limited to chemicals used to replace PFAS. PFAS as a class do not meet our minimum criteria for safer. Chemical alternatives that are used to replace PFAS must meet the minimum criteria for safer in order to be considered safer alternatives.

Alternative products or processes where no chemical treatments are used to repel aqueous liquids or oils are not evaluated against our minimum criteria for safer. Instead, they cannot contain chemicals known to be in products during use at concentrations greater than 100 ppm that have known hazards of concern (such as known carcinogens, mutagens or reproductive or developmental toxicants). We do not evaluate chemicals found in both the priority product and the alternatives for known hazards of concern. For example, a toxic chemical found in both untreated and PFAS-treated carpet would not be considered because it's found in both the priority product and the alternative product or process.

Our evaluation of the hazards of carpets and rugs was limited to PFAS used for premarket topical treatments. Comparing the hazards of one component of a product or process (such as the topical treatment) to the hazards of an entire product or process is uneven. If a topical treatment can be avoided by using an alternative material, product, or process, then the alternative is safer—provided there are no known chemical hazards that would be considered regrettable substitutions.

Many alternatives have been identified by searching the Cradle to Cradle Certified® (C2CC®) product database (C2CC®, 2021d). The Cradle to Cradle Products Innovation Institute certifies products based on assessment of five categories:

- Material Health
- Material Reuse
- Renewable Energy and Carbon Management
- Water Stewardship
- Social Fairness

Products are certified as basic, Bronze, Silver, Gold, or Platinum for each category. The lowest score is used to define the product's final certification level. Products with Material Health Certificates™ of Gold or Platinum are likely to meet our criteria for safer. However, for products evaluated against the Material Health Standard Version 3.1, we need to confirm two points:

- There are no very persistent and very bioaccumulative chemicals used to function like priority chemicals.
- Any adjustments for exposure potential still meet our criteria for safer.

Products with a Silver or Bronze Material Health Certificates™ may also meet our minimum criteria for safer. However, we need to confirm not only the details described above, but also that the ingredients functioning like priority chemicals were included in the analysis and are green or yellow. More information about how C2CC® products can meet our criteria for safer can be found in Appendix E, focused on safer certifications.

We identified alternative chemical treatments and alternative processes that can increase the cleanability of carpets and rugs, and maintain their appearance over time.

Alternative processes: Using untreated leather, textiles, or other materials to make products

Inherently soil- or stain-resistant fibers can be used to make carpets and rugs that do not require any topical treatments. We reviewed available information and determined that the untreated materials below would not be regrettable substitutions.

Polypropylene (PP) textiles do not require additional topical treatments (Ikea, 2021g). We did not identify any known regrettable substitutions in PP. The Minnesota Office of Environmental Assistance ranked six plastics by estimated environmental risk, and found that PP has the lowest environmental risk (Minnesota, 1998). Similarly, Clean Production Action's plastics scorecard scores polypropylene with an A-, the highest score achieved in version 1.4 (CPA, 2011). PP is a polyolefin plastic formed by the polymerization of propylene. PP (CAS: 9003-29-6) is listed on the EPA's SCIL as a green circle, indicating that at least certain PP can be made that is not a regrettable substitute (EPA, 2021b). Find more information about polypropylene in the Leather and Textile Furnishing Section.

Wool is an inherently stain-resistant fabric made from fibers obtained from sheep or other animals. We identified one commercial carpet product that uses a wool blend that has a Silver C2CC® Material Health Certificate™ (C2CC®, 2021e). We confirmed that this product contains no chemical topical stain treatments and that the anti-soiling properties come from the use of wool in the fiber blend (Ditmer, 2021). We conclude that we did not identify any known regrettable substitutions associated with wool.

Polyester can be used to make synthetic fibers with inherent stain-resistance properties (Ruggable, 2021a, 2021b). One known concern about polyester fabrics is the potential for antimony to be present (Bivar, 2021). Antimony is "reasonably anticipated to be a human carcinogen" according to the U.S. National Toxicology Program (NTP, 2018a) and a Chemical of High Concern to Children (Washington State, 2018). We determined that polyester was not a regrettable substitution because:

- Polyester carpets that are C2CC® (C2CC®, 2021g, 2021m, 2021n) cannot have antimony concentrations over 100 ppm. This suggests that carpet polyester can be made with low concentrations of antimony.

- Polyester carpets can be made with and without treatments. Untreated polyester is safer than polyester carpets treated with PFAS.

Nylon can be used to make a synthetic fabric with inherent stain-resistance properties. The shape of these fibers can also be controlled such that they are more soil-resistant. We identified nylon fibers that do not require additional topical treatments for stain- or soil-resistance, which we determined are safer than nylon fibers that have been treated with PFAS (Interface, 2021a). Additionally, some nylon carpets are C2CC®, indicating that they do not contain regrettable substitutions (C2CC®, 2021k, 2021l). Since these C2CC® products are treated, it also demonstrates that nylon carpets can be treated or untreated, supporting the identification of untreated nylon carpets and rugs as safer alternatives.

Alternative processes: Designing products to make surface fibers easier to clean

Some manufacturers make rugs where the rug cover—which contains surface fibers—can be removed and cleaned in a washing machine. Topical treatments are not necessary because the rug can be washed (Ruggable, 2021c). Washable rugs can be made out of polyester, which is used in carpets with and without topical treatments. Washable polyester rugs without topical treatments are safer than rugs treated with PFAS (which can be made out of polyester).

This process also requires laundry detergent. Find a list of EPA Safer Choice laundry detergents in Chapter 5 (alkylphenol ethoxylates).

Alternative processes: Cleaning untreated carpets

Instead of using pretreated carpets, untreated carpets and rugs can be cleaned using EPA Safer Choice cleaning products. Table 21 identifies a number of Safer Choice cleaning products that do not contain any regrettable substitutions.

Alternative chemical treatments

Acrylate copolymer (CAS 25322-99-0): Mohawk Industries uses an acrylate copolymer to provide stain and soil resistance (Marshall, 2017). This polymer is a green full circle on EPA's SCIL (EPA, 2021b). It has been evaluated against the polymer criteria (EPA, 2015b). The polymer criteria meets our minimum criteria for safer. Find more information about how chemicals on SCIL meet our criteria for safer in Appendix E, focused on safer certifications.

Eco-Ensure: Tarkett makes Eco-Ensure, a water-based, non-fluorinated anti-soiling product that is applied to carpet. This product has a Platinum Material Health Certificate™ from C2CC® (Version 3.1) (C2CC®, 2021f). We received an additional declaration from Tarkett that the products evaluated by C2CC® did not contain any very persistent and very bioaccumulative chemicals (Tarkett, 2021a). We also evaluated any potential adjustments for exposure potential and concluded that Eco-Ensure meets our minimum criteria for safer. Find more information about how products with C2CC® certifications can meet our criteria for safer in Appendix E, focused on safer certifications.

Chemical treatments used by Shaw Industries: Shaw Industries has a number of carpet products with Silver C2CC® Material Health Certifications™ (under Version 3.1). We received an additional declaration asserting that all ingredients used for stain or soil resistance were evaluated (Shaw Industries, 2021a, 2021b, 2021c, 2021d, 2021e, 2021f, 2021g). We determined that at least eight products meet our minimum criteria for safer. Find more information about how products with C2CC® certifications can meet our criteria for safer in Appendix E, focused on safer certifications.

- **Commercial Polyester Broadloom Carpets** have a Bronze C2CC® Material Health Certificate™ (Version 3.1) (C2CC®, 2021g).
- **Ecoworx Broadloom Carpets** have a Silver C2CC® Material Health Certificate™ (Version 3.1) (C2CC®, 2021h).
- **Ecoworx Carpet Tiles** have a Silver C2CC® Material Health Certificate™ (Version 3.1) (C2CC®, 2021i).
- **StrataWorx Tile Carpets** have a Silver C2CC® Material Health Certificate™ (Version 3.1) (C2CC®, 2021j).
- **Anso and unbranded Nylon 6 Residential Broadloom Carpets** have a Silver C2CC® Material Health Certificate™ (Version 3.1) (C2CC®, 2021k).
- **Residential Nylon 6,6 Carpets** have a Silver C2CC® Material Health Certificate™ (Version 3.1) (C2CC®, 2021l).
- **Residential Polyester Broadloom Carpets** have a Bronze C2CC® Material Health Certificate™ (Version 3.1) (C2CC®, 2021m).
- **Residential Polyester with Lifeguard Backing Carpets** have a Bronze C2CC® Material Health Certificate™ (Version 3.1) (C2CC®, 2021n).

For each of the above products, the additional declaration we received stated that the chemicals used in the topical treatment were assessed as A, B, or C and are not very persistent or very bioaccumulative chemicals (Shaw Industries, 2021a, 2021b, 2021c, 2021e, 2021f, 2021g, 2021h). We also evaluated any potential adjustments for exposure potential and concluded that the treatment used on these products meets our minimum criteria for safer.

Chemical treatments used by Milliken and Company: Milliken and Company has a number of modular carpet tiles with Silver C2CC® Material Health Certifications™ (under Version 3.1) (C2CC®, 2022). We received an additional declaration stating that all ingredients used for stain or soil resistance were included in the evaluation, did not score X or Gray, and were not very persistent or very bioaccumulative (Milliken and Company, 2022a). There were no adjusted risk flags (Milliken and Company, 2022a). We determined that products included in this certification meet our minimum criteria for safer. Find more information about how products with C2CC® certifications can meet our criteria for safer in Appendix E, focused on safer certifications.

Alternatives are feasible and available

PFAS are used to make carpets resistant to soil and stains, increasing the cleanability, and maintaining the appearance over time. When evaluating alternatives, we identified safer alternative processes and chemicals that can also provide stain and soil resistance and help increase the cleanability of carpets and rugs to maintain appearances.

Because many example alternatives are only available for either residential or commercial uses, this section is divided into four categories, described below. For each product category, we identified manufacturers already using safer alternatives. Based on our criteria for feasible and available, alternatives already in use for the application of interest are both feasible and available.

Residential rugs: A number of manufacturers use untreated fibers that do not require a topical treatment, such as wool, polypropylene, and polyester (Ikea, 2021f, 2021g; Ruggable, 2021a). Some of these rugs are designed to be removed from their backing and cleaned in a laundry machine, increasing the cleanability (Ruggable, 2021c). These alternatives may also use carpet cleaners to help increase the cleanability (Table 21).

Commercial rugs: We identified commercial area rugs made using inherently stain- and soil-resistant fibers. Interface makes both commercial rugs and carpets using solution-dyed nylon fibers with a modification ratio that repels soil. The solution-dyed fiber is resistant to stains because there are no vacant dye sites for stains to bind to. The modification ratio describes the shape of the carpet fiber. The more round the carpet fiber is, the better it can repel soil. Interface uses this technology in commercial carpets and rugs (Interface, 2021a, 2021b). Commercial carpets sold by Mohawk use an acrylate copolymer previously identified as safer (Marshall, 2017, 2021; Mohawk Group, 2021a).

Residential carpets: We identified a safer acrylate copolymer that is used by Mohawk (Marshall, 2017). We confirmed that this product is used in residential and commercial products (Mohawk, 2021c; Marshall, 2021). We also identified a number of C2CC® residential nylon and polyester carpets—manufactured by Shaw Industries and affiliates—which use topical treatments that meet our minimum criteria for safer (C2CC®, 2021k, 2021l, 2021m, 2021n; Shaw Industries, 2021e, 2021f, 2021g, 2021h).

Commercial carpets: We identified a number of safer alternatives that are used in commercial products. Interface (described above) uses inherently stain-resistant fibers to make commercial rugs and carpets (Interface 2021a, 2021c). Dansk Wilton A/S Rolortec Rethink uses a wool blend to create inherently stain-resistant fibers (C2CC®, 2021e; Dansk Wilton, 2021; Ditmer, 2021). Tarkett uses Eco-Ensure in products sold for commercial use (C2CC®, 2021f; Tarkett, 2021b). Mohawk uses an acrylate copolymer in commercial products (Marshall, 2017, 2021; Mohawk Group, 2021b). We also identified a number of commercial nylon and polyester carpets—manufactured by Shaw Industries and affiliates—which use topical treatments that meet our minimum criteria for safer (C2CC®, 2021g, 2021h, 2021i, 2021j, 2021k, 2021l, 2021m; Shaw Industries, 2021a, 2021b, 2021c, 2021d, 2021e). Milliken and Company use treatments that meet our minimum criteria for safer on the WellBac comfort and WellBac Comfort Plus modular carpet tiles that are sold in the U.S. (Milliken and Company, 2022b).

Table 25. Summary of safer, feasible, and available alternatives to PFAS in carpet.

Alternative	Safer	Feasible and available*	Application categories
Wool	No topical chemical treatments, C2CC® Silver	Ikea, Dansk	Commercial carpets, residential rugs
Polyester	No topical chemical treatments	Ruggable	Residential rugs, commercial carpets
Solution dyed / shaped fibers	No topical chemical treatments	Interface	Commercial carpets and rugs
Washable rugs	No topical chemical treatments	Ruggable	Residential rugs
Acrylate copolymer	Green circle on SCIL	Mohawk	Residential and commercial carpets, commercial rugs
Eco-Ensure	C2CC® Platinum (+ declaration)	Tarkett	Commercial carpets
Commercial Polyester Broadloom Carpets	C2CC® Bronze (+ declaration)	Shaw Industries	Commercial carpets
Ecoworx Broadloom Carpets	C2CC® Silver (+ declaration)	Shaw Industries	Commercial carpets
Ecoworx Carpet Tile	C2CC® Silver (+ declaration)	Shaw Industries	Commercial carpets
Nylon StrataWorx Tile Carpets	C2CC® Silver (+ declaration)	Shaw Industries	Commercial carpets
Anso and unbranded Nylon 6 Residential Broadloom Carpets	C2CC® Silver (+ declaration)	Shaw Industries	Residential carpets
Residential Nylon 6,6 Carpets	C2CC® Silver (+ declaration)	Shaw Industries	Residential carpets
Residential Polyester Broadloom Carpets	C2CC® Bronze (+ declaration)	Shaw Industries	Residential carpets
Residential Polyester with Lifeguard Backing Carpets	C2CC® Bronze (+ declaration)	Shaw Industries	Residential carpets
Modular Carpet Tiles WellBac Comfort and WellBac Comfort Plus	C2CC® Silver (+ declaration)	Milliken and Company	Commercial carpets

Note: * = Any reference in this publication to persons, organizations, services, products, or activities does not constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

Conclusion

We found that safer alternatives are feasible and available for residential and commercial carpets and rugs as demonstrated by the responses to the questions in Table 26.

We found safer alternatives for all four categories of carpet. However, we expect that there will be some level of transferability between residential and commercial applications—as demonstrated by Mohawk's ability to use the same polymer for both applications. Further, we find some alternative processes, like using wool blends or polyester fibers, to be applicable in both residential rugs and commercial carpets. Restricting the use of PFAS in carpets and rugs would reduce a significant source of exposure for people and the environment.

Table 26. Questions from IC2 Guide for evaluating feasibility and availability of alternative(s).

IC2 Guide feasibility and availability metrics	Determination
Is the alternative used for the same or a similar function?	Yes, we identified alternative chemicals, products and processes that increase the cleanability and maintain the appearance of carpets.
Is the alternative used in similar products on the commercial market?	Yes, the alternatives identified are already being used in commercial and residential rugs and carpets.
Is the alternative marketed in promotional materials for application of interest?	Yes, the alternatives are used in products marketed for stain and soil resistance.
Is this a favorable alternative based on answers to the above questions?	Yes, we found that alternatives are widely used in the same or similar products and thus they are feasible and available.

Reducing a significant source or use

In order to restrict or prohibit priority chemicals in priority products, RCW 70A.350.040[107] requires Ecology and Health to determine that either:

- The restriction will reduce a significant source or use of a priority chemical, or
- The restriction is necessary to protect the health of sensitive populations or sensitive species.

We identified carpets and rugs as a significant source and use of PFAS in our 2020 report to the Legislature.[108] That report became effective at the end of the 2021 legislative session on April 25, 2021. Based on that report, we determined that restricting any of the chemical-product combinations in that report would reduce a significant source or use of a priority chemical class. With this determination, further evaluating whether a restriction would reduce a significant source or use (RCW 70A.350.040(3)(b)(ii)) is not required by statute.

Carpets and rugs that have been treated during the manufacturing process for stain-, oil-, and water-resistance are a significant source of exposure and use of PFAS (Ecology, 2020a). These products contribute to the amounts of PFAS in our homes, workplaces, and environment, and have the potential to expose infants, young children, and women of childbearing age. We considered the potential for exposure to sensitive populations and the estimated volume of products sold or present in Washington, and determined that a restriction on the use of PFAS in carpets would reduce a significant source or use of PFAS.

People are exposed to PFAS, with children often being more exposed than adults. A wide range of PFAS have been frequently detected in nearly all people, including women of childbearing

[107] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.040
[108] https://apps.ecology.wa.gov/publications/summarypages/2004019.html

age, infants, and young children (CDC-NHANES, 2015, 2017). Concentrations of PFAS in dust are important because children, including infants, spend more time on or near the floor, and have relatively high respiration rates and frequent hand-to-mouth activity. As such, they are exposed to more contaminated air, carpet, and house dust compared to their body weight than older people. Karaskova et al. (2016), Shoeib et al. (2011), Tian et al. (2016), and Trudel et al. (2008) found that house dust is an important PFAS exposure route for toddlers. Washburn et al. (2005) estimated that the reasonable maximum exposure scenario for PFOS in carpet was two orders of magnitude higher for infants than adults, meaning infants could be exposed to PFAS at a level that is about 100 times higher than adults. Some studies have not separated exposures to different products, but have included exposure to furnishings and carpets, some of which may have had aftermarket treatments.

Recently a number of the PFAS used in carpet have been detected in breastmilk (Zheng et al., 2021). Of the 12 PFAS assessed, PFOA, PFOS, and PFHxA were detected at the highest concentrations (Zheng et al., 2021). This is noteworthy because a recent intervention study found that replacing PFAS containing carpet and furniture decreased PFAS concentrations in dust by 78%, and that PFHxA had the biggest reduction (Young et al., 2021). This is in line with other studies showing women living in homes with treated carpet or upholstery had higher exposure to PFNA and PFDeA (Boronow et al., 2019).

Studies show that children with carpets in their bedrooms have higher concentrations of PFOS, PFHxS, and Me-PFOSA-AcOH in their bodies than children with other types of bedroom flooring (Harris et al., 2017). Fraser et al. (2012) found that office workers in buildings with higher concentrations of FTOH in the air had higher concentrations of PFOA in their blood. Trudel et al. (2008) found that treated carpet could be a prominent source of consumer product exposure. They estimated that between 5 and 64% of PFOS exposure was related to contact with treated carpet. Reducing the use of PFAS in carpets and furniture significantly reduces PFAS in dust and may eventually lead to reductions in breastmilk concentrations.

We estimate that 1,300 – 2,000 metric tons (2.8 – 4.4 million pounds) of PFAS are brought into Washington homes and workplaces in carpet each year—a significant portion of PFAS use in total (Ecology, 2020a). We estimate that 36,000 – 58,000 metric tons of PFAS-treated carpet end up in Washington landfills, and 47 – 76 metric tons of PFAS-treated carpet are illegally dumped each year in Washington (Ecology, 2020a).

As outlined in our priority product report, use of PFAS in carpets and rugs is a significant source of PFAS to humans and the environment. Therefore, restricting the use of PFAS in carpets and rugs will reduce a significant source of PFAS exposure to people and the environment.

Priority product: Aftermarket stain- and water-resistance treatments

Scope of priority product

Aftermarket stain- and water-resistance treatments applied to textile and leather consumer products used in residential and commercial settings and in vehicles.

These treatments may be used on a variety of products by consumers or commercial applicators (including carpets, rugs, furniture, home textiles, apparel, and shoes) after the product is purchased. This scope does not include products marketed or sold exclusively for use at industrial facilities during the process of carpet, rug, clothing, shoe, or furniture manufacturing.

Function of priority chemical in priority product

To identify potential safer alternatives, we first determine whether the function provided by the priority chemical is necessary to meet the performance requirements of the priority product at the chemical, material, product, or process level. If the priority chemical does not provide a necessary function, the chemical can be removed and there is no need to identify alternatives.

PFAS are added to aftermarket stain- and water-resistance treatments to provide water resistance or to increase the cleanability of the treated surface. Table 27 describes the function of PFAS in aftermarket treatments at the chemical, material, product, and process levels.

Table 27. The function of PFAS in aftermarket stain- and water-resistance treatments at the chemical, material, product, and process levels.

Level	Function
Chemical	PFAS repel aqueous and oily liquids.
Material	PFAS-coated material help limit seepage of liquids through the material.
Product	Applied to other products to restore or create a surface barrier that limits seepage of liquids through to the material below.
Process	Keeps object under or within the treated surface dry and enhances cleanability of the treated surface.

Not all the functions PFAS provide are necessary for every application of aftermarket treatments. In order to identify alternatives that meet the performance requirements for specific applications, we separated treatments into three categories:

- **Outdoor apparel and gear treatments**: PFAS provide water resistance to keep people and gear dry. Examples of products these treatments can be applied to include raincoats, shoes, tents, and outdoor gear.
- **Outdoor textile treatments:** PFAS provide water-resistance and increase cleanability. Examples of products these treatments can be applied to include furniture and other upholstery.

- **Indoor textile and leather treatments**: PFAS provide stain-resistance for textiles, which increases the cleanability of the product. Examples of products these treatments are marketed for include carpets, furniture, and other upholstery, including vehicle interiors.

Alternatives are safer, feasible, and available

Alternatives are safer

The scope of this assessment is limited to chemicals used to replace PFAS. PFAS as a class do not meet the minimum criteria for safer. Chemical alternatives that are used to replace PFAS must meet the minimum criteria for safer in order to be considered safer alternatives.

Alternative products or processes where no chemical treatments are used to repel aqueous liquids or oils are not evaluated against our minimum criteria for safer. Instead, they cannot contain chemicals known to be in products during use at concentrations greater than 100 ppm that have known hazards of concern (such as known carcinogens, mutagens or reproductive or developmental toxicants). We do not evaluate chemicals found in both the priority product and the alternatives for known hazards of concern.

Our evaluation of the hazards of aftermarket stain- and water-resistance treatments was limited to PFAS used for increasing the cleanability. Comparing the hazards of one component of a product or process (such as the topical treatment) to the hazards of an entire product or process is uneven. If a topical treatment can be avoided by using an alternative material, product, or process, then the alternative is safer—provided there are no known chemical hazards that would be considered regrettable substitutions.

Alternative chemicals

Nikwax products: We received ingredient information from Nikwax through a confidential business information agreement. We reviewed a hazard assessment conducted by assessors at Scivera using Scivera GHS+. Find more information about Scivera GHS+ in Appendix E, focused on safer certifications. In addition to the Scivera assessment, all Nikwax products comply with a relatively comprehensive restricted substances list (Nikwax, n.d.a).

- **Fabric and Leather Proof:** A Scivera assessment of all intentionally added ingredients, impurities, and residual monomers was conducted through a confidential business information agreement with Nikwax (Scivera, 2021t). We found that all the intentionally added ingredients, residual monomers, and impurities present above 1,000 ppm met our minimum criteria for safer. Impurities and residual monomers present between 100 and 1,000 ppm did not score high (based on our criteria for safer) for group one human health hazards (carcinogenicity, mutagenicity, reproductive and developmental toxicity, or endocrine disruption). We conclude that Nikwax Fabric and Leather Proof meets our minimum criteria for safer. Find more details about how chemicals evaluated using Scivera GHS+ meet our minimum criteria for safer in Appendix E, on safer certifications.
- **TX.Direct® wash-in or spray on:** A Scivera assessment of all intentionally added ingredients, impurities, and residual monomers was conducted through a confidential

business information agreement with Nikwax (Scivera, 2021u). We found that all but one of the intentionally added ingredients, residual monomers, and impurities present above 100 ppm met our minimum criteria for safer. The one chemical that scored red had very high skin and eye irritation predicted based on the high pH of the chemical (pH of 12). The pH of the overall product is approximately 4.5 (Nikwax, 2006). Therefore, we do not anticipate skin or eye irritation of the individual chemical being relevant to the use phase. We conclude that TX.Direct® wash-in or spray on meets our minimum criteria for safer. Find more details about how chemicals evaluated using Scivera GHS+ meet our minimum criteria for safer in Appendix E, on safer certifications.

Safer Chemical Ingredients List: Chemicals that meet the EPA Safer Choice master criteria also meet our minimum and additional criteria for safer. Some chemicals are evaluated against functional class criteria, and these may also meet our minimum criteria—but we evaluate them on a case-by-case basis. Chemicals evaluated against the colorants, polymers, preservatives, and related chemicals criteria (EPA, 2019) meet our minimum criteria for safer, and chemicals listed as processing aids and additives are equivalent to meeting our minimum criteria for safer.

We identified a number of chemicals on SCIL that are used in leather treatment products (Table 28) (EPA SCIL, 2021b). All these chemicals have been evaluated against criteria as or more stringent than our minimum criteria for safer. Orange oil was not identified as a safer chemical based on the SCIL listing alone. We also identified a verified Scivera assessment (CAS 8028-48-6) with a yellow score, indicating that it meets our minimum criteria for safer (Scivera, 2021v). In addition to being on the SCIL processing aids and additives list, lanolin oil was also evaluated as a green/yellow chemical in Scivera (Scivera, 2022l). Find more details about how chemicals evaluated as green/yellow or yellow using Scivera GHS+ meet our minimum criteria for safer in Appendix E, on safer certifications. We conclude that the alternatives listed in Table 28 meet our minimum criteria for safer. We discuss the feasibility and availability of these chemical alternatives below.

Table 28. Alternative chemicals listed on EPA's Safer Chemical Ingredients List (SCIL) that meet our minimum criteria for safer.

Chemicals listed on EPA's SCIL	CAS(s)	SCIL Criteria or other hazard assessment results
Lanolin oil	70321-63-0	SCIL processing aid or additive and Scivera-green/yellow 8006-54-0
Beeswax, white	8012-89-3	SCIL master criteria
Safflower oil	8001-23-8	SCIL master criteria
Vitamin E	N/A	SCIL preservatives and antioxidants criteria
Orange oil	8008-57-9 8028-48-6*	SCIL fragrances criteria (8008-57-9) Scivera—yellow (8028-48-6)
Butyrospermum parkii (shea) butter	194043-92-0	SCIL master criteria
Butyrospermum parkii (shea) oil	91080-23-8	SCIL master criteria
Carnauba wax	8015-86-9	SCIL master criteria

Note: * = CAS not on SCIL.

Alternative products

Safer Choice products: EPA also certifies products as Safer Choice. For a product to meet the Safer Choice standard, all ingredients must meet the criteria for inclusion in the SCIL list, and the product must meet supplemental requirements specific to the product-class. We identified a number of Safer Choice products that provide stain-resistance in addition to cleaning (EPA, 2021c). The chemicals used to provide stain-resistance are identified as polymers, and meet the Safer Choice polymer criteria (EPA, 2015b). The alternative polymers in Table 29 meet our minimum criteria for safer.

Alternative processes

Protecting existing furniture with slipcovers: A safer alternative to aftermarket treatment is covering furniture with slipcovers. These slipcovers can be made with the untreated fabrics described in the leather and textile furniture and furnishings section. In this example, no chemicals are used to replace PFAS.

Using stain removers to clean existing textiles: Instead of pretreating products to avoid stains, Safer Choice stain removers can be used to clean the product after a stain occurs. These products do not provide the same function as PFAS. Therefore, no chemicals are used to replace PFAS. Instead of evaluating these alternatives against our minimum criteria for safer, we determine whether there are any known chemical hazards that would be considered regrettable substitutions. Find a non-exhaustive list of Safer Choice (EPA, 2021c) stain removers in Table 21.

Alternatives are feasible and available

PFAS are used in aftermarket stain- and water-resistance treatments to repel aqueous and oily liquids, which increases the cleanability of the product and provides water resistance. We identified a number of safer chemicals and processes that can be used instead of PFAS-containing aftermarket treatments. We discuss these alternatives separately for the three product subcategories identified for aftermarket treatments.

Outdoor apparel and gear treatments

PFAS are added to outdoor apparel and gear treatments to provide water resistance, keeping people and gear dry. We describe examples of safer alternatives used for the application of interest below.

Alternative chemicals

- Nikwax Fabric and Leather Proof is marketed as leaving a flexible, water-repellent treatment on individual fibers" of fabric and leather products (Nikwax, n.d.b). It is sold at REI and on Amazon (Nikwax, n.d.b).
- Nikwax TX.Direct® wash-in or spray on is marketed as leaving a "flexible water-repellent treatment on individual fibers" (Nikwax n.d.c, n.d.d). It is sold at REI and on Amazon (Nikwax n.d.c, n.d.d).

- Boot Wax by Otter Wax Leathercare (Portland, OR, sold online) contains beeswax and lanolin. It is marketed for use on leather to “naturally repel water and stains” (Otter Wax, n.d.a).
- Leather Oil by Otter Wax Leathercare (Portland, Oregon, sold online) contains safflower oil, vitamin e, and sweet orange oils. It is marketed for use on boots, belts, bags, and more (Otter Wax, n.d.b). When combined with leather salve, leather oil can help protect leather by creating a “natural sealant.”
- Leather Salve by Otter Wax Leathercare (Portland, Oregon, sold online) contains shea butter and carnauba wax. This product is marketed to protect leather by acting as a “natural sealant.” (Otter Wax, n.d.c)

Outdoor furniture treatments

In outdoor furniture, PFAS provide water resistance and increase cleanability. Examples of products these treatments can be applied to include furniture and other upholstery. Examples of safer alternatives used for the application of interest are described below.

Alternative chemicals

Nikwax TX.Direct® wash-in or spray on is marketed as leaving a flexible, water-repellent treatment on individual fibers (Nikwax, n.d.c, n.d.d). It is sold at REI and on Amazon. It is marketed for outdoor gear, but could also be used on outdoor upholstery.

Alternative processes

Using cleaning products and stain removers: Safer Choice products can be used to clean outdoor furniture. Table 21 shows a non-exhaustive list of Safer Choice products that can be used on outdoor furniture and upholstery to increase the cleanability.

Indoor textile treatments

PFAS are added to indoor textile treatments to increase the cleanability of the product. We identified alternative chemicals and processes that can be used to increase the cleanability of indoor textiles, including carpets and upholstery.

Alternative chemicals

- Leather Oil by Otter Wax Leathercare (Portland, Oregon, sold online) contains safflower oil, vitamin e, and sweet orange oils. It is marketed for use on leather couches as well as outdoor apparel and gear (Otter Wax, n.d.b). When combined with leather salve, leather oil can help protect leather by creating a “natural sealant.”
- Leather Salve by Otter Wax Leathercare (Portland, Oregon, sold online) contains shea butter and carnauba wax. This product is marketed to protect leather by acting as a “natural sealant.” (Otter Wax, n.d.c)

Alternative products

Instead of using a treatment for stain resistance, another way to increase the cleanability of indoor textiles is to use cleaning products that also provide stain resistance. Table 29 shows Safer Choice carpet and upholstery treatments that provide stain resistance and increase the future cleanability of the product.

Table 29. Safer Choice Products that clean and provide stain resistance for indoor textiles.

Alternative	Product name*	Product manufacturer*	Uses	Qualifying language
Proprietary sulfonated anionic aqueous polymer	Bissell Advanced Clean + Protect	BISSELL Homecare, Inc.	Home carpets and upholstery	StainProtect™ Technology to keep carpets cleaner longer
Proprietary sulfonated anionic aqueous polymer	Bissell Clean + Protect	BISSELL Homecare, Inc.	Home carpets and upholstery	StainProtect™ Technology to keep carpets cleaner longer
Proprietary anionic polymer	EncapuGuard GREEN	Bridgepoint Systems (Bridgewater Company)	Business carpet	Post cleaning protective treatment that provides soil resistance, stain protection, wicking prevention, and neutralizing
Proprietary anionic polymer, Anionic detergent polymer, Functionalized anionic polymer	TOTALCARE® Green Carpet Stain & Soil Remover – Concentrate	SHAW®	Home and business carpet	Provides protection against reoccurring spots.

Note: * = Any reference in this publication to persons, organizations, services, products, or activities does not constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

Alternative processes for increasing the cleanability of indoor textiles

Protecting furniture with slipcovers: One way to increase the cleanability of existing furniture is to use a slipcover. Slipcovers are widely available and can be purchased at many major retailers including Target, Amazon, Home Depot, and many more. Slipcovers can be used in homes and vehicles to increase the cleanability of upholstery. Table 30 includes examples of slipcovers that are feasible and available (Amazon 2021a, 2021b; Autozone, 2021; Home Depot, 2021; Kohl’s, 2021; Target, 2021; Walmart, 2021).

Table 30. A non-exhaustive list of brands and retailers of slipcovers for home and auto use that protect upholstery and increase cleanability.

Brand*	Retailer*	Products	Qualifying language
Sure Fit	Target	Couches, dining room chairs, living room chairs	Add a new look and great protection to your furniture. Machine washable.
Innovative Textile Solutions	Home Depot	Sofa, chairs	Protect your furniture from spills and stains.
Pure Fit	Amazon	Sofa, chairs	Protects your sofa furniture from daily wears and tears, kids, scratches from pets, dogs or accidental spills. Machine washable.
Kathy Ireland	Kohl's	Sofa	Machine wash.
FH Group	Amazon	Vehicle seats	Easy to clean, machine washable, air dry.
Mighty Rock	Walmart	Vehicle seats	Protection against spills and stains that might occur inside of your vehicle.
Pro Elite	Autozone	Vehicle seats	Machine washable.

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Using stain removers: Instead of pretreating products to avoid stains, Safer Choice stain removers can be used to clean the product after a stain occurs. These products do not provide the same function as PFAS. Therefore, no chemicals are used to replace PFAS. These products have the Safer Choice label, indicating that they do not contain regrettable substitutions. They are currently used for the application of interest. Find a non-exhaustive list of Safer Choice (EPA, 2021c) stain removers in Table 21. These cleaners meet our criteria for being feasible and available.

Conclusion

Find a summary of the safer, feasible, and available alternatives we identified in Table 31. The three product subcategories were based on whether the relevant material being treated is a fabric or leather.

Table 31. A summary of safer, feasible, and available alternative to PFAS in aftermarket stain- and water-resistance treatments.

Product type	Relevant materials	Alternatives identified*	Conclusion
Outdoor apparel and gear	Fabric	Nikwax TX.Direct®, Nikwax Fabric & Leather Proof	Safer, feasible, and available
Outdoor apparel and gear	Leather	Nikwax Fabric & Leather Proof, Otterwax treatments	Safer, feasible, and available
Outdoor textiles	Fabric	Safer Choice cleaners, Nikwax	Safer, feasible, and available

Product type	Relevant materials	Alternatives identified*	Conclusion
Indoor textiles (including carpet)	Fabric	Safer Choice carpet treatments, Safer Choice upholstery treatments, furniture covers	Safer, feasible, and available
Indoor leather	Leather	Nikwax Fabric & Leather Proof, Otterwax treatments	Safer, feasible, and available

Note: * = Any reference in this publication to persons, organizations, services, products, or activities does not constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

PFAS in aftermarket stain- and water-resistance treatments increase product cleanability and provide water resistance to protect people, gear, or foam. We use modules from the IC2 Guide to address the performance requirements below, and to determine whether safer alternative chemicals and processes can also serve this function (Table 32).

Table 32. Questions from IC2 Guide for evaluating feasibility and availability of alternative(s).

IC2 Guide feasibility and availability metrics	Determination
Is the alternative used for the same or a similar function?	Yes, we found alternative chemicals and processes that can provide water resistance and increase the cleanability of products.
Is the alternative used in similar products on the commercial market?	Yes, the alternative chemicals and processes we identified are widely used in products on the commercial market.
Is the alternative marketed in promotional materials for application of interest?	Yes, many product advertise increased cleanability or water resistance, or include other relevant performance language.
Is this a favorable alternative based on answers to the above questions?	Yes, the alternatives are favorable.

We determined that safer alternatives to PFAS in aftermarket stain- and water-resistance treatments are feasible and available. Restricting the use of PFAS in aftermarket treatments would reduce a significant source of exposure for people and the environment.

Reducing a significant source or use

In order to restrict or prohibit priority chemicals in priority products, RCW 70A.350.040[109] requires Ecology and Health to determine that either:

- The restriction will reduce a significant source or use of a priority chemical, or
- The restriction is necessary to protect the health of sensitive populations or sensitive species.

We identified aftermarket stain and water-resistance treatment as a significant source or use of PFAS in our 2020 Priority Consumer Products Report to the Legislature.[110] That report became effective at the end of the 2021 legislative session on April 25, 2021. Based on that report, we determined that restricting any of the chemical-product combinations in that report would reduce a significant source or use of a priority chemical class. With this determination, further evaluating whether a restriction would reduce a significant source or use (RCW 70A.350.040(3)(b)(ii)) is not required by statute.

As outlined in our 2020 report (Ecology, 2020a), the use of aftermarket treatments for stain-, oil-, and water-resistance for textile and leather products is a significant source and use of PFAS (Ecology, 2020a). These products contribute to the amounts of PFAS in our homes, workplaces, and environment, and can expose infants, young children, and women of childbearing age.

People are exposed to PFAS, with children being more exposed than adults. Studies frequently detect a wide range of PFAS in nearly all people, including women of childbearing age, infants, and young children (CDC-NHANES, 2015, 2017). Concentrations of PFAS in dust are important because children, including infants, spend more time on or near the floor, and have relatively high respiration rates and frequent hand-to-mouth activity. As such, they are exposed to more contaminated air, carpet, and house dust compared to their body weight than older people.

Karaskova et al. (2016), Shoeib et al. (2011), Tian et al. (2016), and Trudel et al. (2008) have found that house dust is an important PFAS exposure route for toddlers. Washburn et al. (2005) estimated that the reasonable maximum exposure scenario for PFOS in carpet was two orders of magnitude higher for infants than adults, meaning infants could be exposed to PFAS at a level that is about 100 times higher than adults. Some studies have not separated exposures to different products, but have included exposure to furnishings and carpets, which can include exposures from applied aftermarket treatments.

The specific PFAS used in stain- and water-resistance treatments have changed over time. From 1970 to 2002, the largest use of PFOS-derived substances was for carpet treatments (48,000 tons globally from 1970 to 2002) (DEPA, 2014; Paul, Jones, & Sweetman, 2009). According to safety data sheets, carpet treatments contain fluorochemicals at concentrations between 3 and 7% (Ecology, 2020a), and fabric treatments can contain fluorochemicals at concentrations up to 3% (Ecology, 2020a). Fluorotelomer-based sidechain fluorinated polymers can release PFCAs and FTOHs in the environment (Washington & Jenkins, 2015). PFCAs and FTOHs have been

[109] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.040
[110] https://apps.ecology.wa.gov/publications/summarypages/2004019.html

detected in impregnation and sprays, including carpet treatments (EPA, 2009a; Kotthoff et al., 2015).

We estimate that 2,300 metric tons (approximately 5 million pounds) of stain- and water-resistance treatments are used on carpet alone each year in Washington. Additional uses of stain- and water-resistance treatments include furniture, home textiles, apparel, and shoes

People can be exposed to PFAS from stain- and water-resistance treatments during application and as the product wears off over time. During application, dermal exposure and inhalation may occur. Reapplications could lead to increased exposure and increasing concentrations of PFAS in carpet and other products over time. Manufacturers recommend reapplying to furniture every six months and reapplying to apparel after each wash or dry clean. Applications that are more frequent could lead to higher exposures. We received information from the Afghan Health Initiative about a survey on the frequency of use for PFAS-containing aftermarket spray for furnishings (AHI, 2021). In this community, 25% of people used this product once a week, 18% once a month, 20% once every 3 months, and 30% once every six months. This shows that some users reapply aftermarket treatments more often than every six months (as the manufacturer recommends).

When applied to products, the exposure pathway during product degradation is similar for aftermarket treatments and pretreated products. For example, as carpet treatment wears off, PFAS can be released into indoor air and accumulate in dust. Beesoon et al. (2012) reported high blood concentrations of PFHxS, PFOS, and PFOA in a family who had their carpet commercially treated approximately every two years for 15 years. PFAS were also detected in their carpet, house dust, and indoor air. Homes and offices with carpet can have higher concentrations of various PFAS compared to non-carpeted facilities (Fraser et al., 2013; Gewurtz et al., 2009; Kubwabo, Stewart, Zhu, & Marro, 2005). Karaskova et al. (2016) found that the combined concentration of 20 PFAS on carpeted floors was higher than other floor types.

Apparel can also be treated to increase water-resistance. Since manufacturers recommend retreating after every wash, it is likely that the PFAS used in the product wear off relatively quickly. One study noted that children who wear water-resistant apparel more frequently have higher exposures to PFAS (Wu et al., 2015).

As outlined in our priority product report, use of PFAS in aftermarket treatments for textile and leather products is significant, and represents a significant source of PFAS to humans and the environment. Therefore, restricting the use of PFAS in aftermarket treatments for textile and leather products will reduce a significant source of PFAS exposure to people and the environment.

Chapter 4: Bisphenols

Chapter overview

The Washington State Legislature listed bisphenols as a priority chemical class. Ecology and Health (jointly "we") identified thermal paper and food and beverage can linings containing bisphenols as priority products. We considered the hazards associated with bisphenols and determined they fail to meet the minimum criteria outlined in our criteria for safer and described in the hazards of bisphenols section of this chapter.

Thermal paper

We identified safer alternatives for use in thermal paper (commonly used in transaction receipts) that meet our minimum criteria for safer and that are feasible and available (see the alternatives are safer, feasible, and available subsection of the thermal paper section of this chapter). In support of our priority product determination, we considered both the volume of bisphenols used in thermal paper, and the contribution of thermal paper as a source of bisphenols to the environment. We also considered the potential for exposure to bisphenols in humans, including in sensitive populations (see the reducing a significant source or use subsection of the thermal paper section of this chapter).

Food and drink cans

We also identified safer alternatives for use in metal drink can linings that meet our minimum criteria and that are feasible and available (see the alternatives are safer, feasible, and available subsection of the can linings section of this chapter). We considered the use of bisphenols in can linings and their contribution as a source of bisphenols to the environment. We also considered the potential for exposure to bisphenols in humans, including in sensitive populations (see the reducing a significant source or use subsection of the can linings section of this chapter).

Scope of priority chemical class

Bisphenols can be defined as a chemical class based on their chemical structure as two phenol rings connected by a 'linker' region. We used a set of guidelines to further clarify this definition. The additional guidelines that describe the priority chemical class are as follows:

1. Must have two six-membered aromatic rings connected by a linker atom.
2. The linker atom can also be substituted but the linker length must be a single atom.
3. Both rings must have at least one hydroxyl substituent (i.e., phenol rings).

Hazards of bisphenols

Bisphenols as a priority chemical class

We approach bisphenols as a class because RCW 70A.350.010 identifies bisphenols collectively as a priority chemical. The statute's directive is reasonable and well supported for several reasons:

- Many bisphenols have endocrine disrupting properties.
- Many bisphenols impact sensitive biological systems during critical windows of susceptibility.
- Previous actions reducing the use of some bisphenols led to increased exposure from other bisphenols.

Many bisphenols are associated with endocrine disruption and reproductive and developmental toxicity (see hazards of data rich bisphenols). Exposure to low doses of endocrine disruptors early in life can have consequences throughout the lifespan (de Boo and Harding, 2006). Therefore, we should approach classes with chemicals known to cause endocrine disruption and developmental toxicity with caution (Braun et al., 2017).

People are exposed to mixtures of bisphenols before birth and throughout their lifespan (Chen et al., 2016). Studies detect BPA, BPF, and BPS in indoor dust samples, food, and urine (Chen et al., 2016). Because bisphenols can impact similar biological pathways, it is important to consider the potential impacts of cumulative exposures (Karrer et al., 2018, 2020; Liu et al., 2021).

Human biomonitoring data suggest that although exposure to BPA decreased in recent years (La Kind & Naiman, 2015), people are now also widely exposed to BPS and BPF (Lehmler et al., 2018). Exposure data align with the general observation that BPS and BPF were regrettable substitutions for BPA in some applications (Eladak et al., 2015).

Approach for setting the criteria for safer

We approach safer as a spectrum, using minimum or additional criteria to identify safer alternatives. We based both our minimum and additional criteria on 18 hazard endpoints, which we describe in detail in Appendix C. Our evaluation of the hazards of the priority chemical class informs the criteria alternatives need to meet to be safer than the existing chemical or process.

We applied elements of the hazard assessment scoping plan from the National Academies of Sciences' Class Based Approach to Organohalogen Flame Retardants (NAS, 2019) to assess the hazards of bisphenols as a class. We first determined whether the class identified in the law is unified by "structure, physiochemical properties, biology, or some combination thereof." We concluded that a single class of bisphenols can be defined by structure based on certain criteria:

- Must have two six-membered aromatic rings connected by a linker atom
- The linker atom can also be substituted, but the linker length must be a single atom
- Both rings must have at least one hydroxyl substituent (i.e., phenol rings)

We then reviewed the data rich chemicals within the class. Data rich chemicals either:

- Were evaluated by authoritative sources.
- Have third-party reviewed or publicly available hazard assessments that we can compare against our criteria for safer.

We determined whether each data rich chemical met or failed to meet our minimum criteria for safer. This approach assumes that data poor chemicals within the class are potentially hazardous. It helps us avoid the pitfalls of assuming chemicals with limited hazard data or data gaps are not hazardous. If the data rich chemicals in the class fail to meet the minimum criteria for safer, then alternatives that do are safer.

In cases of toxicological diversity, where some data rich chemicals in the class meet and others fail to meet the minimum criteria for safer, we rely on two options (described in Appendix C):

1. Using the criteria (minimum or additional) that allows us to identify alternatives that are safer than the data rich priority chemicals potentially found in the priority product.
2. Using the minimum criteria to conservatively identify alternatives that are safer than the data rich hazardous chemicals in the class.

To be considered a within-class safer alternative, priority chemicals must meet the within-class criteria. The within-class criteria applies more protective hazard criteria to priority chemicals present over 100 ppm. It requires priority chemicals present as impurities or residual monomers under 100 ppm to meet the minimum criteria for safer.

Using the within-class criteria to identify safer chemicals within the class helps prevent regrettable substitutions. Chemicals within the class are more likely to share hazards (Chen et al., 2016; Cordner et al., 2016; NAS, 2019; Lioy et al., 2015; Vos et al., 2003). Therefore, we need to approach them with added caution (Birnbaum et al., 2021; Blum et al., 2015; DiGangi et al., 2010).

Many bisphenols are associated with endocrine disruption, and reproductive and developmental toxicity (see hazards of data rich bisphenols). To confirm that a bisphenol does not share these hazards, the within-class criteria requires evidence of the lack of both endocrine disruption and reproductive and developmental toxicity (among other criteria). The within-class criteria sets a transparent bar to identify chemicals within the class that have sufficient data showing they are safer and exclude them. See a full description in Appendix C.

The vast majority of data rich bisphenols did not meet our minimum criteria for safer. We identified one data rich bisphenol that met the minimum criteria for safer, but not the within-class criteria, tetramethylbisphenol F (TMBPF). This means that in applications where TMBPF is present as a residual monomer at concentrations below 100 ppm, it may be considered a safer alternative. Find more detail in the special considerations section below. With this exception, we concluded that bisphenols as a class do not meet our minimum criteria for safer, and alternatives that do are safer.

Hazards of the data rich bisphenols

The bisphenols priority chemical class does not meet our minimum criteria for safer. In making this determination, we considered available data on hazard endpoints described in our criteria for safer for members of the chemical class. For bisphenols without sufficient data to adequately characterize certain endpoints, we relied on professional judgement, previous analyses by other agencies, and hazard data on structurally similar bisphenols to anticipate the potential hazards of these chemicals.

Bisphenol A (BPA) (CAS: 80-05-7) has been the most widely used member of the bisphenols class as a developer in thermal paper and as a component of epoxy resin-based can linings (ECHA, 2020c; Ecology 2020). The hazards of BPA are well-documented, and several agencies have published hazard assessments on BPA. A GreenScreen® assessment prepared for the Maine Department of Environmental Protection scored BPA as a Benchmark-1 chemical (BM-1) (TechLaw, 2012). The assessment was not conducted by a listed licensed profiler, however, we reviewed it and agree with the final BM-1 score assigned. Its conclusions are further supported by the subsequent inclusion of BPA on authoritative lists that do not meet our minimum criteria for safer, including the California Proposition 65 and the EU – Substance of Very High Concern lists (Table 33) (ECHA, 2021c; OEHHA, 2021). In addition, recent research provides additional evidence that supports the BM-1 score for BPA (NTP, 2018b). Chemicals scored as BM-1 do not meet our minimum criteria for safer.

Other bisphenols also score as BM-1 chemicals including:

- Bisphenol S (BPS, CAS: 80-09-1) (ToxServices, 2016c).
- Bisphenol F (BPF, CAS: 620-92-8) (ToxServices, 2016d).
- Bisphenol AF (BPAF, CAS: 1478-61-1) (ToxServices, 2019c).
- Tetrabromobisphenol A (TBBPA, CAS: 79-94-7) (CPA, 2014c).

TBBPA scored $BM\text{-}1_{TP}$, indicating the score was due to the transformation product, BPA (CPA, 2014c). However, addition of more recently published research to that assessment would elevate its score to BM-1 due to its classification by the International Agency for Cancer Research (IARC) as 'probably carcinogenic to humans' (Group 2A), and its listing by California Proposition 65 in 2017 as a carcinogen.

Several bisphenols, including BPA, BPS, BPF, and TBBPA, are already included on the Washington State Chemicals of High Concern to Children reporting list.[111] Use of BPA is restricted in sports bottles and children's cups in Washington state. Use of TBBPA as an additive flame retardant at concentrations over 1,000 ppm is restricted in our state as well. Chemicals that score high for certain human health hazards—including carcinogenicity, mutagenicity, reproductive or developmental toxicity, and endocrine activity—do not meet our minimum criteria for safer. Below are additional details on how the data rich bisphenols identified do not meet our criteria for safer for these endpoints.

[111] https://ecology.wa.gov/Regulations-Permits/Reporting-requirements/Reporting-for-Childrens-Safe-Products-Act/Chemicals-of-high-concern-to-children

Developmental toxicity

BPA scored high for developmental toxicity using the GreenScreen® methodology. This was based on multiple studies showing evidence of developmental impairment effects in animals and humans, especially effects on neurodevelopment (NTP, 2008; TechLaw, 2012). BPA is also included in the authoritative California Proposition 65 list as a developmental toxicant (OEHHA, 2009, 2021). A GreenScreen® assessment for developmental toxicity scored BPF high due to its high structural similarity with BPA (ToxServices, 2016d).

Our minimum criteria for safer requires that developmental toxicity score moderate or lower. Both BPA and BPF fail this requirement.

Reproductive toxicity

Under EU GHS, BPA was categorized as a presumed reproductive toxicant ('may damage fertility' (H360F)) in 2016 (ECHA, 2020a). Based on this classification, BPA scores high for this endpoint in our criteria. This hazard score is further supported by inclusion of BPA in the authoritative California Proposition 65 list, beginning in 2015, based on several female reproductive toxicity endpoints (OEHHA, 2015).

BPS scored high for reproductive toxicity under GreenScreen® based on a reproductive and developmental toxicity study conducted in rats that demonstrated effects on fertility consistent with designation as a GHS Category 1B reproductive toxicant (ToxServices, 2016c).

BPF scored high for reproductive toxicity in a GreenScreen® assessment as a result of animal studies on rats showing increased weight of testes in males and increased uterine weight in females following exposure, as well as its structural similarity to BPA (ToxServices, 2016d).

BPAF scored high for this endpoint in a GreenScreen® assessment as it has been classified as a Category 1B reproductive toxicant under GHS based on reproductive tract abnormalities and reduced fertility observed in male and female rats following exposures prior to mating (ToxServices, 2019c).

Our minimum criteria does not allow for chemicals that score as high for reproductive toxicity. BPF, BPS, and BPAF do not meet our minimum criteria.

Endocrine activity

BPA is included on the authoritative EU – SVHC Candidate List due to clear evidence of endocrine disrupting properties. BPA scores high for endocrine activity based on evidence of reproductive effects consistent with an estrogenic mechanism of action (TechLaw, 2012).

BPF scored high for endocrine activity in the aforementioned GreenScreen® based on its inclusion in several screening lists and *in vitro* and *in vivo* evidence of estrogenic and anti-androgenic activity (ToxServices, 2016d).

BPAF scored high for endocrine activity due to studies showing effects on reproduction (see previous section) that are plausibly related to endocrine disruption as well as *in vitro* and *in vivo* data that suggest estrogenic activity (ToxServices, 2019c).

Our minimum criteria does not allow for either endocrine activity scores of high or for known endocrine disruptors present on authoritative lists. BPA, BPF, and BPAF do not meet our minimum criteria.

Aquatic toxicity and persistence

Acute aquatic toxicity scores of chemicals in the bisphenol class vary from moderate (BPS) to high (BPA, BPF, BPAF). For chronic aquatic toxicity, the range of scores is wider—low (BPA), high (BPF), and very high (BPS, BPAF).

None of the chemicals within the bisphenols class would fail our minimum criteria for acute or chronic aquatic toxicity alone. However, the aquatic toxicity of BPAF would cause it to fail our requirements, as it also scores very high for persistence (ToxServices, 2019c). Our minimum criteria allow high aquatic toxicity only if persistence does not score very high.

Although environmental persistence is not pronounced with non-halogenated bisphenols such as BPA, longer persistence of bisphenols that contain halogenated atoms, for example BPAF, is a cause of concern. In addition to retaining reproductive toxicity and other toxic potentials, these compounds also persist for long periods of time before they break down in the environment, prolonging their opportunities to cause harm.

Our minimum criteria does not allow for chemicals that score very high for persistence in combination with a very high acute or chronic aquatic toxicity score. BPAF fails this requirement.

Conclusions

Bisphenols as a chemical class can be defined based on their chemical structure and connectivity, using the guidelines outlined above. As a chemical class, bisphenols do not meet our minimum criteria for safer, and we consider data poor members of this class as potentially hazardous. This is based on reliable data for several members of the class, which share hazards and have been used in priority products.

We did not find sufficient data demonstrating that any individual chemical in the class would meet our within-class criteria to be treated as less hazardous than the class as a whole. Based on this analysis, we determined it is necessary to identify safer alternatives to bisphenols in the two relevant priority products. Bisphenols do not meet our minimum criteria for safer, and so alternatives that do meet those criteria will be considered safer.

Special considerations

Our criteria for safer requires that all chemicals intentionally added to serve the same function as priority chemicals meet our minimum criteria or additional criteria and, if applicable, within-class criteria. For within-class alternatives, our criteria requires that residual monomers or unintentionally added chemicals (present at less than 100 ppm) meet our minimum criteria or additional criteria, but not our within-class criteria. For more information on our within-class criteria, please see our criteria for safer.

This evaluation determined that tetramethyl bisphenol F (TMBPF, CAS: 5384-21-4) does meet our minimum criteria for safer because TMBPF is a BM-2 chemical (ToxServices, 2020c).

However, it does not meet our more protective within-class criteria for chemicals in the bisphenols class. Our within-class criteria requires that chemicals score as low for endocrine disruption, reproductive toxicity, and developmental toxicity, as these endpoints are hazards associated with bisphenols as a class. TMBPF scores moderate for both endocrine activity and developmental toxicity, so it does not meet this requirement.

Our within-class criteria do not allow for chemicals that score high for persistence or bioaccumulation. TMBPF scores as high for persistence, and therefore, also does not meet this requirement. This means applications where TMBPF is intentionally added to serve the function of priority chemicals, or present above 100 ppm, do not meet our criteria for safer. However, applications where TMBPF is only present as a residual monomer under 100 ppm could meet our criteria.

Table 33. Data rich bisphenols, common hazards, and presence on authoritative lists.

Common name and CAS(s)	Meets minimum criteria?	Hazard assessment score—GreenScreen® or List Translator	Endpoints of concern based on GreenScreen® score (high or very high) or authoritative listings
Bisphenol A 80-05-7	NO	LT-1 BM-1	**Developmental / reproductive toxicity:** CA Prop 65 EU – GHS (H360F) **Endocrine activity:** EU – SVHC Candidate List EU – SVHC Prioritisation List **Eye irritation:** EU – GHS (H318) Acute aquatic toxicity
Bisphenol S 80-09-1	NO	BM-1	Reproductive toxicity, endocrine activity, chronic aquatic toxicity
Bisphenol F 620-92-8	NO	BM-1	Developmental toxicity, reproductive toxicity, endocrine activity, systemic toxicity (repeat-dose), skin irritation, eye irritation, acute and chronic aquatic toxicity

Common name and CAS(s)	Meets minimum criteria?	Hazard assessment score—GreenScreen® or List Translator	Endpoints of concern based on GreenScreen® score (high or very high) or authoritative listings
Tetrabromobisphenol A 79-94-7	NO	LT-1 BM-1	**Acute aquatic toxicity:** EU – GHS (H400) **Carcinogenicity:** CA Prop 65 IARC (2A) **Persistence:** OSPAR U.S. EPA – TRI (PBT) Department of Ecology (PBT) Chronic aquatic toxicity
Bisphenol AF 1478-61-1	NO	BM-1	Reproductive toxicity, endocrine activity, systemic toxicity (single- and repeat-dose), eye irritation, acute and chronic aquatic toxicity, persistence
Tetramethyl bisphenol F 5384-21-4	YES*	BM-2	Acute and chronic aquatic toxicity, persistence

Note: * = Tetramethyl bisphenol F does not meet our within-class criteria for safer if intentionally added or present as a residual monomer above 100 ppm.

Referenced hazard assessments

The hazard assessments were conducted by Licensed GreenScreen® Profilers (with the exception of the BPA assessment as previously discussed) and are publicly available.

- GreenScreen® hazard assessments of bisphenol S (ToxServices, 2016c), bisphenol F (ToxServices, 2016d), bisphenol AF (ToxServices, 2019c), and tetramethyl bisphenol F (ToxServices, 2020c) are available from the ToxServices database.[112]
- The GreenScreen® hazard assessments of bisphenol A (TechLaw, 2012) and tetrabromobisphenol A (CPA, 2014c) are available on the IC2 website.[113]
- GreenScreen® List Translator (LT) scores were determined using Licensed GreenScreen® List Translator Automators: Toxnot search tool[114] or Pharos website.[115]

[112] https://database.toxservices.com
[113] http://theic2.org/hazard-assessment
[114] https://toxnot.com/Substances/Search
[115] https://www.greenscreenchemicals.org/learn/greenscreen-list-translator

Priority product: Thermal paper

Scope of priority product

Thermal paper is paper coated with a material formulated to change color when exposed to heat. Examples of thermal paper products include sales receipts, packing labels, and tickets.

Function of priority chemical in priority product

To identify potentially safer alternatives, we first determine whether the function provided by the priority chemical is necessary to meet the performance requirements of the priority product at the chemical, material, product, or process level. If the priority chemical does not provide a necessary function, the chemical can be removed and there is no need to identify alternatives.

We determined that, in some cases, a chemical developer is necessary for the priority product to perform. Bisphenols act as a developer in formulations used to coat paper that change color when exposed to heat (such as thermal paper). Thermal paper is primarily used for point-of-sale receipts in retail transactions. The chemical function provided by bisphenols as a developer contributes to the performance of thermal paper. Another option when physical receipts or other documents are needed is printed paper using ink, which does not require a developer. In cases where an electronic receipt can serve the same function, the performance characteristics provided by bisphenols are also not required.

Alternatives are safer, feasible, and available

Alternatives are safer

The bisphenols priority chemical class does not meet our minimum requirements for safer, so we will apply our minimum criteria to evaluate potential safer alternatives.

Benzenesulfonamide, 4-methyl-N-[[[3-[[(4- methylphenyl)sulfonyl]oxy]phenyl] amino]carbonyl]-) (CAS: 232938-43-1)

We identified benzenesulfonamide, 4-methyl-N-[[[3-[[(4- methylphenyl)sulfonyl]oxy]phenyl] amino]carbonyl]-) (CAS: 232938-43-1) as a safer alternative chemical. It functions as a chemical developer in thermal paper applications. CAS 232938-43-1 was assessed by a Licensed GreenScreen® Profiler, and that assessment has been certified (ToxServices, 2020d). It scored BM-2 (signifying "use but search for safer substitutes"). This meets our minimum criteria for safer. Therefore, it is considered a safer alternative.

CAS 232938-43-1 scored as moderate for carcinogenicity, reproductive toxicity, and developmental toxicity in the assessment, and a data gap was noted for endocrine activity. Additionally, it scored high for persistence. Our minimum criteria requires carcinogenicity, reproductive toxicity, and developmental toxicity score as moderate or lower, and CAS 232938-43-1 meets these requirements. Our minimum criteria allows for chemicals that score high for persistence when bioaccumulation is not very high—CAS 232938-43-1 scored very low for bioaccumulation, so it meets our criteria. Although the endocrine activity endpoint scored as a data gap, it was due to limited data on thyroid effects. The available data for CAS 232938-43-1 was summarized in the GreenScreen® assessment as suggesting the chemical does not disrupt androgenic or estrogenic signaling (ToxServices, 2020d).

Résiste® RX

Appvion shared third-party reviewed, redacted GreenScreen® hazard assessments for the chemicals intentionally used in or present in the Résiste® RX thermal paper formulation at concentrations greater than 100 ppm. The two chemicals in the formulation were assessed as GreenScreen™ BM-2 chemicals, and met our minimum criteria for safer. Both of the chemicals in the formulation score high or very high for aquatic toxicity, but neither are persistent or bioaccumulative. Neither chemical has a high score for carcinogenicity, mutagenicity, reproductive, developmental toxicity or endocrine disruption. Both these chemicals meet our minimum criteria for safer. Find more information about how GreenScreen® BM-2 chemicals meet our minimum criteria for safer in Appendix E.

Appvion Tradenames

Appvion shared third-party reviewed, redacted GreenScreen® hazard assessments for chemicals intentionally used in or present in two other tradenames at concentrations greater than 100 ppm. All chemicals present in the product at concentrations above 100ppm scored BM-2.

One tradename contained five chemicals. Four scored BM-2 and one chemical present at concentrations below 100 ppm scored BM-U due to data gaps. We only require chemicals present above 100 ppm to meet our minimum criteria for safer. The other tradename contained two chemicals, both of which scored BM-2, and meet our minimum criteria for safer.

Therefore, both tradenames meet our minimum criteria for safer. Find more information about how GreenScreen® BM-2 chemicals meet our minimum criteria for safer in Appendix E.

Digital or electronic receipts (e-receipts)

We also identified digital or electronic receipts (e-receipts) as a safer alternative process for some applications. We acknowledge that this alternative may not be feasible in all instances as a replacement for thermal paper. However, it provides an additional option for businesses and other users. E-receipts do not require a chemical or material alternative to serve the function of the priority chemical. Therefore, in this case, the priority chemical is considered not functionally necessary. Since no alternative chemical serves the function of the priority chemical in this case, there are no chemical hazards to review and no further analysis of safer is required. As such, we consider e-receipts a safer alternative.

Alternatives are feasible and available

To evaluate alternatives to bisphenols in thermal paper, we determined whether safer chemical alternatives could function as chemical developers. We then evaluated whether these safer alternatives are feasible and available using modules from the Interstate Chemicals Clearinghouse (IC2) Guide to address performance requirements (see Table 34).

- Chemical level: The chemical acts as a developer in thermal paper. When melted, they react with leuco dyes to change their color.
- Material/product level: The product must quickly create a record of information.

4-methyl-N-[[[3-[[(4- methylphenyl)sulfonyl]oxy]phenyl] amino]carbonyl]-) (CAS: 232938-43-1) is used in Pergafast 201®, which is a drop-in replacement developer for BPA and BPS in thermal paper. Pergafast 201® containing receipts are used by several major retailers, such as Best Buy, Inc., CVS, Inc., and Whole Foods, Inc. (Dickman, 2021; The Ecology Center, 2018), as well as smaller retailers such as the Tacoma Food Co-op (personal communication). Thermal receipts using Pergafast 201® as a developer are available online (for example, POSPaper.com, Printerstock.com, POSSupply.com, Amazon.com (Amazon, 2021c; POS Paper, n.d.; POS Supply, n.d.; Printerstock.com, n.d.)).

Pergafast 201® is mentioned in marketing materials as being used in other applications of thermal paper, such as event or transportation tickets and self-adhesive labels (Pergafast 201® Color Developer For Thermal Papers) (Solenis, 2021). In addition, testing from Germany shows Pergafast 201® in use in receipts, labels, and tickets (Eckardt et al., 2020). Therefore, we find that Pergafast 201® is feasible and available for all uses of thermal paper.

Résiste® RX by Appvion met our minimum criteria for safer and is currently offered for sale for prescription applications (Appvion, 2021). Résiste® RX is a safer, feasible, and available alternative.

The other Appvion tradenames evaluated as safer alternatives are not currently on the market, but could be feasible and available in the future. Appvion reported that they expect these tradenames to be available in package delivery, vial label, lottery, and dispersible products by the end of 2023.

E-receipts are also feasible and available alternatives to thermal receipts containing bisphenols. E-receipts are available from several retail outlets such as Home Depot, Inc., CVS, Inc., and REI, Inc., and they are the main form of receipt from online vendors such as Amazon, Inc. (CVS, 2021). E-receipts are extensively used by smaller businesses, such as those using Square® to conduct transactions—which normally does not allow the option for a physical receipt. We communicated with numerous smaller businesses, who all expressed the opinion that e-receipts are suitable for the majority of their transactions.

Conclusion

In conclusion, we determined that Pergafast 201® and e-receipts are safer, feasible, available alternatives to thermal paper containing bisphenols, as summarized in Table 34. Restricting the use of bisphenols in thermal paper would reduce a significant source of exposure for people and the environment.

Table 34. Questions from the IC2 Guide for evaluating feasibility and availability of alternative(s) for thermal paper.

IC2 Guide feasibility and availability metrics	Determination
Is the alternative used for the same or a similar function?	Yes. Pergafast 201®-containing thermal paper, Résiste® RX, and e-receipts are used for the same purpose as bisphenol-containing thermal paper.

IC2 Guide feasibility and availability metrics	Determination
Is the alternative used in similar products on the commercial market?	Yes. Receipts using Pergafast 201® as a developer are sold and used on the U.S. market, and Résiste® RX, and e-receipts are commonly used as well.
Is the alternative marketed in promotional materials for application of interest?	Yes. Receipts using Pergafast 201® are marketed as effectively printing and conveying information in all applications of interest. Résiste® RX is marketed for prescription applications. E-receipts are suitable for most transactions and customers.
Is this a favorable alternative based on answers to the above questions?	Yes. Pergafast 201®, Résiste® RX, and e-receipts are favorable alternatives.

Reducing a significant source or use

In order to restrict or prohibit priority chemicals in priority products, RCW 70A.350.040[116] requires Ecology and Health to determine that either:

- The restriction will reduce a significant source or use of a priority chemical, or
- The restriction is necessary to protect the health of sensitive populations or sensitive species.

We identified thermal paper as a significant source or use of bisphenols in our 2020 report to the Legislature.[117] That report became effective at the end of the 2021 legislative session on April 25, 2021. Based on that report, we determined that restricting any of the chemical-product combinations in that report would reduce a significant source or use of a priority chemical class. With this determination, further evaluating whether a restriction would reduce a significant source or use (RCW 70A.350.040(3)(b)(ii)) is not required by statute.

In our report to the Legislature on priority consumer products (Ecology, 2020a), we determined that thermal papers are a significant source and use of phenolic compounds, specifically bisphenols, under the criteria specified in RCW 70A.350.030. Multiple industries and businesses use thermal paper for applications such as printing receipts, tickets, and labels. In our report on priority consumer products, we estimated 3,300 tons of thermal paper are used annually in Washington, based on data for 2015 (Ecology, 2020a).

Bisphenols such as BPA and BPS—and also BPF and other phenolic derivative compounds—function as developers in the chemical reaction that provides color when printing on thermal paper. The bisphenol, dyes, and other components are mixed into a thermally reactive layer and are applied as a coating to a wide range of base papers. Some manufacturers are shifting to alternative developers, including other bisphenols and phenolic derivatives (EPA, 2015c).

[116] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.040
[117] https://apps.ecology.wa.gov/publications/summarypages/2004019.html

However, we expect BPA and BPS are still widely used based on the data available when we wrote our report on priority consumer products (see Chapter 8, Table 12[118]) (Ecology, 2020a).

Use, disposal, and recycling of thermal paper contributes to bisphenol contamination in the environment. Bisphenols are found in wastewater treatment plant effluent (Hu et al., 2019). They produce documented detrimental effects in fish and other wildlife species (Canesi and Fabbri, 2015; Flint et al., 2012), and are an emerging concern for the endangered Puget Sound orca population (Southern Resident Orca Task Force, 2018). A King County study reported BPA in stormwater and surface waters (King County, 2007). BPA was also found in the bile from male English sole from Puget Sound (da Silva et al., 2013, 2017). Recycling thermal paper is considered an important route of environmental contamination by bisphenols, as reported in Europe (Aschberger et al., 2008) and Japan (Terasaki et al., 2007).

People are exposed to bisphenols through contact with thermal paper and uptake through the skin, and by ingesting foods to which bisphenols have been transferred after contamination of the hands (Biedermann et al., 2010; Hormann et al., 2014). Retail workers who regularly handle thermal paper receipts are especially highly exposed (Ndaw et al., 2016, 2018; Thayer et al., 2016). Our report on priority consumer products found that handling thermal paper contributes a significant fraction of human exposure to BPA and BPS—the most thoroughly studied bisphenols. Thermal paper is second only to the dietary route among the leading contributors to BPA exposure in the general population (EFSA, 2015; Liao et al., 2011, 2012).

An observational study of thermal paper handling in a U.S. city suggested that bisphenol exposure levels from thermal paper receipts may be higher than previously estimated (Bernier & Vandenberg, 2017). People with occupational exposures may have higher total exposure to BPA. There is some discussion in the peer-reviewed literature that current analytical methods may under-report BPA exposure substantially, meaning exposure levels from studies reported to date could be underestimates (Gerona et al., 2020).

Since we published our report on priority consumer products, ECHA reported that alternative developing chemicals continue to replace BPA in thermal papers used in Europe. However, the leading alternative to BPA at this time is another bisphenol compound that is also concerning, BPS. BPA-based thermal paper declined 43% in 2019, while BPS-based thermal paper use increased by 153%, almost entirely offsetting the decrease in BPA (ECHA, 2020c). Similarly, a study that sampled thermal papers from a number of countries, including 12 samples from four U.S. states, reported that all of the U.S. samples contained BPS, and none contained BPA (Frankowski et al., 2020). In addition to BPS, there are signs of growth in the use of less studied derivatives of bisphenols (Pelch et al., 2017). These findings emphasize that bisphenols continue to be used at high levels in thermal paper, and support regulatory actions to address the entire bisphenol class rather than individual members.

As outlined in our report on priority consumer products, thermal paper products are a significant use of bisphenols in commerce (Ecology, 2020a). There is widespread exposure to

[118] https://apps.ecology.wa.gov/publications/documents/2004019.pdf#page=75

bisphenols in the U.S. (Lehmler et al., 2018). Handling thermal papers produces especially high exposure to people in occupational settings (such as retail businesses with point-of-sale receipts). People with occupational exposure are considered a sensitive population under RCW 70A.350.010.[119] Restricting the use of bisphenols in thermal paper will reduce a significant source or use of bisphenols, thereby reducing potential exposures to sensitive populations and species.

Priority product: Food and drink cans

Scope of priority product

Food and drink cans.

Function of priority chemical in priority product

To identify potential safer alternatives, we first determine whether the priority chemical is necessary to meet the performance requirements of the priority product at the chemical, material, product, or process level. If the priority chemical is not necessary, the chemical can be removed and there is no need to identify alternatives.

We determined that, in some cases, the priority chemical is necessary for the priority product to perform. Bisphenols are a component of epoxy resins used to coat the interiors of aluminum and steel cans. These liners prevent interactions between the can's metal and the food or beverage. Liners need to be able to withstand the production and sterilization process and preserve the food or beverage for several years. In some instances, storing food or beverages in other types of containers means can liners are not needed. Other storage options include glass jars and bottles, or paper cartons with plastic liners.

Alternatives are safer, feasible, and available

Alternatives are safer

The bisphenols priority chemical class does not meet our minimum criteria for safer, so we will apply our minimum criteria to evaluate potential safer alternatives.

We do not evaluate alternative products or processes where no chemical treatments are used to line food or beverage containers against our minimum criteria for safer. Instead, they cannot contain chemicals known to be in products during use at concentrations over 100 ppm with known hazards of concern (such as known carcinogens, mutagens, or reproductive or developmental toxicants).

Our evaluation of the hazards of food and drink cans was limited to bisphenols in the lining. Comparing the hazards of one component of a product or process (such as a can lining) to the hazards of an entire product or process is uneven. If a lining can be avoided by using an alternative material, product, or process, then the alternative is safer—provided there are no known chemical hazards that would be considered regrettable substitutions.

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[119] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.010

We identified many alternatives by searching the Cradle to Cradle Certified® (C2CC®) product database (C2CC®, 2021d). The Cradle to Cradle Products Innovation Institute certifies products based on an assessment of five categories:

- Material Health
- Material Reuse
- Renewable Energy and Carbon Management
- Water Stewardship
- Social Fairness

Products are certified as Basic, Bronze, Silver, Gold, or Platinum for each category. The lowest score defines the product's final certification level. Products with Material Health Certificates™ of Gold or Platinum are likely to meet our criteria for safer. However, for products evaluated against the Material Health Standard Version 3.1, we need to confirm two points:

- There are no very persistent and very bioaccumulative chemicals used to function like priority chemicals.
- Any adjustments for exposure potential still meet our criteria for safer.

Products with a Silver or Bronze Material Health Certificates™ may also meet our minimum criteria for safer. However, we need to confirm not only the details described above, but also that the ingredients functioning like priority chemicals were included in the analysis and are Green or Yellow. More information about how C2CC® products can meet our criteria for safer can be found in Appendix E, focused on safer certifications.

We identified several can lining products that were assessed by Cradle to Cradle Certified® (C2CC®). We confirmed that the C2CC® assessments did not identify any very persistent or very bioaccumulative chemicals or contain exposure adjustments that impact whether the alternative meets our minimum criteria for safer (Metlac Group, 2021; PPG®, 2021). For the C2CC® valPure formulations, we know the identity of the chemical functioning like priority chemicals (TMBPF), and it meets our requirements (as described below). Table 35 lists C2CC® can lining formulations with Material Health scores of Gold or Platinum.

METPOD100 uses a polyolefin-based technology (Metlac Group, 2022) and does not contain bisphenols. PPG® Innovel® is a non-bisphenol spray coating (PPG®, 2022).

The Sherwin-Williams® valPure® non-BPA product line uses an epoxy coating that is made using TMBPF. The process for manufacturing this epoxy coating is publicly available (Soto et al., 2017). TMBPF is a precursor to the epoxy resin, but is not expected to be present in the final product at concentrations greater than 100 ppm (Canatsey, 2021; Soto et al., 2017).

A partially redacted GreenScreen® on the TMBPF-based epoxy resin did not find residual monomers in the final product at concentrations greater than 100 ppm (Canatsey, 2021). This is supported by Soto et al. (2017), which did not detect TMBPF in leachate using a 0.2 ppb level of detection. This is partially due to changes in the manufacturing process, which require the monomer to be added once instead of twice, as is the case with BPA-based epoxies (Soto et al., 2017).

Our criteria for safer requires within-class alternatives to meet the within-class criteria if they are present above 100 ppm, and to meet the minimum criteria for safer if they are present below 100 ppm. That means, because TMBPF is a bisphenol, it must meet the minimum criteria for safer—even when present at levels below 100 ppm (see hazards of bisphenols). A GreenScreen® hazard assessment found that TMBPF met our minimum criteria for safer (see hazards of bisphenols). Therefore, valPure® can linings are considered safer alternatives.

Table 35. Cradle to Cradle Certified® aluminum beverage can lining formulations.

Manufacturer*	C2CC® can lining*	C2CC® Material Health Level (V3.1)
PPG®	PPG2012-820C: Innovel® PRO Non-BPA/Non-Bisphenol beverage inside spray	Gold (C2CC®, 2021o)
PPG®	PPG3316-801D: Innovel® EVO Non-BPA/Non-Bisphenol beverage inside spray	Gold (C2CC®, 2021p)
Sherwin Williams®	valPure® V70Q11AA Non-BPA Inside Spray lacquer	Platinum (C2CC®, 2021q)
Sherwin Williams®	valPure® V70Q25AA/AC Non-BPA Inside Spray lacquer	Platinum (C2CC®, 2021r)
Sherwin Williams®	valPure® V70Q38AA Non-BPA Inside Spray lacquer	Platinum (C2CC®, 2021s)
Sherwin Williams®	valPure® V43Q02AB-01 Non-BPA Inside Spray lacquer	Platinum (C2CC®, 2021t)
Sherwin Williams®	55Q01AB Non-BPA Inside Spray Lacquer	Platinum (C2CC®, 2021u)
Sherwin Williams®	valPure® V71Q02AB-11/ V71Q02AE	Platinum (C2CC®, 2021v)
Metlac®	METPOD 100®	Platinum (C2CC®, 2021w)

Note: * = Any reference in this publication to persons, organizations, services, products, or activities does not constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

Other alternatives to bisphenol-based can linings include alternate food and beverage storage methods, such as glass jars and paper cartons. In this case, to be considered safer, alternatives cannot contain chemicals known to be in products during use at concentrations greater than 100 ppm that have known hazards of concern (such as known carcinogens, mutagens, or reproductive or developmental toxicants). Chemicals found in both the priority product and the alternatives are not evaluated because they do not change. Glass jars have traditionally contained BPA-based liners on the lids, but BPA-free lids can now be purchased, and recent testing did not detect any bisphenols in bottle caps (Healthy Canning, 2017; The Ecology Center, 2021). Cartons such as Tetra Pak® are also commonly used to store food and beverages. Tetra Pak® containers are composed of paperboard, polyethylene, and aluminum foil—with polyethylene as the inner-most layer contacting food and drink. Polyethylene does not contain any components of known high concern, and Ecology's PFAS in Food Packaging Alternatives Assessment[120] identified it as a safer alternative (Ecology, 2020b). Based on this information, glass jars and paper cartons provide additional options for food and beverage storage and may serve as safer alternatives in some, but not all, applications.

[120] https://apps.ecology.wa.gov/publications/summarypages/2104004.html

Alternatives are feasible and available

Of the coatings listed in Table 36 that are C2CC®, all are only suitable for beverage cans, not food cans, and not all are commercially available in the U.S. However, we contacted the manufacturers and confirmed that several of these formulations or "sister" formulas are currently used in U.S. products (Table 36).

Table 36. Aluminum beverage can linings availability in the U.S. and application(s).

Manufacturer*	Commercially available beverage can lining (sister formulation(s))*	Application(s)
PPG®	PPG2012-823, PPG2012-823B, PPG2012-827B (PPG2012-820C) (PPG®, 2022)	Beverage can linings
Sherwin Williams®	valPure® V70Q11AA Non-BPA Inside Spray lacquer (Sherwin-Williams®, 2022, Niederst, 2021)	Beverage can linings (bodies)
Sherwin Williams®	valPure® V70Q25AA/AC Non-BPA Inside Spray lacquer (Sherwin-Williams®, 2022, Niederst, 2021)	Beverage can linings (bodies)
Sherwin Williams®	valPure® V70Q38AA Non-BPA Inside Spray lacquer (Sherwin-Williams®, 2022, Niederst, 2021)	Beverage can linings (bodies)
Sherwin Williams®	valPure® V70Q05AC (valPure® V71Q02AB-11/V71Q02AE) (Sherwin-Williams®, 2022, Niederst, 2021)	Beverage can linings (lids and ends)
Metlac®	METPOD 100® (Metlac Group, 2022)	Beverage can linings

Note: * = Any reference in this publication to persons, organizations, services, products, or activities does not constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

Due to differences in regulations between the EU and U.S., slightly different formulations are used between countries, but we confirmed that these "sister" formulations do not affect the components of cured can liners in any way that would not meet our minimum criteria for safer. Table 37 summarizes our analysis of the feasibility and availability of these beverage can linings.

Table 37. Questions from IC2 Guide for evaluating feasibility and availability of alternative(s) for beverage cans.

IC2 Guide feasibility and availability metrics	Determination
Is the alternative used for the same or a similar function?	Yes. Safer alternative beverage can linings are used in a wide variety of products including soda, beer, energy drinks, and juice.
Is the alternative used in similar products on the commercial market?	Yes. Safer alternative beverage can liners are used by major drink manufacturers.
Is the alternative marketed in promotional materials for application of interest?	Yes. Safer alternative beverage can liners are marketed as being suitable for beverage cans.
Is this a favorable alternative based on answers to the above questions?	Yes. Safer alternative beverage can liners are feasible and available.

None of the C2CC® can liners are currently used for food cans, and we were unable to identify any safer food can liners to conduct a feasibility and availability assessment (summarized in Table 38).

Table 38. Questions from IC2 Guide for evaluating feasibility and availability of alternative(s) for food cans.

IC2 Guide feasibility and availability metrics	Determination
Is the alternative used for the same or a similar function?	No. Safer alternative can liners were only identified for beverage cans, not food cans. According to manufacturers, beverage can liners are not suitable for use in food cans.
Is the alternative used in similar products on the commercial market?	No.
Is the alternative marketed in promotional materials for application of interest?	No. Safer alternatives identified are only marketed for use in beverage cans.
Is this a favorable alternative based on answers to the above questions?	No. Safer alternative liners identified are not suitable for food cans.

Multiple manufacturers identified differences in performance requirements between beverage and food can bodies that mean liners cannot be substituted. Several differences noted by manufacturers were:

- Beverage cans are aluminum while food cans are steel.
- Food cans pass through additional high retort and sterilization processes.
- Ingredients and chemistry of food products are significantly different from beverages.
- Manufacturing processes are significantly different for beverage can bodies versus lids and ends.

This is supported by the evidence that PPG2489-814A—which has a similar acrylic based chemistry as PPG2012-820C but is designed for beverage can ends—is only certified to C2CC® Bronze Material Health level, whereas PPG2012-820C is Gold level certified. This suggests that differences in effective formulations for different applications affect their hazard scores.

In addition to the chemical can liners above, we find that glass jars and bottles and paper cartons are feasible and available for both food and beverages in most cases, as evidenced by their widespread use in such products. However, there are concerns that these alternatives may not be suitable for all applications. Manufacturers communicated that both glass containers and paper cartons have a shorter storage period compared to canned goods. Glass containers are heavier and bulkier than cans. For both cartons and glass containers, efficient recycling is harder and less developed than with cans. These alternative storage methods are a good supplement to the chemical can liners identified above, but cannot replace can liners for all applications.

Conclusion

In conclusion, can liner alternatives that meet our minimum criteria for safer, identified by their C2CC® Material Health score of Gold or Platinum, are feasible and available for use in beverage cans. Other storage methods such as glass bottles or jars and paper cartons are also feasible and available for this application.

However, at this time, we could not identify can liner alternatives meeting our minimum criteria for safer for use in food cans. While it does appear that alternatives are used for food cans, the formulation information is confidential business information, so we could not identify them as safer alternatives. This does not mean current alternatives on the market are of equal hazard or more hazardous than bisphenols, but we do not have sufficient information to evaluate them using our criteria.

Can liners, including both bisphenol-epoxy lined cans and alternatives, are regulated at the federal level by the FDA, which has its own distinct requirements for food contact materials. Our criteria is not in conflict with FDA's authority. Rather, we based our determination on applying our methods as outlined in our criteria for safer (Appendix C) under the Safer Products for Washington program.

Restricting the use of bisphenols in can linings would reduce a significant source of exposure to people and the environment.

Reducing a significant source or use

In order to restrict or prohibit priority chemicals in priority products, RCW 70A.350.040[121] requires Ecology and Health to determine that either:

- The restriction will reduce a significant source or use of a priority chemical, or
- The restriction is necessary to protect the health of sensitive populations or sensitive species.

We identified food and beverage can linings as a significant source or use of bisphenols in our 2020 report to the Legislature.[122] That report became effective at the end of the 2021 legislative session on April 25, 2021. Based on that report, we determined that restricting any of the chemical-product combinations in that report would reduce a significant source or use of a priority chemical class. With this determination, further evaluating whether a restriction would reduce a significant source or use (RCW 70A.350.040(3)(b)(ii)) is not required by statute.

Bisphenols used in the manufacture of epoxy can linings serve to separate foods and beverages from the exterior metal container, but can migrate into the food and beverage contents. The Can Manufacturers Institute (CMI) reports that approximately 100 billion aluminum beverage cans and another 25 billion food cans are shipped by can manufacturers every year in the U.S.

[121] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.040
[122] https://apps.ecology.wa.gov/publications/summarypages/2004019.html

(CMI, 2020). Based on the population in Washington state, we estimate that approximately 2.5 billion cans are sold here each year.

Beverage cans represent roughly 80% of cans shipped for use in the U.S. Earlier studies, cited in our report on priority consumer products, reported high prevalence of BPA in beverage can linings (Bureau of Chemical Safety, 2010; Cao et al., 2009; Ecology, 2020a). A recent analysis of beverage cans and lids was conducted at Rutgers University (Zhang et al., 2020). The samples analyzed were procured and provided to the study authors by the International Life Sciences Institute's Food Packaging Safety Committee, who also sponsored the study. The study found that BPA, BPC, and BPF were present only in the lids of the sample beverage cans (Zhang et al., 2020).

We previously reported that bisphenols were found in a high proportion of food cans and canned food (Ecology, 2020a). We found that 10 – 70% of cans contained BPA-derived epoxies. In October 2020, the CMI submitted comments to Ecology stating that 95% of U.S. food can production transitioned out of BPA-based liners (CMI, 2021).

CMI analyzed can samples from a market basket survey of canned foods purchased in Washington, and two of 234 cans tested positive for BPA. Both cans that tested positive were imported, and not produced in the U.S. This work has not been published in peer-reviewed scientific literature. Further, it was not designed to assess the prevalence of BPA-containing cans in import specialty markets such as international food stores, and may not be representative of what some communities in Washington purchase in terms of food cans. While it suggests BPA use in can linings has decreased over time, even if we assume that 95% of U.S. cans no longer contain BPA, the remaining 5% would comprise 125 million cans with BPA used annually in Washington.

Food and beverage containers were identified as the largest source of human exposure to bisphenols (EFSA, 2015; NTP, 2008). Exposure to bisphenols is widespread. Three bisphenols are detected in most U.S. participants—90% of recent urine samples contained BPA, 89% contained BPS, and 57% contained BPF (CDC-NHANES, 2019; Lehmler et al., 2018; Mendy et al., 2020). Bisphenol exposure is particularly concerning for fetuses, infants, and children undergoing sensitive growth periods—when endocrine disruption can lead to adverse developmental effects (Rochester et al., 2013; Vom Saal et al., 2021).

Children also take in more food per kg of body weight than adults. Populations identified in the Priority Consumer Product Report[123]) that are expected to have higher exposure to BPA from food can linings due to increased consumption of canned food include (Calafat et al., 2008; LaKind and Naiman, 2011; Nelson et al., 2012, Comerford et al., 2015):

- Black people (identified in the study as African Americans)
- The elderly
- People with lower income who receive assistance through the Supplemental Nutrition Assistance Program (SNAP) and Woman, Infant and Children (WIC) Programs

[123] https://apps.ecology.wa.gov/publications/summarypages/2004019.html

Overall, ongoing bisphenol uses in food and beverage cans represent a significant source that contaminates environmental media and results in human exposures. These exposures may be disproportionate for people who consume more canned products or more imported canned foods. Restricting these uses when safer alternatives are feasible and available will protect sensitive populations and species from the endocrine disrupting effects from this class of chemicals.

Chapter 5: Alkylphenol Ethoxylates (APEs)

Chapter overview

The Washington State Legislature identified alkylphenol ethoxylates (APEs) as a priority chemical class. Ecology and Health (jointly "we") identified laundry detergent containing APEs as a priority product. In support of our priority product determination, we considered both the volume of APEs used in laundry detergent and the exposure potential to humans and other organisms (see the reducing a significant source or use section of this chapter).

We considered the hazards associated with APEs and determined they do not meet our minimum criteria for safer, as outlined in our criteria for safer (see the hazards of alkylphenol ethoxylates section of this chapter). We identified safer alternatives for use in laundry detergent that do meet our minimum criteria for safer and that are feasible and available (see the alternatives are safer, feasible, and available section of this chapter).

Scope of priority chemical class

Alkylphenol ethoxylates (APEs) as a class can be defined by the chemical structure in which a branched or linear alkyl chain is attached to a polyethoxylated phenolic ring. The general chemical formula of APEs is C_nH_{2n+1}-$C_6H_5O(CH_2CH_2O)_m$, where 'n' represents the length of the alkyl chain and 'm' represents the number of repeating ethoxylate (EO) units.

APEs discussed in scientific literature generally refer to nonylphenol ethoxylates (NPEs) and octylphenol ethoxylates (OPEs). NPEs and OPEs are the most commonly used APEs and account for approximately 80 – 85% and 15 – 20%, respectively, of the total APE market (EPA, 2010; Staples et al., 1998; van Ginkel, 2007). Nonyl or octyl refers to the length of the alkyl chain attached to the phenol ring (9- or 8-carbons, respectively). Both NPEs and OPEs can contain a varying number of EO units. In cleaning products and detergents, the number of EO units is generally between 4 and 15, and the most commonly manufactured NPE contains 9 EO units (DTSC, 2018).

APEs as a priority chemical class

We approach APEs as a class because RCW 70A.350.010 identifies APEs collectively as a priority chemical. The statute's directive is reasonable and well supported for several reasons:

- The most common APEs have similar biological hazards, including endocrine disruption and aquatic toxicity.
- APEs have toxic transformation products.

The available data on NPEs and OPEs suggest they share similar biological hazards in mammalian species and other organisms, and do not suggest other APEs would differ in this regard (DTSC, 2018; Servos, 1999; Staples et al., 1998). This includes NPEs and OPEs with any length of EO units, as well as APEs with differing branched or linear alkyl chain lengths attached to the phenolic ring (such as dodecylphenol ethoxylates).

APEs share biological hazards partly because of the breakdown process and transformation products associated with them, which we discuss in detail later in this chapter. The majority of NPEs and OPEs break down to shorter chain APEs, carboxylates, or alkylphenols (BAuA, 2012, 2014; DTSC, 2018). APEs generally increase in toxicity as the number of EO units decreases (NICNAS, 2020). Therefore, degradation of APEs can lead to hazardous transformation products with reduced EO units (DTSC, 2018). This supports the rationale for including APEs with any number of EO units in the priority chemical class.

Approach for setting the criteria for safer

We approach safer as a spectrum, using minimum or additional criteria to identify safer alternatives. We based both our minimum and additional criteria on 18 hazard endpoints, which we describe in detail in Appendix C. Our evaluation of the hazards of the priority chemical class informs the criteria alternatives need to meet to be considered safer than the existing chemical or process.

We applied elements of the hazard assessment scoping plan from the National Academies of Sciences' Class Based Approach to Organohalogen Flame Retardants (NAS, 2019) to assess the hazards of APEs as a class. We first determined whether the class as defined in the law is unified by "structure, physiochemical properties, biology, or some combination thereof."

We concluded that APEs can be defined by structure in which a branched or linear alkyl chain is attached to a polyethoxylated phenolic ring. The general chemical formula of APEs is C_nH_{2n+1}-$C_6H_5O(CH_2CH_2O)_m$, where 'n' represents the length of the alkyl chain and 'm' represents the number of repeating ethoxylate (EO) units.

We then review the data rich chemicals within the class. Data rich chemicals either:

- Were evaluated by authoritative sources.
- Have third-party reviewed or publicly available hazard assessments that we can compare against our criteria for safer.

We determined whether each data rich chemical met or failed to meet our minimum criteria for safer. This approach assumes that data poor chemicals within the class are potentially hazardous. It helps us avoid the pitfalls of assuming chemicals with limited hazard data or data gaps are not hazardous. If the data rich chemicals in the class fail to meet the minimum criteria for safer, then alternatives that do are safer.

We did not identify any APEs that met our minimum criteria for safer. Therefore, we concluded that APEs as a class do not meet our minimum criteria for safer and alternatives that do are safer.

Hazards of data rich alkylphenol ethoxylates

We determined that APEs, as a priority chemical class, do not meet our minimum criteria for safer. This finding is based on several relevant hazard assessments for NPEs and OPEs, as well as consideration of available data for hazard endpoints described in our criteria for safer. We considered NPEs and OPEs as representative of the broader chemical class of APEs for several reasons:

- They are the most widely used chemicals within the class.
- There are sufficient data describing their hazard potential.
- There are inadequate data available for other APEs that would suggest hazards dissimilar to those identified for NPEs and OPEs.

NPEs were scored as BM-1_{TP} in a GreenScreen® hazard assessment, conducted by a licensed profiler (linear and branched, 1 – 20 EO units, CAS: 9016-45-9, 127087-87-0, 68412-54-4, and 26027-38-3) (NSF Sustainability, 2014). Benchmark-1 (BM-1) chemicals have hazards that do not meet our minimum criteria for safer. The subscript "TP" indicates that the Benchmark score was driven by transformation products, which are discussed in more detail in a subsequent section of this chapter.

OPEs (CAS: 9002-93-1) are also classified as LT-1 using the GreenScreen® list translator methodology. This indicates that if a GreenScreen® assessment were conducted, these would also most likely be classified as BM-1 chemicals. Of particular concern are available hazard data describing evidence of NPEs, OPEs, and their transformation products as endocrine disruptors.

Endocrine activity

In 2017, the European Chemicals Agency added NPEs to the EU Substances of Very High Concern (SVHC) Authorisation List as a substance which through degradation, has endocrine disrupting properties (see transformation products section below). Based on their presence on this authoritative list, this endpoint scores as high in our criteria (ECHA, 2021a). OPEs are also present on the EU SVHC Authorisation List, and NPEs and OPEs are included on additional screening lists as substances with known or potential endocrine disrupting properties (ECHA, 2021a, 2021c).

Our minimum criteria for safer do not allow for an endocrine activity score of high, and NPEs and OPEs fail this requirement. There is inadequate data available to demonstrate that other APEs do not share the endocrine disrupting properties associated with NPEs and OPEs.

Aquatic toxicity and persistence

Based on both measured and modeled data, NPEs score as very high for acute aquatic toxicity and very high for chronic aquatic toxicity (NSF Sustainability, 2014). While this score for this endpoint could still meet our minimum criteria, it is concerning and important to note—especially coupled with the high rating for persistence in the same assessment.

Transformation products

The toxicity of APEs is also driven by formation of transformation products. The majority of NPEs and OPEs are not mineralized during wastewater treatment, and rather are converted to shorter chain APEs, carboxylates, or to alkylphenols (BAuA, 2012, 2014; DTSC, 2018). APEs are subject to degradation primarily through reduction in the number of EO units (Acir & Guenther, 2018; van Ginkel, 2007; NICNAS, 2020; Talmage, 1994). It has been suggested there is a general trend of reduced toxicity of APEs as the number of EO units increase (NICNAS, 2020). However, degradation of APEs forms analogous, more hazardous transformation products with reduced EO units (DTSC, 2018). This further supports the rationale for including APEs with any number of EO units in the priority chemical class.

Studies also demonstrate that degradation of APEs in soils and sediment is a slow process, and is dependent on the amount of oxygen available (BAuA, 2012; 2014). Further, this slow degradation is expected to act as a continual source of alkylphenols in the environment (BAuA, 2012; 2014). Alkylphenols (APs) are the most concerning transformation products of APEs—for NPEs and OPEs, these are nonylphenols (NPs) and octylphenols (OPs), respectively. The transformation products NPs and OPs have been shown to be highly toxic to aquatic organisms and persistent in the environment, and they are associated with endocrine disruption, neurotoxicity, and immunotoxicity (Acir & Guenther, 2018; Servos, 1999). NPs and OPs are included on the Washington Chemicals of High Concern to Children (CHCC) reporting list under the Children's Safe Products Act (RCW 70A.430[124]).

Endocrine activity

The transformation products identified in the GreenScreen® assessment of NPEs included multiple NP isomers that scored as LT-1 (2-NP, 3-NP, 4-NP and mixed, CAS: 25154-52-3, 104-40-5, 136-83-4, 139-84-4) (NSF Sustainability, 2014). NPs are present on authoritative lists as endocrine disruptors, corresponding to a score of high in our criteria (Table 39) (ECHA, 2021c). OPs (CAS: 140-66-9) are expected to share comparable hazard profiles to NPs—they also score as high for endocrine activity in our criteria due to their presence on authoritative lists (Table 39) (ECHA, 2021c).

Our minimum criteria do not allow for chemicals with transformation products that score as high for endocrine activity. Therefore, NPs and OPs do not meet our minimum criteria.

Aquatic toxicity and persistence

The EU GHS criteria classifies NPs and OPs as acutely toxic to aquatic life (H400, Category 1). This translates to a score of very high for acute aquatic toxicity (BAuA, 2012; 2014). Modeled data suggest NP (4-nonylphenol, branched) may be persistent in the environment, and would score as very high for persistence based on a previously estimated half-life of 340 days in sediment via the PBT Profiler (Hansen & Lassen, 2008). OP (4-tert-octylphenol) also meets the criteria for a very high persistence score based on these data (Hansen & Lassen, 2008).

Studies of degradation of NPs and OPs in soils and sediment have shown high to very high persistence—especially in anaerobic conditions (BAuA, 2012; 2014). There are data describing NPs and OPs as less persistent in aerobic environments compared to anaerobic sediments (ECHA, 2014; OSPAR, 2006). However, we consider NPs and OPs as persistent based on a protective, precautionary approach.

Our minimum criteria for safer does not allow for chemicals that score as very high for persistence and very high for aquatic toxicity. NPs and OPs fail this requirement.

[124] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.430

Conclusions

APEs as a chemical class do not meet our minimum criteria and are considered as potentially hazardous. This determination is based on sufficient, coherent data—available for the most commonly utilized chemicals within the class (NPE, OPE) and significant corresponding transformation products (NP, OP).

There are also inadequate data available to demonstrate that any within-class APEs would not share the same hazards as those identified for NPEs, OPEs, and their transformation products. With this in mind, it is necessary to identify safer alternatives to APEs for use in laundry detergent. Since APEs do not meet our minimum criteria for safer, alternatives will be considered safer if they do meet the minimum criteria.

Table 39. Example APEs: Safer criteria status, GreenScreen® scores, common hazards, and presence on authoritative lists.

Common name, associated CAS(s)	Meets minimum criteria?	GreenScreen® assessment or List Translator score	Endpoints of concern based on GreenScreen® score (high or very high) or authoritative listings
Nonylphenol ethoxylate, branched and linear isomers 9016-45-9* 20427-84-3 27942-27-4 7311-27-5 68412-54-4* 26027-38-3* 14409-72-4 1119449-38-5 156609-10-8 1119449-37-4 127087-87-0* 20636-48-0 37205-87-1 34166-38-6 104-35-8 27177-05-5 26571-11-9 26264-02-8	NO	BM-1$_{TP}$ LT-1	**Endocrine activity:** EU SVHC – Candidate List EU SVHC – Authorisation List Skin and eye irritation, acute and chronic aquatic toxicity, persistence
Octylphenol ethoxylate, branched and linear isomers 2497-59-8 9036-19-5 2315-67-5 2315-61-9 9002-93-1	NO	LT-1	**Endocrine activity:** EU SVHC – Candidate List EU SVHC – Authorisation List Skin and eye irritation, acute aquatic toxicity

Common name, associated CAS(s)	Meets minimum criteria?	GreenScreen® assessment or List Translator score	Endpoints of concern based on GreenScreen® score (high or very high) or authoritative listings
Nonylphenol, branched and linear isomers 104-40-5 142731-63-3 186825-36-5 84852-15-3 52427-13-1 30784-30-6 17404-66-9 26543-97-5 521947-27-3 25154-52-3 186825-39-8 90481-04-2 11066-49-2	NO	LT-1	**Endocrine activity:** EU SVHC – Candidate List **Acute aquatic toxicity:** EU – GHS (H400) Skin and eye irritation
Octylphenol, branched and linear isomers 27193-28-8 67554-50-1 1806-26-4 140-66-9	NO	LT-1	**Endocrine activity:** EU SVHC – Candidate List **Acute aquatic toxicity:** EU – GHS (H400) Skin and eye irritation

Note: * = Chemical groups associated with these CAS numbers were assessed by NSF Sustainability (2014). All CAS numbers shown in this table appear on various screening and authoritative lists.

Referenced hazard assessments

- A Licensed GreenScreen® Profiler conducted the hazard assessment of NPEs, and Ecology reviewed it (NSF Sustainability, 2014).
- GreenScreen® List Translator (LT) scores were determined using Licensed GreenScreen® List Translator Automators: Toxnot search tool[125] or Pharos website.[126]

[125] https://toxnot.com/Substances/Search
[126] https://www.greenscreenchemicals.org/learn/greenscreen-list-translator

Priority product: Laundry detergent

Scope of priority product

Laundry detergent.

Function of priority chemical in priority product

To identify potential safer alternatives, we first determine whether the function provided by the priority chemical is necessary to meet the performance requirements of the priority product at the chemical, material, product, or process level (see our criteria for feasible and available for more details).

We determined that the function the priority chemical provides is necessary for the priority product to perform. APEs function chemically as surfactants in laundry detergent and contribute to the performance of laundry detergents by facilitating efficient cleaning of laundry.

Alternatives are safer, feasible, and available

Alternatives are safer

Our analysis above concluded APEs do not meet our minimum criteria for safer. Therefore, we will use our minimum criteria to evaluate potential safer alternatives to APEs in laundry detergents. In this context, we identified several potential alternatives to APEs in laundry detergents that meet our minimum criteria for safer (Table 40).

It is important to note that although APEs fail to meet our minimum criteria in part due to their presence on authoritative lists as endocrine disruptors, data for endocrine disruption is not required to meet our minimum criteria. To score as high for endocrine activity, a chemical must either:

- Be present on an authoritative list (like NPEs, OPEs, NP, and OP).
- Have data showing evidence of endocrine activity in combination with a plausibly related adverse human health outcome.

We do require data for reproductive or developmental toxicity, and these are the most common endpoints that could contribute to an endocrine activity score of high in combination with evidence of endocrine disruption.

Linear (C12 and C14) alkyl alcohols, ethxoylated (6 EO units) (CAS: 68439-50-9)

This group of chemicals scored BM-2 in a GreenScreen® assessment, and this meets our minimum criteria for safer (ToxServices, 2021b). We also require data for two of three of the following endpoints:

- Acute toxicity.
- Neurotoxicity (single or repeat-dose).
- Systemic toxicity (repeat-dose).

The assessment noted data gaps for endocrine activity and repeat-dose neurotoxicity endpoints. Our criteria allow this data gap for repeat-dose neurotoxicity since there were sufficient data to score the systemic toxicity (single and repeat-dose) and neurotoxicity (single dose) endpoints.

Data for endocrine activity are not required in our minimum criteria, and the GreenScreen® assessment did not identify any data for this endpoint. If endocrine activity data does become available, it is unlikely that it could score above moderate given that the scores for reproductive toxicity and developmental toxicity are low and moderate, respectively.

D-Glucopyranose oligomers, decyl octyl glycosides (CAS: 68515-73-1)

This group of chemicals scored BM-2 in a GreenScreen® assessment, and this meets our minimum criteria for safer (ToxServices, 2021c). The assessment noted data gaps for endocrine activity and repeat-dose neurotoxicity endpoints. Our criteria allow this data gap for repeat-dose neurotoxicity given that there was sufficient data to score the systemic toxicity (single and repeat-dose) and neurotoxicity (single dose) endpoints.

Data for endocrine activity are not required in our minimum criteria, and the GreenScreen® assessment did not report sufficient *in vivo* data to assign a score for this endpoint. However, the GreenScreen® assessment summarized both high-throughput *in vitro* data and *in silico* modeling data as not indicating a concern for endocrine activity based on several surrogates (CASs: 110615-47-9, 50-99-7, and 124-07-2).

Sodium lauryl sulfate and C10 – C16 alkyl alcohol sulfuric acid, sodium salt (CASs: 151-21-3, 68585-47-7)

This group of chemicals scored BM-2 in a GreenScreen® assessment, and this meets our minimum criteria for safer (ToxServices, 2021d). The assessment noted data gaps for reproductive toxicity, endocrine activity, and neurotoxicity (single and repeat-dose) endpoints. Our criteria allow a data gap for reproductive toxicity when a score is determined for developmental toxicity—this group of chemicals scores low for the latter endpoint.

A chemical can meet the minimum criteria for safer with a data gap for the neurotoxicity (single and repeat-dose) endpoint given that this group of chemicals had sufficient data to score acute toxicity and systemic toxicity endpoints (single and repeat-dose).

Data for endocrine activity are not required in our minimum criteria, and the GreenScreen® assessment did not find sufficient *in vivo* data to assign a score for this endpoint. However, the GreenScreen® assessment summarized the weight of evidence of high-throughput *in vitro* data and *in silico* modeling data as indicating that sodium lauryl sulfate is unlikely to interact with estrogen, androgen, or thyroid receptors, or to affect steroidogenesis (ToxServices, 2021d).

Cocamidopropyl betaine (CAS: 61789-40-0)

This chemical scored BM-2 in a GreenScreen® assessment, and this meets our minimum criteria for safer (ToxServices, 2021e). The assessment noted data gaps for reproductive toxicity, endocrine activity, and neurotoxicity (repeat-dose). Our criteria allow the data gap for neurotoxicity (repeat-dose) since there were adequate data to score neurotoxicity (single-dose). Our criteria allow a data gap for reproductive toxicity when a score is determined for developmental toxicity—this chemical scores as moderate for the latter endpoint.

Data for endocrine activity are not required in our minimum criteria, and there were insufficient data to assign a score for this endpoint in the GreenScreen® assessment. However, the GreenScreen® assessment included modeling data that predicted cocamidopropyl betaine is unlikely to interact with estrogen or androgen receptors, or with thyroperoxidase.

Sulfuric acid, mono-C12-18-alkyl esters, sodium salts (CAS: 68955-19-1)

This group of chemicals scored BM-2 in a GreenScreen® assessment, and this meets our minimum criteria for safer (ToxServices, 2021f). The assessment noted data gaps for endocrine activity and neurotoxicity (repeat-dose). Our criteria allow the data gap for neurotoxicity (repeat-dose) since there were adequate data to score neurotoxicity (single-dose).

Data for endocrine activity are not required in our minimum criteria, and the GreenScreen® assessment did not find sufficient *in vivo* data to assign a score for this endpoint. However, the GreenScreen® assessment summarized the weight of evidence of high-throughput *in vitro* results of a surrogate—sodium lauryl sulfate (CAS: 151-21-3)—and modeling data as indicating the compound is unlikely to interact with estrogen, androgen, or thyroid receptors, or to affect steroidogenesis.

Amides, coco, N-3-(dimethylamino)propyl, N-oxides (CAS: 68155-09-9)

This group of chemicals scored BM-2 in a GreenScreen® assessment, and this meets our minimum criteria for safer (ToxServices, 2021g). The assessment noted a data gap for endocrine activity. Data for endocrine activity are not required in our minimum criteria, and the GreenScreen® assessment did not identify any data for this endpoint. If endocrine activity data became available, it is unlikely this endpoint would score above moderate given that both reproductive and developmental toxicity scored low in the assessment.

Table 40. Identified safer alternatives to APEs in laundry detergent.

Associated CAS(s)	Common name	GreenScreen® assessment Score	Meets minimum criteria?	Data gaps identified
68439-50-9	Linear (C12 and C14) alkyl alcohols, ethoxylated (6 EO units)	BM-2	YES	Endocrine activity, neurotoxicity (repeat-dose)
68515-73-1	D-Glucopyranose oligomers, decyl octyl glycosides	BM-2	YES	Endocrine activity, neurotoxicity (repeat-dose)
151-21-3 68585-47-7	Sodium lauryl sulfate and C10 – C16 alkyl alcohol sulfuric acid, sodium salt	BM-2	YES	Reproductive toxicity, endocrine activity, neurotoxicity (single and repeat-dose)
61789-40-0	Cocamidopropyl betaine	BM-2	YES	Reproductive toxicity, endocrine activity, neurotoxicity (repeat-dose)

Associated CAS(s)	Common name	GreenScreen® assessment Score	Meets minimum criteria?	Data gaps identified
68955-19-1	Sulfuric acid, mono-C12-18-alkyl esters, sodium salts	BM-2	YES	Endocrine activity, neurotoxicity (repeat-dose)
68155-09-9	Amides, coco, N-3-(dimethylamino)propyl, N-oxides	BM-2	YES	Endocrine activity

Note: The GreenScreen® assessments referenced above are all publicly available in the ToxServices database.[127]

Alternatives are feasible and available

APEs in laundry detergent chemically function as surfactants. We start by determining whether the safer alternative chemicals can also serve this function. We then use modules from the Interstate Chemicals Clearinghouse Guide for Alternatives Assessments (IC2 Guide) to determine whether these alternatives meet the performance requirements, and to evaluate if they are feasible and available using the questions posed in Table 41 (IC2, 2017).

Based on the IC2 Guide, we identified the following performance requirements for APEs:

- APEs or alternatives serve as surfactants in laundry detergent and are important for performance at the chemical level.
- APEs or alternative surfactants are needed to enable the efficient cleaning of laundry.
- Laundry detergent as a product must be able to effectively clean laundry.
- APEs or alternative surfactants must mix easily with other components of the detergent.

Table 41. Questions from IC2 Guide for evaluating feasibility and availability of alternative(s).

Feasibility and availability metrics	Determination
Is the alternative used for the same or a similar function?	Alternatives determined as safer (see above) are present in many laundry detergents and listed as a surfactant. A list of detergents is provided below.
Is the alternative used in similar products on the commercial market?	Safer surfactants are used in a wide variety of products including those marketed for industrial and commercial use, in liquid, powder, and pack form. They are also marketed for use for cleaning different types of laundry—including for babies, colored laundry, and cold wash laundry.

[127] https://database.toxservices.com/

Feasibility and availability metrics	Determination
Is the alternative marketed in promotional materials for the application of interest?	Safer surfactants are marketed in many laundry detergents of all types, with a variety of label claims (such as "removing tough stains," "protecting color," and "removing dirt and grease").
Is this a favorable alternative based on the answers to the above questions?	Yes, safer surfactants meet all of the feasibility and availability metrics required.

Conclusion

We identified several laundry detergents that utilize the safer alternative surfactants described in the alternatives are safer section above. These alternative surfactants are currently used in laundry detergents—the application of interest—and are described in marketing materials as meeting the performance requirements we identified. We determined that these safer alternative surfactants are both feasible and available, as summarized in Table 42. Restricting the use of APEs in laundry detergent would reduce a significant source of exposure for people and the environment.

Table 42. Examples of safer alternative surfactants used in laundry detergents.

Manufacturer*	Surfactants used	Product names*
Grove Collaborative	Alcohol ethoxylates (CAS: 68439-50-9) Sodium lauryl sulfate (CAS: 68585-47-7)	Ultra-Concentrated Liquid Laundry Detergent (Grove Collaborative, 2021a) Pure Power Laundry Detergent (Grove Collaborative, 2021b) Care and Renew Liquid Laundry Detergent" (Grove Collaborative, 2021c) Cold Wash Laundry Detergent (Grove Collaborative, 2021d) Laundry Powder Packs (Grove Collaborative, 2021e)
Seventh Generation	Decyl glucosides (CAS: 68515-73-1) Alcohol ethoxylates (CAS: 68439-50-9) Sodium lauryl sulfate (CAS: 68585-47-7) Sodium lauryl sulfate (CAS: 151-21-3)	Professional Liquid Laundry Detergent (Amazon, 2021d) Laundry Detergent Packs (Seventh Generation, 2021a) Ultra Power Plus Laundry Detergent Packs (Seventh Generation, 2021b) EasyDose Ultra Concentrated Laundry Detergent (Seventh Generation, 2021c) Laundry Detergent (Seventh Generation, 2021d) Concentrated Laundry Detergent (Seventh Generation, 2021e) EasyDose Power + Ultra Concentrated Laundry Detergent (Seventh Generation, 2021f)

Manufacturer*	Surfactants used	Product names*
Presto! (Amazon Brand)	Alcohol ethoxylates (CAS: 68439-50-9) Sodium lauryl sulfate (CAS: 68585-47-7)	Concentrated Liquid Laundry Detergent (Amazon, 2021e) "Laundry Detergent Packs" (Amazon, 2021f)
Mama Bear (Amazon Brand)	Alcohol ethoxylates (CAS: 68439-50-9) Sodium lauryl sulfate (CAS: 68585-47-7)	Gentle Baby Laundry Detergent (Amazon, 2021g)
ECOS	Cocamidopropyl betaine (CAS: 31789-40-0) Sodium pentadecyl sulfate (CAS: 68955-19-1) Cocamidopropyldimethylamino oxide (CAS: 68155-09-9)	Hypoallergenic Laundry Detergent (ECOS, 2021a) Hypoallergenic Baby Laundry Detergent (ECOS, 2021b) ECOS PRO Liquid Laundry Detergent (ECOS, 2021c)
Solutex, Inc.	Cocamidopropyl betaine (CAS: 31789-40-0) Cocamidopropyldimethylamino oxide (CAS: 68155-09-9)	Refresh 2x HE Laundry Detergent (Solutex, 2015)
W.W. Grainger	Cocamidopropyl betaine (CAS: 31789-40-0) Cocamidopropyldimethylamino oxide (CAS: 68155-09-9)	Grainger Tough Guy Laundry Detergent (Grainger, 2021)
Friendly Organic	Cocamidopropyl betaine (CAS: 31789-40-0) Sodium pentadecyl sulfate (CAS: 68955-19-1) Cocamidopropyldimethylamino oxide (CAS: 68155-09-9)	Laundry Detergent (Friendly Organic, 2021) Baby Laundry Detergent (Friendly Organic, 2021)

Note: * = Any reference in this publication to persons, organizations, services, products, or activities does not constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

Reducing a significant source or use

In order to restrict or prohibit priority chemicals in priority products, RCW 70A.350.040[128] requires Ecology and Health to determine that either:

- The restriction will reduce a significant source or use of a priority chemical, or
- The restriction is necessary to protect the health of sensitive populations or sensitive species.

We identified laundry detergent as a significant source or use of APEs in our 2020 report to the Legislature.[129] That report became effective at the end of the 2021 legislative session on April 25, 2021. Based on that report, we determined that restricting any of the chemical-product combinations in that report would reduce a significant source or use of a priority chemical class. With this determination, further evaluating whether a restriction would reduce a significant source or use (RCW 70A.350.040(3)(b)(ii)) is not required by statute.

As outlined in our report to the Legislature on priority consumer products, the largest use of APEs in consumer goods are as a component of laundry detergents (Ecology, 2020a). Discharge of laundry detergent waste is a significant source of APEs in the environment (Ecology, 2020a). Studies detect APEs and their degradation products in environmental media in Washington state, including in WWTP effluent, stormwater, streams, rivers, and estuarine and marine waters (Ecology, 2010b; King County, 2007; Meador et al., 2016). APEs and APs are also detected in tissues of fish from Washington state lakes and rivers (Ecology, 2016b; Meador et al., 2016). The dominant use of NPEs is in institutional cleaners—including laundry detergents and other cleaning products—which accounts for approximately 39% of the total volume used globally (DTSC, 2018).

We estimated in our priority products report that Washington on-premise laundries (such as those found in hospitals, hotels, and nursing homes) discharge approximately two million pounds of laundry detergent, containing up to 370,000 pounds of NPEs, yearly (Ecology, 2020a). Therefore, restricting the use of APEs in laundry detergents would reduce a significant use of APEs and a significant source of APEs in the environment.

[128] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.040
[129] https://apps.ecology.wa.gov/publications/summarypages/2004019.html

Chapter 6: Ortho-phthalates

Chapter overview

The Washington State Legislature identified ortho-phthalates as a priority chemical class and Ecology and Health (jointly "we") identified fragrances in personal care and beauty products and vinyl flooring products containing ortho-phthalates as priority products. We considered the hazards associated with ortho-phthalates and determined that most do not meet our criteria for safer. Three ortho-phthalates did meet our minimum criteria for safer, but none met our additional criteria for safer. We did not identify sufficient evidence of lack of hazard to treat these ortho-phthalates differently. This is outlined in our criteria for safer and described in the hazards of ortho-phthalates section of this chapter.

Vinyl flooring

The ortho-phthalates found in vinyl flooring products do not meet our minimum criteria for safer. We identified alternatives to ortho-phthalates in vinyl flooring products that meet our minimum criteria for safer and are feasible and available (see the alternatives are safer, feasible, and available subsection of the vinyl flooring section of this chapter).

In support of our priority product determination, we considered both the volume of ortho-phthalates used in vinyl flooring and the contribution of vinyl flooring as a source of ortho-phthalates in the environment. We also considered the potential for exposure to ortho-phthalates in humans, including in sensitive populations (see the reducing a significant source or use subsection of the vinyl flooring section of this chapter).

Fragrances in personal care and beauty products

The ortho-phthalates found in fragrances that are used in personal care and beauty products meet our minimum criteria for safer, but do not meet our additional criteria for safer. We identified safer alternatives to ortho-phthalates in personal care and beauty product fragrances that meet our additional criteria and that are feasible and available (see the alternatives are safer, feasible, and available subsection of the personal care and beauty products section of this chapter).

In support of our priority product determination, we considered both the volume of ortho-phthalates used in fragrances in personal care and beauty products and the contribution of fragrances in personal care and beauty products as a source of ortho-phthalates in the environment. We also considered the potential for exposure to ortho-phthalates in humans, including in sensitive populations (see the reducing a significant source or use subsection of the personal care and beauty products section of this chapter).

Scope of priority chemical class

RCW 70A.350.010[130] defines phthalates as a class as "synthetic esters of phthalic acid" based on their chemical structure. The National Library of Medicine (NLM) defines the term phthalic acid as a "benzenedicarboxylic acid consisting of two carboxy groups at ortho positions" (NLM, 2021). This definition does not include benzenedicarboxylic acid with two carboxy groups in either the meta or para configurations (e.g., isophthalic acid or terephthalic acid). Thus, the definition of this priority chemical class can be clarified to include only ortho-phthalates.

Hazards of ortho-phthalates

Ortho-phthalates as a priority chemical class

We approach ortho-phthalates as a class because RCW 70A.350.010 defines ortho-phthalates collectively as a priority chemical. In addition, the statute's directive is reasonable and well supported for several reasons:

- People are exposed to mixtures of ortho-phthalates that can have cumulative impacts on health and development.
- Many ortho-phthalates impact sensitive biological systems during critical windows of susceptibility.
- Previous actions reducing the use of some ortho-phthalates led to increased exposure from other ortho-phthalates.

Many ortho-phthalates are associated with endocrine disruption and reproductive and developmental toxicity (see hazards of data rich ortho-phthalates). When exposure to multiple ortho-phthalates occurs, it can have cumulative effects on reproduction and development (NAS, 2008). This is concerning because nearly everyone is exposed to mixtures of ortho-phthalates before birth and throughout their lifespan.

Studies detect multiple ortho-phthalates in cord blood, breastmilk, and the urine of toddlers, children, and adults (Wang et al., 2019). Human biomonitoring data suggest that as exposure to some ortho-phthalates decreased, exposure to others increased (Zota et al., 2014). This change in exposure suggests that in some products, manufacturers replaced ortho-phthalates such as DEHP with other ortho-phthalates.

Many chemicals within the ortho-phthalates class can disrupt testosterone synthesis during development, which spurred concerns around these chemicals (Furr et al., 2014). These impacts support the approach of considering cumulative exposures to multiple ortho-phthalates in decision-making (Lioy et al., 2015). Not all ortho-phthalates impact testosterone synthesis (Furr et al., 2014). However, even ortho-phthalates that do not impact testosterone synthesis have been shown to adversely affect reproduction or development (NTP, 2003; Weaver et al., 2020). Human epidemiological studies amplify concerns regarding the impact of ortho-phthalates (Eales et al., 2022)—whether or not they impact testosterone synthesis—on reproduction and

[130] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.010

development (Radke et al., 2018, 2019, 2020), particularly neurodevelopment (Engle et al., 2021).

Given our increased susceptibility during early life stages (Braun, 2017; de Boo & Harding, 2006) and the potential for cumulative impacts and regrettable substitutions, experts call for actions on ortho-phthalates as a class to protect sensitive populations (Birnbaum & Bornehag, 2021; Engle et al., 2021).

Approach for setting the criteria for safer

We approach safer as a spectrum, using minimum or additional criteria to identify safer alternatives. We based both our minimum and additional criteria on 18 hazard endpoints and we describe them in detail in Appendix C. Our evaluation of the hazards of the priority chemical class informs the criteria alternatives need to meet to be considered safer than the existing chemical or process.

We applied elements of the hazard assessment scoping plan from the National Academies of Sciences' Class Based Approach to Organohalogen Flame Retardants (NAS, 2019) to assess the hazards of ortho-phthalates as a class. We first determined whether the class as defined in the law is unified by "structure, physiochemical properties, biology, or some combination thereof." We concluded that phthalates can be defined by structure based on the definition in RCW 70A.350.010[131] as "synthetic esters of phthalic acid."

We then reviewed the data rich chemicals within the class. Data rich chemicals either:

- Were evaluated by authoritative sources.
- Have third-party reviewed or publicly available hazard assessments that we can compare against our criteria for safer.

We determined whether each data rich chemical met or failed to meet our minimum criteria for safer. This approach assumes that data poor chemicals within the class are potentially hazardous. It helps us avoid the pitfalls of assuming chemicals with limited hazard data or data gaps are not hazardous. If the data rich chemicals in the class fail to meet the minimum criteria for safer, then alternatives that do are safer.

In cases of toxicological diversity, where some data rich chemicals in the class met and others failed to meet the minimum criteria for safer, we have two options (as described in Appendix C):

1. Using the criteria (minimum or additional) that allows us to identify alternatives that are safer than the data rich priority chemicals potentially found in the priority product.
2. Using the minimum criteria to conservatively identify alternatives that are safer than the data rich hazardous chemicals in the class.

We identified data rich ortho-phthalates that met and failed to meet our minimum criteria for safer. Most data rich ortho-phthalates did not meet our minimum criteria for safer. We

[131] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.010

concluded that there is toxicological diversity within the ortho-phthalates class (see hazards of data rich ortho-phthalates). Therefore, we reviewed the ortho-phthalates potentially found in the priority product to set the criteria for identifying safer alternatives.

If the data rich chemicals potentially found in the product met the minimum criteria for safer, we used the additional criteria for safer to identify alternatives. Conversely, if the data rich chemicals potentially found in the product failed to meet the minimum criteria for safer, we concluded that alternatives that do are safer. In this scenario, the criteria we use to identify safer alternatives to ortho-phthalates varies by product.

We did not identify any ortho-phthalates that met our within-class criteria. Using the within-class criteria to identify safer chemicals within the class helps prevent regrettable substitutions. Chemicals within the class are more likely to share hazards (Chen et al., 2016; Cordner et al., 2016; Lioy et al., 2015; NAS, 2019; Vos et al., 2003) and we need to approach them with added caution (Birnbaum et al., 2021; Blum et al., 2015; DiGangi et al., 2010).

Many ortho-phthalates are associated with endocrine disruption, and reproductive and developmental toxicity (see hazards of data rich ortho-phthalates). In order to confirm that an ortho-phthalate does not share these hazards, the within-class criteria requires evidence of the lack of both endocrine disruption and reproductive and developmental toxicity (among other criteria). The within-class criteria sets a transparent bar to identify chemicals within the class that have sufficient data showing they are safer and exclude them. See a full description in Appendix C.

Hazards of the data rich ortho-phthalates

The hazards associated with ortho-phthalates are well-documented and this class of chemicals is relatively well-studied. The majority of the data rich ortho-phthalates do not meet our minimum criteria for safer. Two ortho-phthalates meet our minimum criteria for safer. However, we did not identify any ortho-phthalates that meet our additional criteria for safer, nor any ortho-phthalates with sufficient data indicating they are less hazardous than the class as a whole and should be treated differently.

We identified 15 data rich ortho-phthalates present on authoritative lists or with existing hazard assessments (Table 43). Of these, 13 did not meet our minimum criteria for safer. We found seven ortho-phthalates on authoritative lists that do not meet our minimum criteria for safer (ECHA, 2020b, 2021a, 2021c; OEHHA, 2021). We also identified eight ortho-phthalates with publicly available or third-party reviewed GreenScreen® hazard assessments. Five of these scored as Benchmark-1 chemicals and also do not meet our minimum criteria for safer. Two ortho-phthalates—diethyl phthalate (DEP) and dimethyl phthalate (DMP)—meet our minimum criteria for safer, but do not meet our additional criteria for safer. We discuss these in more detail below.

Among the ortho-phthalates that do not meet our minimum criteria for safer, carcinogenicity, reproductive and developmental toxicity, and endocrine disruption are frequently observed. Di(2-ethylhexyl) phthalate (DEHP), di-n-hexyl phthalate (DnHP, DHP), and diisononyl phthalate (DINP) score high for carcinogenicity based on animal studies or their inclusion in several authoritative lists (ToxServices, 2016e, 2016f, 2021h).

DEHP, dicyclohexyl phthalate (DCHP), and DnHP score high for both developmental and reproductive hazards based on their presence on multiple authoritative lists or animal studies (ToxServices, 2016e, 2016f, 2016g). Studies on DEHP also demonstrate reduced fertility and reproductive tract malformations following exposure (Blystone et al., 2010; ToxServices, 2016e).

DEHP also scores high for endocrine activity along with DCHP and DnHP. Diisodecyl phthalate (DIDP) and DINP score moderate for this endpoint (ToxServices, 2021i, 2021h). The endocrine activity hazard score of high denotes the chemical as being a suspected endocrine disruptor in combination with evidence of an adverse health effect for a related endpoint (such as reproductive or developmental toxicity). For example, DEHP is both a known endocrine disruptor and has been shown to induce reproductive tract malformations in studies. Many ortho-phthalates are also included on authoritative lists due to endocrine disrupting properties and reproductive toxicity including the EU – SVHC Candidate List and the EU – SVHC Authorisation List (BBP, DEHP, BMEP, DBP, DCHP, DHP, DIBP, DIHP, DIPP, DPP, etc.) (ECHA, 2021a, 2021c).

We identified two ortho-phthalates (DPHP and DMP) that scored as Benchmark-2 in expired GreenScreen® assessments previously listed on the TCO Certified Accepted Substance List, which were removed since expiring (TCO Certified, 2022). In an updated GreenScreen® assessment of DPHP, it was scored as a BM-U chemical, and this does not meet our minimum criteria for safer.

The expired DMP assessment indicated it may have met our minimum criteria. However, there is evidence it shares similar hazard concerns (yet may be less potent relative to other ortho-phthalates in the class). Verified Scivera assessments (with overall scores of yellow) identified hazards associated with DPHP and DMP that fail to meet our additional criteria for safer (Scivera, 2021w, 2021x). We discuss the hazards of DPHP and DMP below.

Limited studies are available for DMP. The available data does not suggest that DMP causes as overt reproductive or developmental toxicity relative to other ortho-phthalates at similar doses. However, an *in vivo* study reported a significant decrease in testosterone and dihydrotestosterone in the testes and serum of rats following exposure to DMP for seven days (Oishi & Hiraga, 1980). Other studies showed DMP causing a dose-dependent reduction on human sperm motility *in vitro* (Fredricsson et al., 1993). NICNAS assigned a LOAEL of 197 mg/kg/day for fertility-related effects for DMP. This was based on read-across from a two-generation *in vivo* study on DEP in rats that reported (Fujii et al., 2005; Australia, 2014):

- A dose-dependent reduction in serum testosterone
- Increased incidence of abnormal and tailless sperm
- Similar effects of DMP observed at higher doses

Based on this information, DMP scores as moderate in our criteria for both reproductive toxicity and endocrine activity. DEP was also used as a surrogate in assigning scores of moderate for reproductive toxicity in both Scivera (yellow/grey) and ChemFORWARD (moderate, *Cat 2*) hazard assessments of DMP (ChemFORWARD, 2019g; Scivera, 2020x). Scoring moderate for reproductive toxicity means DMP does not meet our additional criteria for safer.

We received public comments requesting more information about the hazards of DPHP. We contracted an updated GreenScreen® assessment of DPHP that is publically available (ToxServices, 2022b). The previous GreenScreen® scored DPHP as a Benchmark-2, with a moderate score for carcinogencitity (due to structural similarities to other carcinogenic ortho-phthalates). This aligned with a 2017 decision by the MAK to classify DPHP as a carcinogen category 3B based on structural and mechanistic similarities to DEHP (Toxservices, 2022b). Other authoritative bodies, such as CPSC and ECHA, found the surrogate data for carcinogenicity inconclusive. Based on the lack of experimental data for DPHP and the uncertainty in the surrogate data, DPHP was assigned a data gap for carcinogenicity. This translates to a BM-U score, which does not meet our minimum criteria for safer.

Because of the prevalence of DEP use in fragrances, we contracted a GreenScreen® assessment of DEP. In this assessment, DEP scored moderate for reproductive toxicity, developmental toxicity, and endocrine disruption hazard endpoints (ToxServices, 2020e). Because our scoring for reproductive and developmental toxicity is slightly modified from GreenScreen®, DEP scores low for developmental toxicity in our criteria. This is because our scoring system integrates the guidance values from EPA's Safer Chemical Ingredients List (SCIL), and the developmental effects from DEP were observed at doses greater than 250 mg/kg/day for oral exposure.

However, reproductive effects were observed at lower doses. The GreenScreen® cites the NICNAS (2011) report, which found a NOAEL of 40 mg/kg/day and LOAEL of 197 mg/kg/for male fertility-related effects based on decreased serum testosterone in the parent generation and increased abnormal sperm and tailless sperm in the parent and offspring generation (NICNAS, 2011). Based on these data, DEP scores as moderate for both reproductive toxicity and endocrine activity in our criteria, and does not meet our additional criteria for safer.

In addition to information from animal studies, we also considered evidence from human studies. Interpreting epidemiological studies can be challenging because there are often confounders and effect modifiers. However, when human and animal studies show impacts on similar biological systems, the cause and effect relationship becomes more likely (Fedack et al., 2015).

Systematic reviews of human epidemiological studies identify associations between DEP exposure and adverse reproductive and developmental outcomes. Studies link DEP exposure during development with:

- Reduced anogenital distance (Radke et al., 2018)
- Impaired neurodevelopmental parameters (Radke et al., 2019; Zang et al., 2020)
- Preterm birth (Radke et al., 2019)

Several studies associate higher DEP exposure in pregnant women with increased risk of gestational diabetes mellitus (GDM) or factors that increase risk for GDM (Barrett et al., 2022; Bellavia et al., 2017; James-Todd et al., 2016; Schaffer et al., 2019; Zukin et al., 2021). Other studies did not find this association (Fisher et al., 2018; Robledo et al., 2015).

Research published after Radke et al.'s 2018 and 2019 cumulative review papers reported associations between ortho-phthalate metabolites and sex steroid hormones in adults. Studies significantly associated urinary MEP, the major metabolite of DEP, with:

- Increased serum hormone binding globulin in women (Zhu et al., 2022)
- Decreased ratio of estrogen to testosterone in pregnant women (Pacyga et al., 2021)

Taken together, this suggests that at least some toxicities observed in animals may also occur in human populations, which heightens concerns around DEP and the class as a whole (Birnbaum & Bornehag, 2021; Engle et al., 2021).

Conclusions

There is toxicological diversity within the phthalate class. Most data rich ortho-phthalates do not meet our minimum criteria for safer. Two data rich ortho-phthalates meet our minimum criteria for safer, but do not meet our additional criteria for safer. One of the ways we take toxicological diversity of the class into account when identifying safer alternatives is by considering the hazards of chemicals that are found in the products.

Vinyl flooring

Ortho-phthalates detected in vinyl flooring products include DEHP, DINP, DnBP, and BBP (Ecology, 2020a). These ortho-phthalates do not meet our minimum criteria for safer. We also noted DPHP listed in Health Product Declarations (HPDs) for some vinyl flooring products. However, it was not listed as the primary plasticizer used in these products. The data do not warrant treating DPHP differently from the rest of the class. There is evidence to suggest DPHP may have similar hazards as other ortho-phthalates in the class, including carcinogenicity and reproductive toxicity. Therefore, non-phthalate alternatives that meet our minimum criteria are safer than ortho-phthalates in vinyl flooring.

Fragrances in personal care and beauty products

The only ortho-phthalate we found detected in fragrances at concentrations above 100 ppm is DEP (Ecology, 2020a). However, the EPA FUse model predicted functional use in fragrance of DMP, DEHP, DCHP, DHP, and BBP (CompTox, 2021). The Functional Use Database (FUse) relies on reported functional uses of chemicals and structural classification, combined with machine-learning based models, to predict chemicals that are potential functional use substitutes (Phillips et al., 2017). DEP meets our minimum criteria for safer, but the moderate score for reproductive toxicity means it doesn’t meet our additional criteria for safer. Alternatives that meet our additional criteria for safer are safer than ortho-phthalates in personal care and beauty products.

Table 43. Data rich chemicals within the ortho-phthalate class.

Common name, associated CAS(s)	Meets minimum criteria?	Hazard assessment score(s)—GreenScreen®, List Translator, ChemFORWARD, or Scivera	Endpoints of concern (high or very high) based on GreenScreen® assessments or authoritative lists
Dimethyl phthalate (DMP) 131-11-3	YES	BM-2 (expired) ChemFORWARD Hazard Band C Scivera yellow	Unknown (not publicly available in full)
Diethyl phthalate (DEP) 84-66-2	YES	BM-2	Moderate for developmental toxicity, reproductive toxicity and endocrine disruption
Di(2-propylheptyl) phthalate (DPHP) 53306-54-0	YES	BM-U ChemFORWARD Hazard Band C Scivera yellow	Carcinogenicity data gap
Di-n-butyl phthalate (DnBP) 84-74-2	NO	Scivera red LT-1	**Developmental and reproductive toxicity:** CA Prop 65 U.S. NIH Reproductive and Developmental monographs **Endocrine disruption:** EU SVHC Authorisation List **Aquatic toxicity:** EU GHS H400
Diisobutyl phthalate (DIBP) 84-69-5	NO	Scivera red LT-1	**Developmental and reproductive toxicity:** EU GHS H360Df **Endocrine disruption:** EU SVHC Authorisation list
Di-n-pentyl phthalate (DnPP) 131-18-0	NO	Scivera red LT-1	**Developmental and reproductive toxicity:** EU GHS (H360FD) **Aquatic toxicity:** EU GHS (H400)
Butyl benzyl phthalate (BBP) 85-68-7	NO	Scivera red LT-1	**Developmental and reproductive toxicity:** CA Prop 65 **Endocrine activity:** EU – SVHC Candidate List **Aquatic toxicity:** EU GHS H400

Common name, associated CAS(s)	Meets minimum criteria?	Hazard assessment score(s)—GreenScreen®, List Translator, ChemFORWARD, or Scivera	Endpoints of concern (high or very high) based on GreenScreen® assessments or authoritative lists
Dicyclohexyl phthalate (DCHP) 84-61-7	NO	BM-1 Scivera red	**Developmental and reproductive toxicity:** EU GHS (H360D) **Endocrine activity:** EU – SVHC Candidate List
Di-n-hexyl phthalate, Dihexyl phthalate (DnHP, DHP) 84-75-3	NO	BM-1 Scivera red	**Developmental and reproductive toxicity:** CA Prop 65 U.S. – NIH Repro. & Develop. EU GHS (H360FD) Carcinogenicity, endocrine disruption, chronic aquatic toxicity
Diisohexyl phthalate 71850-09-4	NO	LT-1	**Developmental and reproductive toxicity:** EU GHS H360FD EU SVHC candidate list
Diisoheptyl phthalate 71888-89-6	NO	Scivera red LT-1	**Developmental and reproductive toxicity:** EU GHS (H360D) EU Annex VI CMRs Category 1B
Di(2-ethylhexyl) phthalate (DEHP) 117-81-7	NO	BM-1 Scivera red	**Carcinogenicity** CA Prop 65 MAK (Carc 4) IARC (2B) U.S. NIH – Report on Carc. U.S. EPA – IRIS Carc. **Developmental and reproductive toxicity:** CA Prop 65 U.S. NIH – Repro. & Develop. EU GHS (H360FD) **Endocrine activity:** EU – SVHC Candidate List EU – SVHC Priortisation List
Diisononyl phthalate (DINP) 28553-12-0	NO	BM-1 Scivera red	**Carcinogenicity:** CA Prop 65
Diisodecyl phthalate (DIDP) 26761-40-0	NO	BM-1 Scivera red	**Carcinogenicity:** MAK Carcinogen (Carc. 3B) **Developmental and reproductive toxicity:** CA Prop 65
Diisooctyl phthalate 27554-26-3	NO	LT-1	**Developmental and reproductive toxicity:** EU GHS (H360FD)

Referenced hazard assessments

The hazard assessments for DMP, DPHP, DEP, DCHP, DnHP/DHP, DEHP, DINP, and DIDP were conducted by Licensed GreenScreen® Profilers and are publicly available or have been third-party reviewed.

- GreenScreen® hazard assessments (ToxServices, 2016e, 2021f, 2021g) are available from the ToxServices database.[132]
- GreenScreen® hazard assessment for DMP was previously referenced on the TCO Certified Accepted Substance List (TCO Certified, 2022).
- GreenScreen® hazard assessment for DEP and DPHP are available on the IC2 website.[133]
- GreenScreen® List Translator (LT) scores were determined using Licensed GreenScreen® List Translator Automators: Toxnot search tool[134] or Pharos website.[135]
- The ChemFORWARD assessments for dimethyl phthalate (DMP) and di(2-propylheptyl) phthalate (DPHP) are available from the ChemFORWARD website.[136]
- The Scivera GHS+ assessments for dimethyl phthalate (DMP), di(2-propylheptyl) phthalate (DPHP), di-n-butyl phthalate (DnBP), diisobutyl phthalate (DIBP), di-n-pentyl phthalate (DnPP), butyl benzyl phthalate (BBP), dicyclohexyl phthalate (DCHP), di-n-hexyl phthalate, dihexyl phthalate (DnHP, DHP), diisoheptyl phthalate, di(2-ethylhexyl) phthalate (DEHP), diisononyl phthalate (DINP), and diisodecyl phthalate (DIDP) are available on the Scivera website.[137]

[132] https://database.toxservices.com
[133] https://www.theic2.org/hazard-assessment#gsc.tab=0
[134] https://toxnot.com/Substances/Search
[135] https://www.greenscreenchemicals.org/learn/greenscreen-list-translator
[136] https://www.chemforward.org/
[137] https://www.scivera.com/ghsplus/

Priority product: Vinyl flooring

Scope of priority product

Vinyl flooring products.

Function of priority chemical in priority product

To identify potential safer alternatives, we first determine whether the function provided by the priority chemical is necessary to meet the performance requirements of the priority product at the chemical, material, product, or process level. If the priority chemical does not provide a necessary function, the chemical can be removed and there is no need to identify alternatives.

We determined that the function ortho-phthalates provide is necessary for vinyl flooring to perform. Ortho-phthalates function as plasticizers and serve to soften and improve the pliability of polyvinyl chloride (PVC) used in vinyl flooring at the material level—contributing to performance of these products.

Alternatives are safer, feasible, and available

Alternatives are safer

The ortho-phthalates used in vinyl flooring are relatively higher molecular weight ortho-phthalates. These include BBP, DEHP, DINP, DIDP, and DPHP. BBP, DEHP, DIDP, and DINP, all of which have existing GreenScreen® or GreenScreen® List Translator assessments, are scored as BM-1 or LT-1 chemicals. They do not meet our minimum criteria for safer. Chemical alternatives used to replace ortho-phthalates as plasticizers in vinyl flooring will need to meet our minimum criteria to be considered safer alternatives. (Alternative flooring that does not require the use of plasticizers may also be safer, but that was not the focus of our analysis.)

We identified several potential alternatives to ortho-phthalates in vinyl flooring that meet our minimum criteria for safer (Table 44). We also identified alternatives to vinyl flooring that do not require a plasticizer and that are potential safer alternatives. It is important to note that although several ortho-phthalates fail to meet our minimum criteria in part due to their presence on authoritative lists as endocrine disruptors, data for endocrine disruption is not required to meet our minimum criteria. To score as high for endocrine activity, a chemical must be either:

- Present on an authoritative list (such as DEHP).
- Have data showing evidence of endocrine activity in combination with a plausibly related adverse health outcome.

Several of the alternatives identified do not have sufficient data to evaluate and score for endocrine activity, but still meet our minimum criteria for safer. (We discuss data available for this endpoint for these alternatives below).

Di(2-ethylhexyl) terephthalate, dioctyl terephthalate (DEHT, DOTP) (CAS: 6422-86-2)

DEHT scored as BM-3_{DG} in a GreenScreen® assessment, and this meets our minimum criteria for safer (ToxServices, 2021j). The assessment noted data gaps for endocrine activity and neurotoxicity (repeat-dose). Data for endocrine activity is not required in our minimum criteria. Our criteria allow the data gap for neurotoxicity (repeat-dose) because there is sufficient data to score the neurotoxicity (single-dose) endpoint as low.

A ChemFORWARD hazard assessment scored DEHT as Band A, further indicating that it meets our minimum criteria for safer (ChemFORWARD, 2019a). The ChemFORWARD analysis did not identify any hazard flags.

DEHT was also scored as a green/yellow chemical overall in a verified Scivera hazard assessment, further demonstrating it meets our minimum criteria for safer (Scivera, 2021y). The assessment noted data gaps for endocrine activity, acute toxicity (inhalation only), and sensory irritation. Our criteria also do not require data for acute toxicity for all routes of exposure, and the assessment scores acute toxicity for both dermal and oral exposure as green. Sensory irritation does not align to a specific endpoint in our criteria and we do not require data for this endpoint.

DEHT is also listed in the CleanGredients database (Palatinol® DOTP) as meeting the Safer Choice master criteria based on an assessment by a Safer Choice authorized third-party profiler. This provides additional evidence that it meets our minimum criteria for safer (CleanGredients, 2019).

Glycerides, castor-oil mono-, hydrogenated, acetates (COMGHA) (CAS: 736150-63-3)

COMGHA scored Band C in a ChemFORWARD hazard assessment, and this meets our minimum criteria for safer (ChemFORWARD, 2019b). The assessment identified hazard flags for moderate to high acute aquatic toxicity and moderate bioaccumulation potential, these meet our minimum criteria for safer. The assessment scored a data gap for neurotoxicity (single-dose) but neurotoxicity (repeat-dose) scored as low.

Diisononyl cyclohexanedicarboxylate (DINCH) (CAS: 166412-78-8, 474919-59-0)

DINCH scored yellow overall in a verified Scivera assessment and this meets our minimum criteria for safer (Scivera, 2021z). The assessment noted data gaps for acute toxicity (inhalation only), respiratory sensitization, and sensory irritation. Our criteria do not require data for acute toxicity for all routes of exposure, and the assessment scores acute toxicity for dermal and oral exposure as green, so this meets our data requirements. A data gap for respiratory sensitization is allowed as skin (dermal) sensitization is scored as green. Sensory irritation does not align to a specific endpoint in our criteria and we do not require data for this endpoint.

DINCH scored Band C in a ChemFORWARD hazard assessment, and this provides additional evidence that it meets our minimum criteria for safer (ChemFORWARD, 2019c). The assessment identified hazard flags for moderate endocrine disruption and skin irritation—these meet our minimum criteria for safer.

Dipropylene glycol dibenzoate (DGD) (CAS: 27138-31-4)

DGD is listed on the SCIL as a full green circle (under emollients, skin conditioning agents). This means it has been evaluated against the SCIL master criteria, which also demonstrates that DGD meets our minimum criteria for safer.

A ChemFORWARD hazard assessment scored DGD Band C, which provides additional evidence it meets our minimum criteria for safer (ChemFORWARD, 2019d). The assessment identified hazard flags for moderate to high acute aquatic toxicity. DGD is classified as GHS Category 2 for developmental toxicity, and this corresponds to a score of moderate in our criteria. These endpoints all meet our minimum criteria for safer. There was a data gap for neurotoxicity (repeat-dose), but neurotoxicity (single-dose) scored as moderate.

DGD scored BM-2 in a GreenScreen® assessment reviewed by TCO Certified. This meets our minimum criteria for safer and data requirements (TCO Certified, 2022).

Acetyltributyl citrate (ATBC) (CAS: 77-90-7)

ATBC scored green/yellow overall in a verified Scivera hazard assessment, and this meets our minimum criteria for safer (Scivera, 2021aa). The assessment noted data gaps for endocrine activity, acute toxicity (inhalation only), respiratory sensitization, and sensory irritation. Data for endocrine activity is not required in our minimum criteria.

Our criteria do not require data for acute toxicity for all routes of exposure, and the assessment scores acute toxicity for dermal and oral exposure as green, so this meets our data requirements. A data gap for respiratory sensitization is allowed as skin (dermal) sensitization is scored as green. Sensory irritation does not align to a specific endpoint in our criteria and we do not require data for this endpoint.

A ChemFORWARD hazard assessment scored ATBC Band B, which provides additional evidence it meets our minimum criteria for safer (ChemFORWARD, 2019e). The assessment identified hazard flags for moderate to high acute aquatic toxicity, which meets our minimum criteria. There was a data gap for neurotoxicity (single-dose), but neurotoxicity (repeat-dose) scored as moderate. There was also a data gap for endocrine disruption, but this endpoint is not required to meet our minimum criteria for safer.

Di-2-ethylhexyl-adipate (DEHA) (CAS: 103-23-1)

DEHA scored yellow overall in a verified Scivera hazard assessment, and this meets our minimum criteria for safer (Scivera, 2021ab). The assessment noted data gaps for respiratory sensitization, aspiration potential, and sensory irritation. The data gap for respiratory sensitization is allowed as skin (dermal) sensitization is scored as green. Sensory irritation and aspiration potential do not align to specific endpoints in our criteria and we do not require data for these endpoints.

A ChemFORWARD hazard assessment scored DEHA Band C, which provides additional evidence it meets our minimum criteria for safer (ChemFORWARD, 2020a). The assessment identified hazard flags for moderate reproductive toxicity, which meets our minimum criteria. There were data gaps identified for carcinogenicity, neurotoxicity (single and repeat-dose), and respiratory sensitization. The data gap for carcinogenicity was due to equivocal findings, but based on classification by the U.S. EPA as a Group C possible carcinogen, this endpoint would score as moderate in our criteria. Our criteria allow the data gaps for neurotoxicity (single and repeat-dose) because systemic (single and repeat-dose) and acute toxicity score as low. They also allow the data gap for respiratory sensitization because skin sensitization scored as low.

Soybean oil, epoxidized (ESBO) (CAS: 8013-07-8)

ESBO scored green/yellow in a verified Scivera assessment, and this meets our minimum criteria for safer (Scivera, 2021ac). The assessment identified data gaps for endocrine activity, neurotoxicity, acute toxicity (inhalation only), respiratory sensitization, and sensory irritation. Data for endocrine activity is not required in our minimum criteria. Our criteria allow the data gap for neurotoxicity as systemic toxicity is scored as green. Our criteria does not require data for acute toxicity for all routes of exposure, and the assessment scores acute toxicity for dermal and oral exposure as green. Sensory irritation does not align to a specific endpoint in our criteria and we do not require data for this endpoint.

A ChemFORWARD hazard assessment scored ESBO Band A, further indicating that it meets our minimum criteria for safer (ChemFORWARD, 2019f). The ChemFORWARD analysis did not identify any hazard flags.

ESBO scored BM-3 in a GreenScreen® assessment reviewed by TCO Certified. This meets our minimum criteria for safer and data requirements (TCO Certified, 2022).

Alternatives are feasible and available

Ortho-phthalates function chemically as plasticizers in vinyl flooring. Plasticizers are used to soften plastics and impart flexibility. When evaluating alternatives, we determined whether safer alternative chemicals can also serve this function, and whether these alternatives are feasible and available. We use modules from the IC2 guide to address the following performance requirements:

- Plasticizers soften plastics and improve pliability of flooring at the **material level**.
- Plasticizers improve flexibility and durability of flooring at the **product level**.

We considered whether the safer alternatives identified are also feasible and available for use as plasticizers to replace the functions ortho-phthalates provide in vinyl flooring products. We concluded alternative plasticizers were feasible and available if they are already utilized in vinyl flooring on the market, as this demonstrates:

- They provide the functions required for performance in these products (e.g., flexibility).
- They are available for use in this application.

The safer alternative plasticizers are available for sale, and several are marketed specifically for use as plasticizers in flooring. Table 44 shows the alternatives we verified are used as plasticizers in vinyl flooring by major manufacturers. Based on chemical properties, current use, and communications with chemical and product manufacturers, the Danish Ministry of the Environment also previously identified several as potential alternative plasticizers (DEPA, 2014).

Table 44. Identified safer alternatives to ortho-phthalates in vinyl flooring.

Alternative plasticizer, associated CAS(s)	Trade name(s)*	Hazard assessment overall score(s)	Marketed for use in flooring?	Identified by authoritative body as a potential alternative?	Current brands* that use it
Di(2-ethylhexyl) terephthalate (DEHT), Dioctyl terephthalate (DOTP) 6422-86-2	Palatinol® DOTP (BASF, 2021a) Eastman 168 (Eastman, 2021b)	GreenScreen® BM-3$_{DG}$ Scivera green/yellow ChemFORWARD Hazard Band A	Yes	Yes (DEPA, 2014)	AHF (Declare, 2021a, 2021b) Altro (Altro Ltd., 2018a, 2018b, 2018c, 2019) Armstrong (Armstrong Flooring Inc., 2021, 2020a, 2020b) Aspecta (Declare, 2019a, 2019b, 2019c) Mannington Mills (Mannington Mills, 2019) Metroflor (Declare, 2018a, 2019d) Milliken (Declare, 2020a) Mohawk (Declare, 2019e) Novalis (Novalis, 2020) Forbo (Declare, 2015a, 2016a, 2016b, 2016c, 2018b) Signature (Declare, 2020b) Tarkett (EPEA, 2021b) Teknoflor (Teknoflor, 2020a, 2020b)
Glycerides, castor-oil mono-, hydrogenated, acetates (COMGHA) 736150-63-3	GRINDSTED® SOFT-N-SAFE (DuPont, 2021)	ChemFORWARD Hazard Band C SCIL Green Circle (*as surfactant)	Yes	Yes (DEPA, 2014)	Tarkett (EPEA, 2021a) Kahrs Upofloor Quartz (Kährs Oy, 2020)

Alternative plasticizer, associated CAS(s)	Trade name(s)*	Hazard assessment overall score(s)	Marketed for use in flooring?	Identified by authoritative body as a potential alternative?	Current brands* that use it
1,2-Cyclohexane dicarboxylic acid, diisononyl ester (DINCH) 166412-78-8, 474919-59-0	Hexamoll® DINCH (BASF, 2021b)	GreenScreen® BM-2 (expired) Scivera yellow ChemFORWARD Hazard Band C	Yes	Yes (DEPA, 2014)	Tarkett (EPEA, 2018, 2021b)
Dipropylene glycol dibenzoate (DGD) 27138-31-4		GreenScreen® BM-2 ChemFORWARD Hazard Band C SCIL Green Circle		Yes (DEPA, 2014)	Forbo (Declare, 2015, 2016b, 2016c)
Acetyltributyl citrate (ATBC) 77-90-7	Citroflex™ A-4 (Vertellus, 2021)	GreenScreen® BM-3 (expired) Scivera green/yellow ChemFORWARD Hazard Band B	No	Yes (DEPA, 2014)	Altro (Altro Ltd., 2018a, 2018b, 2018c, 2019)
Di-2-ethylhexyl-adipate (DEHA) 103-23-1		GreenScreen® BM-2 (expired) Scivera yellow ChemFORWARD Hazard Band C			Altro (Altro Ltd., 2018a, 2018b, 2018c, 2019)
Soybean oil, epoxidized (ESBO) 8013-07-8		GreenScreen® BM-3 Scivera green/yellow ChemFORWARD Hazard Band A			Mannington Mills (Mannington Mills, 2019) Tarkett (EPEA, 2021a)

Note: * = Any reference in this publication to persons, organizations, services, products, or activities does not constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

Conclusion

It appears that DOTP has become the primary alternative plasticizer used to replace DEHP in vinyl flooring. This is demonstrated by its use by many major flooring manufacturers in their products (Table 44). It is also sold commercially by multiple chemical manufacturers and marked for use as a plasticizer in flooring applications. We also found examples of the other safer alternatives identified (COMGHA, DINCH, ATBC, DEHA, and EBSO) in use by flooring manufacturers, albeit to a seemingly lesser extent. Based on these findings, we determined that the safer alternatives identified are both feasible and available for use as plasticizers in vinyl flooring as summarized in Table 45. Restricting the use of ortho-phthalates in vinyl flooring would reduce a significant source of potential exposure for people and the environment.

Table 45. Questions from IC2 Guide for evaluating feasibility and availability of alternative(s).

IC2 Guide feasibility and availability metrics	Determination
Is the alternative used for the same or a similar function?	Yes, the identified chemical alternatives are also used as plasticizers in vinyl flooring.
Is the alternative used in similar products on the commercial market?	Yes, the identified chemical alternatives are in vinyl flooring products available on the market.
Is the alternative marketed in promotional materials for application of interest?	Yes, the identified chemical alternatives are marketed as plasticizers, some for use in flooring.
Is this a favorable alternative based on answers to the above questions?	Yes, the identified chemical alternatives are favorable.

Reducing a significant source or use

In order to restrict or prohibit priority chemicals in priority products, RCW 70A.350.040[138] requires Ecology and Health to determine that either:

- The restriction will reduce a significant source or use of a priority chemical, or
- The restriction is necessary to protect the health of sensitive populations or sensitive species.

We identified vinyl flooring as a significant source or use of ortho-phthalates in our 2020 report to the Legislature.[139] That report became effective at the end of the 2021 legislative session on April 25, 2021. Based on that report, we determined that restricting any of the chemical-product combinations in that report would reduce a significant source or use of a priority chemical class. With this determination, further evaluating whether a restriction would reduce a significant source or use (RCW 70A.350.040(3)(b)(ii)) is not required by statute.

Ortho-phthalates have been used widely in vinyl flooring to confer improved flexibility, softness, and durability. Our report on priority consumer products[140] (Ecology, 2020a), summarized studies of vinyl flooring that estimate the frequency of ortho-phthalate detection

[138] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.040
[139] https://apps.ecology.wa.gov/publications/summarypages/2004019.html
[140] https://apps.ecology.wa.gov/publications/summarypages/2004019.html

and the percent ortho-phthalate by weight in sampled materials. The Resilient Floor Covering Institute (RFCI) estimated that 4.27 billion square feet of vinyl flooring are sold nationally each year. Using Washington's population in proportion to the national population, this translates to about 100 million square feet (approximately 90,000 metric tons) sold annually in the state.

Based on peer-reviewed studies, we found that vinyl flooring can contain ortho-phthalates at 9 – 32% by weight. We estimated that if roughly half of all vinyl flooring sold contained ortho-phthalates, then 10 – 37 million pounds of ortho-phthalates are sold in new vinyl flooring each year in our state, resulting in human exposure and environmental releases (Ecology, 2020a). More recent national sales figures reported in a trade publication for resilient flooring suggests rapid growth—34% increase in square feet—in luxury vinyl tile product sales between 2019 and 2020 (Floor Covering Weekly, 2021). We expect this would be reflected in a positive sales trend in Washington state.

After we published the Report on Priority Consumer Products,[141] manufacturers communicated that ortho-phthalate use in flooring products decreased over the past few years (RFCI, 2020). Using the authority under RCW 70A.350.030,[142] we requested data on current ortho-phthalate use from manufacturers. In data we received from manufacturers to date, the majority no longer use ortho-phthalates and many report using the safer alternative plasticizers identified in this report.

However, we also learned that both DEHP and DINP are still used in a subset of products. While the use of ortho-phthalates in vinyl flooring decreased since our 2020 estimate (Ecology, 2020a), vinyl flooring sales appear to be increasing. Vinyl flooring remains a significant source of potential exposure to ortho-phthalates—particularly for people using and purchasing the vinyl flooring products that contain ortho-phthalates.

People can be exposed to ortho-phthalates that migrate from vinyl flooring and accumulate in house dust and indoor air. Many ortho-phthalates are widely detected in house dust (Mitro et al., 2016). Ortho-phthalates are one of the most abundant classes of semi-volatile chemicals found in dust samples. Numerous studies show that the presence of vinyl flooring results in elevated levels of ortho-phthalates in indoor air and dust samples (Bi et al., 2018; Giovanoulis et al., 2019; Langer et al., 2014; Shu et al., 2019; Xu et al., 2009). Ortho-phthalates found in household air or dust where vinyl flooring is present include DEHP, BBP, DIBP, and DINP.

Ortho-phthalates differ in their physical-chemical properties, but in general, ortho-phthalates can volatilize from vinyl products into air (Bergh et al., 2011). In air, they may be inhaled or adsorbed onto particles, and subsequently incorporated into dust (Eriksson et al., 2020). Mechanical wear of vinyl products further contributes to ortho-phthalates in dust. People can then ingest or inhale dusts with adsorbed ortho-phthalates. Dermal absorption from dusts may also contribute to aggregate and cumulative exposure.

Studies detect ortho-phthalate metabolites in urine from over 90% of Americans (CDC-NHANES, 2021a, 2021b; Wang et al., 2019). This reflects total exposure to ortho-phthalates from

[141] https://apps.ecology.wa.gov/publications/summarypages/2004019.html
[142] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.030

numerous sources. Research finds that vinyl flooring can have a significant impact on personal exposure. People who live, work, or attend school in interiors with vinyl flooring have higher levels of ortho-phthalate metabolites in urine compared people who live, work, or attend school in settings with other flooring. For example, the concentration of BBP metabolites in urine of pregnant women and infants (Carlstedt et al., 2012; Shu et al., 2019) and children (Just et al., 2015) was higher in people living in homes with vinyl floors. Hammel et al. (2019) showed that ortho-phthalate levels in house dust and on hand wipes were higher in the presence of vinyl flooring and were positively correlated with ortho-phthalate metabolites in children's urine. As expected, associations with vinyl flooring at home, school, or work vary across studies because people spend time in many indoor environments.

Infants and children may have higher ortho-phthalate exposure from vinyl flooring. Because they spend more time on the floor and exhibit hand-to-mouth behaviors that result in dust ingestion (EPA, 2011c), infants and small children can be more exposed than adults in the same indoor environment. Very young children may take in more house dust via ingestion than inhalation (Weiss et al., 2018). Data from NHANES indicate generally higher exposure to plasticizers in women and younger children (Nguyen et al., 2019).

Ortho-phthalates can cross the placental barrier and studies detect them in cord blood, amniotic fluid, and breastmilk (Ecology, 2020a). This means infants are exposed during vulnerable periods of development from maternal sources of ortho-phthalates (in addition to the direct exposure to air and dust containing ortho-phthalates).

Ortho-phthalates from vinyl flooring are released into the environment through multiple pathways. Studies routinely detect ortho-phthalates in environmental samples. After products are discarded in municipal waste landfills, ortho-phthalate plasticizers in the vinyl can escape into landfill leachate. Ortho-phthalates are not covalently bound to PVC polymer chains and migrate out over time—although this is variable.

DEHP from vinyl flooring was included in estimates of annual loading to Puget Sound (Ecology, 2011). DEHP loading to Puget Sound from different product uses was estimated to include 220 pounds from vinyl flooring annually. That is an underestimate of the overall impact of ortho-phthalates on the Puget Sound environment, because it did not consider contributions from other ortho-phthalates used in vinyl flooring. Once in the aquatic environment, ortho-phthalates may distribute into sediment and biota. Governor Inslee's Southern Resident Orca Task Force identified ortho-phthalates as chemicals of emerging concern for Puget Sound orcas.

Priority product: Personal care and beauty products

Scope of priority product

Personal care and beauty products that have fragrances. Products regulated by the Food and Drug Administration as drugs, biological products, or medical devices are excluded. Examples of personal care and beauty products include:

- Skincare products and body washes.
- Perfumes, colognes, body mists, and toilet waters.
- Eye and facial makeup.
- Face and body paint.
- Hair care products.
- Deodorants.

Function of priority chemical in priority product

To identify potential safer alternatives, we first determine whether the function(s) provided by the priority chemical is necessary to meet the performance requirements of the priority product at the chemical, material, product, or process level. If the priority chemical does not provide a necessary function, the chemical can be removed and there is no need to identify alternatives.

We determined that the function ortho-phthalates provide is necessary for certain fragrances used in personal care and beauty products to perform. Ortho-phthalates function as solvents at the chemical level, and fixatives in fragrance oils used in personal care and beauty products at the product level. This helps dissolve all the scents and helps hold or “fix” the fragrance ingredients so they evaporate at a slower rate to prolong the desired scent. In some cases, the functions of ortho-phthalates are not needed in these products, such as when alternative fragrance materials (like essential oils) are used. Another example is when alternative ingredients are used to serve other functions, and also have fixative or solvent properties.

DEP is the most commonly reported ortho-phthalate used in fragrances. It is described as an odorless solvent for blending ingredients together (The Fragrance Conservatory, 2021).

Fragrance formulation is complex. The International Fragrance Association reports over 3,000 different ingredients that can be added to fragrances. Each scent requires different ingredients. They are frequently proprietary formulations, and often are not fully disclosed. Further, personal care and beauty products is a broad category. Therefore, our goal was to show that there are many safer alternatives that can be combined and optimized to be feasible and available replacements for all known uses of DEP. We did not identify any personal care or beauty product applications where at least one of these alternatives is not feasible and available.

We identified alternative solvents and fixatives as well as alternative formulations that use carrier oils or isolated aroma chemicals in addition to (or instead of) chemicals specifically added with the main functions of fixatives. We describe these in more detail below.

Alternatives are safer, feasible, and available

Alternatives are safer

The only ortho-phthalate we found detected in fragrances at concentrations above 100 ppm is DEP (Ecology, 2020a). However, EPA's CompTox chemical dashboard predicts that DMP, DEHP, DCHP, DHP, and BBP could have functional use in fragrance (EPA, 2021d). DEP meets our minimum criteria for safer, but the moderate score for developmental toxicity means it does not meet our additional criteria for safer (see hazards of ortho-phthalates).

With this in mind, chemical alternatives used to replace ortho-phthalates as either fixatives, solvents, or both in fragrances used in personal care and beauty products will need to meet our additional criteria to be considered safer alternatives.

A 2018 report by Northwest Green Chemistry identified alternatives to ortho-phthalates in fragrances (Northwest Green Chemistry, 2018). This report identified dipropylene glycol, triethyl citrate, triacetin, isopropyl myristate, benzyl alcohol, and benzyl benzoate as potential safer alternatives. To follow-up on this report, we funded the ChemFORWARD profile on alternatives to ortho-phthalates in fragrances (ChemFORWARD, 2020b). ChemFORWARD assessments are verified, third-party reviewed hazard assessments that—depending on the score—can meet both our minimum and additional criteria for safer (see Appendix E, safer certifications).

We also utilize EPA's SCIL to identify alternatives. Chemicals that meet the SCIL master criteria also meet our additional criteria for safer. The SCIL categorizes chemicals by function, and some categories are assessed only against specific functional criteria rather than the SCIL master criteria. Some of the SCIL functional criteria meet our additional criteria, and others do not (see Appendix E, safer certifications). Relevant functional criteria for this product category that meet our additional criteria include functional criteria for low priority chemicals and processing aids and additives. The functional criteria for solvents, fragrances, and for preservatives and additives do not necessarily meet our additional criteria, and so we need more information (discussed for specific alternatives below).

The hazard assessments for alternative solvents and fixatives that meet our additional criteria for safer are described below. These include alternative chemicals that serve as safer fixatives and solvents. We also identified alternative formulations that leverage carrier oils and isolated aroma chemicals to serve other functions, but also have fixative or solvent properties.

Alternative fixatives and solvents

Dipropylene glycol (DPG) (CAS: 25265-71-8)

U.S. EPA evaluated DPG as a low priority chemical, indicating that it meets the SCIL master criteria and our additional criteria for safer (EPA, 2020). DPG is listed on SCIL as a green full circle (EPA, 2021b). A publicly available, third-party reviewed ChemFORWARD hazard assessment scored DPG as Band A, further indicating that it meets our additional criteria for safer (ChemFORWARD, 2020c). The ChemFORWARD analysis did not identify any hazard flags.

DPG has a data gap for endocrine disruption. In our criteria, a chemical only scores high for endocrine disruption if there is evidence that endocrine disruption is the mechanism of action for another hazard endpoint which scores high. That means that, for example, if systemic toxicity scored high because of thyroid toxicity that was linked to endocrine disruption, then both systemic toxicity and endocrine disruption would score high. Because all other endpoints for DPG are low, it is unlikely that endocrine disruption could score high. Therefore, we conclude that DPG meets our additional criteria for safer.

Isopropyl myristate (IPM) (CAS: 110-27-0)

Isopropyl myristate is in ChemFORWARD Band C (ChemFORWARD, 2020d), a GreenScreen® BM-2 chemical (Toxservices, 2020f), and a green half-circle on SCIL (EPA, 2021b). It has been evaluated against the Safer Choice solvent criteria. The publicly available and third-party reviewed ChemFORWARD assessment shows isopropyl myristate scores yellow for developmental toxicity. The GreenScreen® assessment scores isopropyl myristate as moderate for developmental toxicity. Both these scores are described in the assessments but are based on reduced pup weight gain that occurred at 6.25% of the material diet. This corresponds to an estimated LOAEL of 6,000 mg/kg/day, which exceeds the guidance values for reproductive and developmental toxicity described in our criteria for safer and adopted from the SCIL master criteria. Chemicals with reproductive or developmental toxicity at doses above 250 mg/kg/day can still pass the SCIL criteria and meet our additional criteria for safer since this corresponds to a score of low in our criteria. Since 6,000 mg/kg/day is higher than 250 mg/kg/day, we conclude that the developmental toxicity would pass our additional criteria. It is important to note that dermal exposure to isopropyl myristate at lower doses also did not induce developmental effects, further supporting this rationale.

Isopropyl myristate has a data gap for endocrine disruption. However, isopropyl myristate was only active in one out of 136 ToxCast assays for endocrine activity. In order to score high for endocrine disruption and not meet our additional criteria for safer, isopropyl myristate would have to show that another endpoint scored high because of an endocrine related mechanism. Because no other endpoints score red, it would be unlikely that endocrine disruption would score high. A score of moderate would still meet our additional criteria for safer. All other endpoints meet our additional criteria for safer. Therefore, we conclude that isopropyl myristate meets our additional criteria for safer.

Benzyl alcohol (CAS: 100-51-6)

Benzyl alcohol is listed as a yellow triangle on SCIL (evaluated against the preservatives and antioxidants criteria) (EPA, 2021b). Yellow triangles indicate that a chemical is best in class, but still has some hazard concerns. A publicly available, third-party reviewed ChemFORWARD assessment determined it was Band C (ChemFORWARD, 2020e). In general, Band C chemicals do not meet our additional criteria for safer. Benzyl alcohol scores green for most endpoints (including endocrine disruption), and yellow for systemic toxicity, sensitization, and irritation, which all meet our additional criteria for safer.

However, benzyl alcohol received a score of red for neurotoxicity, which places it in Band C and means it does not meet our additional criteria for safer. In scenarios where we have an alternative and priority chemical that both meet our minimum criteria for safer but do not meet our additional criteria for safer, we consider whether exposure routes might help us determine which hazards are most relevant for the application of interest. (Find more on this approach in our criteria for safer.)

Neurotoxicity scored red because of an association with gasping syndrome when benzyl alcohol was used as a preservative in the intravenous fluid of preterm infants. Oral, dermal, and inhalation exposures, meanwhile, scored low based on animal studies. For use in personal care and beauty products, oral, dermal, and inhalation exposure routes are more relevant than injection. We do not expect any of the personal care and beauty products under evaluation to be injected under normal use. If we base the neurotoxicity score on the more relevant potential exposure routes (oral, dermal, and inhalation), benzyl alcohol would score low. With a score of low for neurotoxicity, benzyl alcohol meets our additional criteria and is safer than ortho-phthalates for use in personal care and beauty products.

Under ECHA Annex III, benzyl alcohol, when used in fragrance compositions, is required to be listed on ingredients of cosmetic products when used at concentrations greater than 0.001% in leave-on and 0.01% in rinse off cosmetic products (ECHA, 2021d).

Triacetin (CAS: 102-76-1)

A publicly available, third-party reviewed ChemFORWARD hazard assessment of triacetin scored it as Band A, indicating that it meets our additional criteria for safer (ChemFORWARD, 2020f). The ChemFORWARD analysis did not identify any hazard flags. Triacetin has a data gap for endocrine disruption. However, the weight of evidence suggest that triacetin is not an endocrine disruptor. ToxCast data did not identify any *in vitro* activity for androgen, estrogen, or thyroid pathways, and there was no evidence of endocrine disruption based on pathological data from reproductive or repeat dose toxicity studies.

In our criteria, a chemical only scores high for endocrine disruption if there is evidence that endocrine disruption is the mechanism of action for another hazard endpoint which scores high. That means that if systemic toxicity scored high because of thyroid toxicity that was linked to endocrine disruption, then both systemic toxicity and endocrine disruption would score high. Because all other endpoints for triacetin are low, it is unlikely that endocrine disruption could score high. Therefore, we conclude that triacetin meets our additional criteria for safer.

Benzyl benzoate (CAS: 120-51-4)

We confirmed benzyl benzoate meets our additional criteria for safer using an unredacted, verified Scivera assessment. Benzyl benzoate scored green/yellow overall, indicating it meets our additional criteria for safer (Scivera, 2021ah). The assessment noted a data-gap for endocrine disruption. ToxCast data indicated that benzyl benzoate was positive in four of 18 estrogen receptor assays and one of 14 androgen receptor assays, suggesting the potential for endocrine activity. However, benzyl benzoate scores as green (low) for both reproductive and developmental toxicity, as well as systemic toxicity (repeat-dose). Acute toxicity scored green (low) for both dermal and inhalation exposures and yellow (moderate) for the oral exposure route. Dermal sensitization scored as yellow (moderate).

In our criteria, a chemical only scores as high for endocrine disruption if there is evidence that endocrine disruption is the mechanism of action for another hazard endpoint that scores as high. That means that if reproductive toxicity scored high because of effects plausibly related to endocrine activity, then both reproductive toxicity and endocrine disruption would score high. Since all other human health endpoints for benzyl benzoate scored low or moderate, it is unlikely that endocrine disruption could score high. Therefore, we conclude that benzyl benzoate meets our additional criteria for safer. We describe how Scivera assessments can meet our criteria for safer in Appendix E, on safer certifications.

ECHA Annex III requires benzyl benzoate (if used in fragrance compositions) to be listed on ingredients of cosmetic products when used at concentrations greater than 0.001% in leave-on and 0.01% in rinse-off cosmetic products (ECHA, 2021d).

Additional alternatives

Castor oil (CAS: 8001-79-4)

Castor oil is listed on SCIL as a green full circle (evaluated against the solvent criteria) (EPA, 2021b). The solvent criteria considers a number of relevant hazard endpoints, but does not address all endpoints required by our criteria for safer. The SCIL solvent criteria considers carcinogenicity, neurotoxicity, acute toxicity, reproductive and developmental toxicity, repeat dose toxicity, persistence, bioaccumulation, and aquatic toxicity (EPA, 2009b). We used an unredacted, verified Scivera assessment to confirm the remaining hazard endpoints (mutagenicity and sensitization) met our additional criteria for safer. Castor oil scored yellow/green in a Scivera assessment, and meets our additional criteria for safer (Scivera, 2021ad). We describe how Scivera assessments can meet our criteria for safer in Appendix E, on safer certifications.

Grapeseed oil (CAS: 85594-37-2)

Grapeseed oil is listed on SCIL as a green full circle (evaluated against the master criteria) (EPA, 2021b). Chemicals evaluated against the SCIL master criteria meet our additional criteria for safer (see Appendix E, safer certifications).

Sweet almond oil (CAS: 8007-69-0)

Sweet almond oil is listed on SCIL as a green full circle (evaluated against the master criteria) (EPA, 2021b). Chemicals evaluated against the SCIL master criteria meet our additional criteria for safer (see Appendix E, safer certifications).

Coconut oil (CAS: 8001-31-8)

Coconut oil scored green/yellow overall in a verified Scivera assessment, and this meets our additional criteria for safer (Scivera, 2021ai). The assessment lists a data gap for endocrine activity, but other related human health endpoints—including reproductive, developmental, and systemic toxicity—scored as low, so it is unlikely endocrine disruption could score as high. Based on this information, coconut oil meets our additional criteria for safer. We describe how Scivera assessments can meet our criteria for safer in Appendix E, on safer certifications.

Coconut oil is listed on SCIL as a green full circle (evaluated against the processing aids and additives criteria) (EPA, 2021b). Chemicals listed on SCIL as processing aids and additives have been evaluated by EPA and identified as low concern. These chemicals are considered generic ingredients and have long-standing safe use, making them a low hazard concern (EPA, 2013).

Jojoba oil (CAS: 61789-91-1)

Jojoba oil is listed on SCIL as a green half-circle (evaluated against the master criteria) (EPA, 2021b). Chemicals evaluated against SCIL master criteria meet our additional criteria for safer (see Appendix E, safer certifications).

Vanillin (CAS: 121-33-5)

We confirmed that vanillin meets our additional criteria using an unredacted, verified Scivera assessment. Vanillin is green in Scivera, indicating that it meets our additional criteria for safer (Scivera, 2021ae) (see Appendix E, safer certifications).

Vanillin is also listed on SCIL as a green full circle (evaluated against the fragrance criteria) (EPA, 2021b). Chemicals evaluated against the SCIL fragrance criteria cannot be known carcinogens, mutagens, or reproductive toxicants. They also cannot be known persistent, bioaccumulative, and toxic chemicals (EPA, 2015d).

Ethyl vanillin (CAS: 121-32-4)

We confirmed that ethyl vanillin meets our additional criteria using an unredacted, verified Scivera assessment. Ethyl vanillin is yellow/green in Scivera, indicating that it meets our additional criteria for safer (Scivera, 2021af) (see Appendix E, safer certifications).

Ethyl vanillin is also listed on SCIL as a green half circle (evaluated against the fragrance criteria) (EPA, 2021b). Chemicals evaluated against the SCIL fragrance criteria cannot be known carcinogens, mutagens, or reproductive toxicants. They also cannot be known persistent, bioaccumulative, and toxic chemicals (EPA, 2015d).

Alternatives are feasible and available

Ortho-phthalates function as solvents and fixatives in fragrance oils used in personal care and beauty products. Solvents help dissolve all the scents and fixatives help hold or “fix” the fragrance ingredients so they evaporate at a slower rate. An ingredient with a low volatility in a personal care or beauty product can help fix the volatile scents in a fragrance. When evaluating alternatives, we determined whether safer alternative chemicals can also serve either or both of these functions and whether these alternatives are feasible and available based on our criteria.

We identified several alternatives that meet our additional criteria for safer, are marketed for use in fragrances, and are widely used in personal care and beauty products (Table 46) (Eastman Chemical Company, 2021a; Lyondell Bassell, 2021; Panten & Surburg, 2016; Perfumer’s World, 2021a). We also identified several chemicals that can be used instead of (or in addition to) the alternative solvents and fixatives in Table 47. In these alternative formulations, carrier oils and isolated aroma chemicals can help fix the fragrance—either without additional chemicals with the sole function of fixative, or in addition to safer fixatives (Table 47).

To determine whether alternatives were used in personal care and beauty products for the application of interest, we used a two-pronged approach. First, we looked for manufacturers selling the alternatives and marketing them for use in personal care and beauty products. Second, we confirmed manufacturers use the alternatives in personal care and beauty products by searching the Environmental Working Group's Skindeep® Database.

Environmental Working Group obtains information on products from online retailers, manufacturers, and product packaging and puts the information in a publicly available database. We did not use the Environmental Working Group's hazard information. We only used the ingredient information to determine whether and in what kind of products alternatives were used.

We recognize fragrances and personal care products are unique. The options provided in Tables 46 and 47 are often used in combination to optimize the needs for the particular application. The lack of transparency around fragrance ingredients makes identifying the function of chemicals in products complicated. Therefore, in addition to demonstrating use of the alternative in the product, we also demonstrate that the alternative is marketed for use in a personal care or beauty product of interest. The lists provided are non-exhaustive and should be thought of as examples that demonstrate safer, feasible, and available alternatives are widely used in personal care and beauty products.

Alternative fixatives and solvents

Table 46. A list of alternatives that can be used as fixatives or solvents for fragrances in personal care and beauty products.

Alternative	CAS	Relevant potential functions	Marketed for use in fragrance	Identified in a range of personal care and beauty products
Dipropylene glycol	25265-71-8	Solvent and fixative	Yes	Yes
Isopropyl myristate	110-27-0	Solvent and fixative	Yes	Yes
Triacetin	102-76-1	Solvent and fixative	Yes	Yes
Benzyl alcohol	100-51-6	Solvent and fixative	Yes	Yes
Benzyl benzoate	120-51-4	Solvent and fixative	Yes	Yes

Dipropylene glycol (CAS: 25265-71-8)

Dipropylene glycol (DPG) is marketed as being a carrier for fragrances and deodorants. It exhibits good cosolvency with water, oils, and hydrocarbons, is colorless, has low volatility, and has low or no odor. Multiple chemical manufacturers sell DPG commercially and market it for use as a solvent in fragrance applications. A few examples of manufactures of DPG are Dow, Lyondell Bassell, and Shell Chemicals, which all market DPG for use in fragrances in personal care and beauty products. Dow lists multiple examples of uses of DGP in fragrances and cosmetics, including (Dow, 2021):

- Perfumes and colognes.
- Skincare (cream, lotions, and sun-care products).
- Deodorants and antiperspirants (roll on, stick deodorants).
- Hair care (shampoos, conditioners, styling, coloring products).
- Shaving products (creams, foams, gels, after-shave lotions).
- Bath and shower products.

Lyondell Bassell markets DPG as a carrier for fragrances and deodorant applications (Lyondell Bassell, 2021). Shell Chemicals lists “solvent in fragrances and cosmetics” as an application of DPG (Shell Chemicals, 2019). Perfumers World specifically lists DPG as a recommended replacement for DEP (Perfume’s World, 2021b). It is not recommended for use in fragrances intended for cold processed soaps or massage oils.

It appears DPG has become a dominant alternative used to replace DEP in fragrances in personal care and beauty products. This is demonstrated by its widespread use in these products. A review of the Environmental Working Group Database SkinDeep® identified in over 60 different sub-categories of products and over 1,500 product lines that disclosed DPG (Environmental Working Group, 2021a).

A second investigation, conducted between January and June 2021, found that of these products, over 40 different sub-categories of personal care and beauty products and over 200 product lines contained DPG and did not list DEP or “fragrance” as an ingredient. The 44 different kinds of products included products with known uses of DEP—such as body wash, shampoo, haircare products, fragrance, and body spray. This helps confirm DPG was not used in addition to DEP.

Benzyl alcohol (CAS: 110-27-0)

Benzyl alcohol is marketed as a solvent, fixative, coalescent, and preservative for use in fragrances in personal care and beauty products. It is a clear oily liquid that is soluble in water and alcohols. It also contributes to the scent of the product by offering a mild, nearly neutral odor, which can add a desired note for some, but not all, fragrances. Multiple chemical manufacturers sell benzyl alcohol commercially and market it for use in fragrance applications. A few examples of manufactures of benzyl alcohol are:

- Symrise (Special Chem, 2021a; Symrise, n.d.).
- Merck KGaA (Merck KgaA, 2021; Special Chem, 2021b).
- Lanxess (Kalama Chemical, 2020; Lanxess, 2021).
- Zheng Zhou Meiya Chemical Products (Zheng Zhou, n.d.).

Kalama® specifically advertises the fixative and solvent functions of benzyl alcohol for fragrances (Kalama Chemical, 2020). Zheng Zhou Meiya Chemical Products markets benzyl alcohol for a broad spectrum of product applications, including “soap, perfume, fragrance, and flavor as well as food additive” (Zheng Zhou, n.d.). Perfumers World specifically lists benzyl alcohol as a recommended replacement for DEP (Perfumer’s World, 2021b).

Benzyl alcohol is commonly used in personal care and beauty products. A review of the Environmental Working Group Database SkinDeep® identified benzyl alcohol was disclosed in over 80 different sub-categories of personal care and beauty products and over 4,500 product lines (Environmental Working Group, 2021b). The wide range of products containing benzyl alcohol included product types known to use DEP—such as fragrances, haircare products, body washes, moisturizers, and makeup.

Isopropyl myristate (CAS: 110-27-0)

Isopropyl myristate is marketed for use as a solvent for fragrances and as an emollient (skin softener) in personal care and beauty product applications. It is colorless, has low volatility, and has low to no odor. Multiple chemical manufacturers sell isopropyl myristate commercially and market it for use in personal care and beauty products. Two examples of isopropyl myristate manufacturers are BASF and Vigon.

Vigon recommends isopropyl myristate for use as a solvent, carrier, or diluent for flavor or fragrance agents (Vigon, 2020). BASF markets isopropyl myristate for use as a "fast speeding emollient suitable for all cosmetic applications" (BASF, 2021c). Both market isopropyl myristate for use in fragrances in personal care and beauty products. Perfumer's World specifically lists isopropyl myristate as a recommended replacement for DEP (Perfumer's World, 2021b).

Isopropyl myristate is widely used in personal care and beauty products. A review of the Environmental Working Group Database SkinDeep® identified isopropyl myristate as an ingredient in 75 different sub-categories of products and over 1,000 different product lines (Environmental Working Group, 2021c). The 75 different sub-categories of products include makeup, haircare products, soaps and washes, moisturizers, and fragrances. Because isopropyl myristate can serve as both an emollient and solvent, we do not know whether isopropyl myristate was serving the function of a solvent in all these applications. However, we confirmed that the Henry Rose fragrance "Windows Down" uses isopropyl myristate as a solvent (Henry Rose, n.d.). This is because Henry Rose provides a high degree of transparency that lists all ingredients and their function.

Triacetin (CAS: 102-76-1)

Triacetin has been identified as an alternative to ortho-phthalates in personal care and beauty products (Northwest Green Chemistry, 2018). It is colorless, has low volatility, and has a fatty odor which would not be compatible with some fragrances. It is marketed as a carrier for flavor and essence concentrates, and as a solvent and plasticizer in cosmetic formulations (Lanxess, 2020b). Examples of manufacturers marketing triacetin for fragrances include Eastman, Lanxess, and Vigon. Eastman recommends triacetin as a "solvent and fixative for many flavors and fragrances" (Eastman Chemical Company, 2021a). Lanxess markets triacetin for the manufacturing of cosmetics and fragrances (Lanxess, n.d.). Vigon's recommended uses include as a fragrance ingredient (Vigon, 2021).

Triacetin is widely used in personal care and beauty products. A review of the Environmental Working Group SkinDeep® Database identified triacetin was disclosed in 20 different sub-categories of products and over 90 different product lines (Environmental Working Group, 2021d). The 20 different sub-categories of products include lip balms, lip sticks, deodorants, serums, essences, and moisturizers. We did not identify any fragrances that use triacetin.

Benzyl benzoate (CAS: 120-51-4)

Benzyl benzoate is marketed as a solvent, fixative, and fragrance ingredient for use in personal care and beauty products. It is a clear, colorless liquid that is soluble in alcohols, oils, and other organic solvents, but not water. It is marketed as nearly odorless in some materials but others state that it can contribute to the scent of the product by offering a mild, floral or balsamic odor. Multiple chemical manufacturers sell benzyl benzoate commercially, and market it for use in fragrance applications. Examples of benzyl benzoate manufacturers include:

- Symrise (SpecialChem, n.d.a; Symrise, 2020.
- Lanxess (Kalama Chemical, 2020; Lanxess, n.d.a).
- Chemceed (SpecialChem, n.d.b; Chemceed, 2015)

Lanxess specifically advertises the fixative and solvent functions of benzyl benzoate for fragrance blends and artificial musks (Kalama Chemical, 2020; Lanxess, n.d.b.).

An example of a fragrance oil that contains 80% benzyl benzoate is one manufactured by Bramble Berry (Bramble Berry, 2019; Bramble Berry, n.d.). This product is recommended for cold process soaps, melt and pour, bath bombs, and candles.

Benzyl benzoate is used in personal care and beauty products. In reviewing the Environmental Working Group Database SkinDeep®, we identified benzyl benzoate disclosed in over 70 different sub-categories of personal care and beauty products and over 1,700 product lines (Environmental Working Group, 2021x). The wide range of products containing benzyl benzoate included product types known to use DEP—such as fragrances, shampoo, haircare products, bar soap, and other products.

Alternatives with fixative properties

In some cases, an alternative fixative or solvent may either not be necessary or may have additional ingredients that support the fixative function. Table 47 shows a non-exhaustive list of safer, feasible, and available alternatives that can be used instead of (or in addition to) the alternatives listed in Table 46. Carrier oils and aromatic compounds are added in a product for functions such as moisturizer or fragrance, respectively. They can also help fix the fragrances in personal care and beauty products. In some cases, they may be used to optimize the fragrance for the specific scent or application of interest.

Table 47. Alternative carrier oils and isolated aroma chemicals that can be used in addition to or instead of the alternatives in Table 46.

Alternative	CAS	Main function	Odor
Castor oil	8001-79-4	Carrier oil	Odorless to very light scent
Grape seed oil	85594-37-2	Carrier oil	Odorless
Sweet almond oil	8007-69-0	Carrier oil	Mild nutty aroma
Coconut oil	8001-31-8	Carrier oil	Light coconut aroma

Alternative	CAS	Main function	Odor
Jojoba oil	61789-91-1	Carrier oil	Essentially odorless
Vanillin	121-33-5	Isolated aroma chemical	Sweet, vanilla
Ethyl vanillin	121-32-4	Isolated aroma chemical	Sweet, vanilla

Carrier oils

Carrier oils can be used instead of (or in addition to) the alternatives listed in Table 46. They are often added for their moisturizing properties, but can also serve a solvent function and help prevent essential oils from evaporating too quickly (Mountain Rose Herbs, 2021; New Direction Aromatics, 2021). Carrier oils with high boiling points support fragrance stabilization. Some examples of carrier oils with high boiling points that meet our additional criteria for safer are listed in Table 47. Many manufacturers sell the carrier oils listed in Table 47 and market them for use in personal care and beauty products. Some examples are The Bulk Apothecary (The Bulk Apothecary, 2021a, 2021b, 2021c, 2021d, 2021e), Wellington Fragrance Company (Wellington Fragrance Company, 2020a, 2020b, 2020c, 2020d, 2020e) and Vinevida (Vinevida, 2021a, 2021b, 2021c, 2021d, 2021e).

Carrier oils are feasible and available for many applications. Some examples include carrier oils used in hand soaps, lotions, body washes, and shower gels (Essential Oils®, 2021; Everyone®, 2021), deodorants (Essential Oils®, 2021; Schmidt’s, 2021; Smart Label, 2021), body and bath oils (Essential Oils®, 2021; Kari Gran Skin Care, 2021), hair care products (Amazon, 2021h; Isabella’s Clearly, 2021; Shea Moisture, 2021).

Further, a review of the Environmental Working Group Database SkinDeep® identified castor oil, coconut oil, jojoba oil, grapeseed oil, and almond oil disclosed in a broad range of personal care and beauty products and thousands of product lines (Table 48) (Environmental Working Group, 2021a, 2021b, 2021c, 2021d, 2021e, 2021f, 2021g, 2021h, 2021i). These alternatives were found in known applications of DEP—including fragrances, body washes, shampoos, conditioners, and haircare products.

Table 48. A review of the Environmental Working Group SkinDeep® database conducted in September 2021 identified carrier oils in a wide range of different products and multiple product lines.

Carrier oil	Number of products	Number of product lines
Castor oil	76	Over 3300
Coconut oil	90	Over 6900
Jojoba oil	86	Over 5600
Grapeseed oil	71	Over 1400
Sweet almond oil	81	Over 2000

Isolated aroma chemicals

Isolated aroma chemicals, such as vanillin and ethyl vanillin, are primarily added for their desired odor. However, due to their high boiling point, they also have properties that can contribute to fixing the fragrance. Isolated aroma chemicals can be used instead of (or in addition to) the alternatives described in Tables 46 and 47 for a fixative function. Because vanillin and ethyl vanillin have sweet scents, they are not feasible for every kind of fragrance. However, they are safer alternatives that are available and feasible for a fixative function for certain fragrances.

Manufacturers market vanillin and ethyl vanillin for sale in personal care and beauty products. Examples of suppliers marketing aroma chemicals for use in fragrances and personal care and beauty products include GC Chemicals, Solvay, and The Bulk Apothecary (GC Chemicals, 2021; Solvay, 2021; The Bulk Apothecary, 2021f). Vanillin and ethyl vanillin are widely used in personal care and beauty products. A review of the Environmental Working Group Database SkinDeep® identified vanillin and ethyl vanillin as disclosed ingredients in 47 and 18 different products, respectively, and over 600 and 200 different product lines, respectively (Environmental Working Group, 2021j, 2021k). These alternatives were found in known applications of DEP—including fragrances, body washes, shampoos, conditioners, and haircare products.

Conclusion

Based on these findings, we determined that the safer alternatives we identified are both feasible and available for use as solvents and fixatives in fragrances in personal care and beauty products (Tables 46 and 47). Table 49 summarizes our responses to the guiding questions from the IC2 Guide (Interstate Chemical Clearing House, 2017) and adopted into our criteria for feasible and available. Restricting the use of ortho-phthalates in fragrances in personal care and beauty products will reduce a significant source of exposure, and help us begin to address disproportionate exposures.

Table 49. Questions from IC2 Guide for evaluating feasibility and availability of alternative(s).

IC2 Guide feasibility and availability metrics	Determination
Is the alternative used for the same or a similar function?	Yes, the identified chemical alternatives are used for the same function as DEP. Both DEP and the chemical alternatives are used as solvents and fixatives in fragrances. Yes, the identified alternative ingredients can serve additional functions, including as solvents and fixatives, and can be used to replace or supplement other solvents and/or fixatives.
Is the alternative used in similar products on the commercial market?	Yes, the identified chemical alternatives are widely used in fragrances in personal care and beauty products available on the market.
Is the alternative marketed in promotional materials for application of interest?	Yes, the identified chemical alternatives are marketed as solvents and fixatives for use in personal care and beauty products.
Is this a favorable alternative based on answers to the above questions?	Yes, the identified chemical alternatives are favorable.

Reducing a significant source or use

In order to restrict or prohibit priority chemicals in priority products, RCW 70A.350.040[143] requires Ecology Health to determine that either:

- The restriction will reduce a significant source or use of a priority chemical, or
- The restriction is necessary to protect the health of sensitive populations or sensitive species.

We identified personal care and beauty products as a significant source or use of ortho-phthalates, particularly DEP, in our 2020 report to the Legislature.[144] That report became effective at the end of the 2021 legislative session on April 25, 2021. Based on that report, we determined that restricting any of the chemical-product combinations in that report would reduce a significant source or use of a priority chemical class. With this determination, further evaluating whether a restriction would reduce a significant source or use (RCW 70A.350.040(3)(b)(ii)) is not required by statute.

DEP is used in a variety of cosmetic and personal care products and can be present at particularly high (up to 44,000 ppm) concentrations in fragrances for personal use, such as perfumes and colognes (Ecology, 2020a). As summarized in our report on priority consumer products, several peer-reviewed studies that sampled fragrances and other personal care products reported frequent detection of DEP (Ecology, 2020a).

We received some input from stakeholders that ortho-phthalate use in fragrances is declining. These comments are supported by work by FDA, which detected DEP in almost half (11 out of 25) of the fragrances sampled in 2010 (FDA, 2013). However, DEP use may vary by product type. A 2018 analysis of black haircare products found DEP in 14 out of 18 products tested (Helm et al., 2018). This suggests DEP use in personal care and beauty products may be contributing to disproportionate exposures.

The DEP used in personal care products results in widespread human exposure. Nearly 100% of the sampled U.S. population has detectable levels of MEP, the primary metabolic product of DEP, in urine (CDC-NHANES, 2021b). MEP is the ortho-phthalate metabolite detected at greatest concentration in human urine, often an order of magnitude higher than other ortho-phthalate by-products and greater than 70% of total measured ortho-phthalate exposure (CDC-NHANES, 2021b; Wang et al., 2019). Personal care product use has been clearly linked to urinary excretion of MEP in numerous studies (Buckley et al., 2012; Parlett et al., 2013; Philippat et al., 2015)—including those we mention below, looking at disproportionate exposures. Intervention studies provide especially strong evidence of association between a suspected source and biological exposure. An intervention study that provided ortho-phthalate-free personal care products to Hispanic teenage girls reduced MEP in urine by 24% (Harley et al., 2016).

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[143] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.040
[144] https://apps.ecology.wa.gov/publications/summarypages/2004019.html

People may have disproportionate exposure to DEP based on race, gender, income, and occupation. For example, some studies found that Black women, as a group, used more hair and intimate care products (Branch et al., 2015; Dodson et al., 2021) on average than are used by other racial groups in the U.S. Higher use of products that may contain ortho-phthalates is likely contributing to disparities in ortho-phthalate exposure. Among ortho-phthalates, MEP shows the highest gender and racial disparities in the CDC data, indicating significantly higher exposure to DEP in women than men, and black Americans compared to white (CDC-NHANES, 2019). Several peer-reviewed studies assessed disparities in exposure to chemicals present in personal care products including ortho-phthalates and DEP. Among women, studies that focused on demographic predictors of DEP exposure have routinely reported that non-Hispanic Black, immigrant, and less educated women have significantly higher concentrations of MEP in urine (Bloom et al., 2019; Chan et al., 2021; Hoffman et al., 2018; James-Todd et al., 2017; Mitro, 2019; Nguyen et al., 2020; Polinski et al., 2018; Wenzel et al., 2018). Findings of elevated urinary MEP in non-Hispanic Black women are consistent with a report of high frequency of ortho-phthalate use in hair products marketed to this population (Helm et al., 2018).

In addition to race and gender, income and occupation can also contribute to disproportionate exposure. A survey of low-income women in Washington state found significantly higher concentrations of MEP in urine when compared to a representative sample of the general Washington population. These studies were conducted in different years, but the trend for DEP nationally would predict a lower average concentration in the 2014 samples than the 2010 – 11 study. The opposite was observed: the low-income population had higher MEP concentrations (Health, in prep.). Self-report of perfume use in the previous 24 hours was a significant predictor of MEP in this study. Workers with high exposure to personal care and beauty products can have disproportionate exposure to DEP. As an example, a study of saleswomen with exposure to fragrances from personal care and beauty products at work reported elevated DEP in air samples, and urinary MEP concentrations (Huang et al., 2018).

Ortho-phthalates in personal care and beauty products can also be released into the environment and expose wildlife. Based on the Puget Sound Toxics Loading Study (Ecology, 2011), we estimate that 17 tons of ortho-phthalates are released from fragrances in personal care products into Washington’s environment each year and that fragrances (including fragrances in personal care products) contributed more than 30% of the ortho-phthalates released annually into Puget Sound.

As outlined in our report on priority consumer products, use of ortho-phthalates in personal care and beauty products is significant, and these products represent a significant source of DEP exposure to humans and the environment. There are significant gender, race, and economic disparities in exposure to DEP. Restricting the use of ortho-phthalates in personal care and beauty products will reduce a significant source of ortho-phthalate exposure, and help address inequities in the burden of exposure among different populations.

Appendix A. Acronyms

Table 50. Acronyms with definition and CAS number (if applicable). This list of CAS numbers is not a comprehensive list of chemicals we are considering for potential regulation.

Acronym	Definition	Chemical Abstracts Service (CAS) number
$\mu g/cm^3$	Micrograms per centimeter cubed	N/A
$\mu g/cm^2$	Micrograms per centimeter squared	N/A
µg/g	Micrograms per gram	N/A
µg/kg	Micrograms per kilogram	N/A
µg/L	Micrograms per liter	N/A
$\mu g/m^2$	Micrograms per meter squared	N/A
2,4,6-TBP	2,4,6-Tribromophenol	118-79-6
AB	Assembly Bill	N/A
ABS	Acrylonitrile butadiene styrene polymers	N/A
ADA	Americans with Disabilities Act	N/A
AHR	Aryl hydrocarbon receptor	N/A
ANSI	American National Standards Institute	N/A
AP/APE	Alkylphenol/alkylphenol ethoxylate	N/A
ASA	Acrylic-styrene-acrylonitrile	N/A
ASTM	American Society for Testing and Materials	N/A
ATBC	Acetyltributyl citrate	77-90-7
ATSDR	Agency for Toxic Substances and Disease Registry	N/A
AU	Australia	N/A
BADGE	Bisphenol A diglycidyl ether	Multiple
BAF	Bioaccumulation Factor	N/A
BBP	Benzyl butyl phthalate	85-68-7
BCF	Bioconcentration Factor	N/A
BDE	Brominated diphenyl ether	N/A
BDP	Bisphenol A bis(diphenyl phosphate)	181028-79-5 and 5945-33-5
BM	Benchmark	N/A
BOD	Biochemical Oxygen Demand	N/A
BPA	Bisphenol A	80-05-7
BPAF	Bisphenol AF	1478-61-1
BPAP	Bisphenol AP	1571-75-1
BPB	Bisphenol B	77-40-7
BPC	Bisphenol C	79-97-0
BPF	Bisphenol F	620-92-8
BPP	Bisphenol P	2167-51-3
BPS	Bisphenol S	80-09-1

Acronym	Definition	Chemical Abstracts Service (CAS) number
BPZ	Bisphenol Z	843-55-0
BTBPE	1,2-Bis(2,4,6-tribromophenoxy)ethane	37853-59-1
C2CC®	Cradle to Cradle Certified®	N/A
CA	California	N/A
CAP	Chemical Action Plan	N/A
CAS	Chemical Abstracts Service	N/A
CAS	Chemical Abstracts Service Reference Number	N/A
CCR	California Code of Regulations	N/A
CDC	Centers for Disease Control	N/A
CEPA	Canadian Environmental Protection Act	N/A
CFR	Code of Federal Regulations	N/A
CHCC	Chemicals of High Concern to Children	N/A
CMI	Can Manufacturers Institute	N/A
CMR	Carcinogenic, mutagenic, reproductive toxics	N/A
CMYK	Cyan, magenta, yellow, and black	N/A
COD	Chemical Oxygen Demand	N/A
COMGHA	Glycerides, castor-oil mono-, hydrogenated, acetates	736150-63-3
CPA	Clean Production Action	N/A
CPSC	Consumer Product Safety Commission	N/A
DBDPE	Decabromodiphenyl ethane	84852-53-9
DBNPG	2,2-Bis(bromomethyl)propane-1,3-diol	3296-90-0
DBP	Di-n-butyl phthalate	84-74-2
DecaBDE	Decabromodiphenyl ether	1163-19-5
DCHP	Dicyclohexyl phthalate	84-61-7
DEHA	Di(2-ethylhexyl) adipate	103-23-1
DEHP	Di(2-ethylhexyl) phthalate	117-81-7
DEHT	Bis(2-ethylhexyl) terephthalate	6422-86-2
DEP	Diethyl phthalate	84-66-2
DEQ	Department of Environmental Quality	N/A
DIBP	Diisobutyl phthalate	84-69-5
DIDP	Diisodecyl phthalate	68515-49-1 and 26761-40-0
DfE	Design for the Environment	N/A
DGE	Dipropylene glycol dibenzoate	27138-31-4
DGS	Deary’s Gymnastics Supply	N/A
DHP	Dihexyl phthalate	84-75-3
DINCH	Diisononyl cyclohexandicarboxylate	474919-59-0 and 166412-78-8
DINP	Diisononyl phthalate	68515-48-0 and 28553-12-0

Acronym	Definition	Chemical Abstracts Service (CAS) number
DMP	Dimethyl phthalate	131-11-3
DnBP	Di-n-butyl phthalate	84-74-4
DnHP	Di-n-hexyl phthalate	84-75-3
DnOP	Di-n-octyl phthalate	117-84-0 and 8031-29-6
DnPP	Di-n-pentyl phthalate	131-18-0
DOTP	Dioctyl terephthalate	6422-86-2
DPG	Dipropylene glycol	25265-71-8
DPHP	Di(2-propylheptyl) phthalate	53306-54-0
DTSC	California Department of Toxic Substances Control	N/A
EBTBP	Ethylenebis(tetrabromoophthalimide)	32588-76-4
EC	European Commission	N/A
ECHA	European Chemicals Agency	N/A
EDI	Estimated daily intake	N/A
EFSA	European Food Safety Authority	N/A
EHDPP	Ethylhexyl diphenyl phosphate	1241-94-7
EO	Ethoxylate	N/A
EPA	U.S. Environmental Protection Agency	N/A
EPEA	Environmental Protection Encouragement Agency	N/A
EPEAT	Electronic Product Environmental Assessment Tool	N/A
ESBO	Epoxidized soybean oil	8013-07-8
ESIS	European chemical Substances Information System	N/A
EU	European Union	N/A
EVA	Ethylene vinyl acetate	N/A
FDA	U.S. Food and Drug Administration	N/A
FOX	Firefighter occupational exposure	N/A
FTOH/FTS	Fluorinated telomer alcohol/sulfonates	N/A
GER FEA	German Federal Environmental Agency	N/A
GHS	Globally Harmonized System of Classification and Labeling of Chemicals	N/A
GM	Geometric mean	N/A
H	High	N/A
HB	House Bill	N/A
HDPE	High density polyethylene	N/A
HF	House File	N/A
HFR	Organohalogen flame retardant	N/A
HIPS	High impact polystyrene	N/A
HPD	Health Product Declaration	N/A
HPDC	Health Product Declaration Collaborative	N/A
HR	House Resolution	N/A

Acronym	Definition	Chemical Abstracts Service (CAS) number
IARC	International Agency for Research on Cancer	N/A
IC2	Interstate Chemicals Clearinghouse	N/A
IEEE	Institute of Electrical and Electronics Engineers	N/A
iPCB	Inadvertent polychlorinated biphenyl	Multiple
IPM	Isopropyl myristate	110-27-0
IPTPP	Isopropylated triphenyl phosphate	68937-41-7
ISO	International Organization for Standardization	N/A
ITRC	Interstate Technology & Regulatory Council	N/A
IUPAC	International Union of Pure and Applied Chemistry	N/A
JP	Japan	N/A
kg	Kilogram	N/A
K_{OW}	Octanol—water partition coefficient	N/A
KR	Republic of Korea (South Korea)	N/A
L	Low	N/A
LD	Legislative Document	N/A
LL	Likely low	N/A
LC_{50}	Lethal Concentration for 50% of test animals studied	N/A
LD_{50}	Lethal Dose for 50% of test animals studied	N/A
LOAEL	Lowest Observed Adverse Effect Level	N/A
LOD	Limit of detection	N/A
LOQ	Limit of quantitation	N/A
LT	List Translator	N/A
M	Moderate	N/A
MBzP	Mono-benzyl phthalate	2528-16-7
MECPP	Mono-(2-ethyl-5-carboxypentyl) phthalate	40809-41-4
MEHHP	Mono (2-ethyl-5-hydroxyhexyl) phthalate	40321-99-1
MEHOP	Mono-(2-ethyl-5-oxohexyl) phthalate	40321-98-0
MEHP	Mono(2-ethylhexyl) phthalate	4376-20-9
MEP	Mono-ethyl phthalate	2306-33-4
Me-PFOSA-AcOH	2-(N-methyl-perfluorooctane sulfonamido) acetate	Multiple
mg	Milligram	N/A
mg/kg	Milligrams per kilogram	N/A
MHINP	Mono(hydroxyisononyl) phthalate	Multiple
MINP	Monoisononyl phthalate	Multiple
MMP	Mono-methyl phthalate	4376-18-5
MnBP	Mono-n-butyl phthalate	34-74-2 and 131-70-4
MOINP	Mono(oxoisononyl) phthalate	Multiple
MPCA	Minnesota Pollution Control Agency	N/A
MRL	Method reporting limit	N/A

Acronym	Definition	Chemical Abstracts Service (CAS) number
N/A	Not applicable	N/A
NAPIM	National Association of Printing Ink Manufacturers	N/A
NAS	National Academies of Sciences	N/A
NCSL	National Conference of State Legislatures	N/A
NFPA	National Fire Protection Association	N/A
ng	Nanogram	N/A
ng/cm^2	Nanograms per centimeter squared	N/A
ng/g	Nanograms per gram	N/A
ng/kg	Nanograms per kilogram	N/A
ng/L	Nanograms per liter	N/A
ng/m^2	Nanograms per meter squared	N/A
ng/mL	Nanograms per milliliter	N/A
NGO	Non-governmental organization	N/A
NHANES	National Health and Nutrition Examination Survey	N/A
NICNAS	National Industrial Chemicals Notification and Assessment Scheme	N/A
NIEHS	National Institute of Environmental Health Sciences	N/A
NIOSH	National Institute for Occupational Safety and Health	N/A
NLM	National Library of Medicine	N/A
NOAEL	No Observed Adverse Effect Level	N/A
NOEC	No Observed Effect Concentration	N/A
NP/NPE	Nonylphenol/nonylphenol ethoxylate (type of APE)	Multiple
NTP	National Toxicology Program (part of U.S. DHHS)	N/A
NZ	New Zealand	N/A
OctaBDE	Octabromodiphenyl ether	32536-52-0
OECD	Organisation for Economic Co-operation and Development	N/A
OEHHA	California Office of Environmental Health Hazard Assessment	N/A
OP/OPE	Octylphenol/octylphenol ethoxylate (type of APE)	Multiple
OPFR	Organophosphate flame retardant	N/A
OR	Oregon	N/A
OSPAR	Oslo and Paris Conventions Commission	N/A
PA	Polyamide	N/A
PAP	Polyfluoroalkyl phosphates	N/A
PASF	Perfluoroalkane sulfonyl fluorides	N/A
PBDEs	Polybrominated diphenyl ethers	Multiple
PBT	Persistent, bioaccumulative, toxic	N/A
PC	Polycarbonate	N/A
PC-ABS	Polycarbonate/ABS blends	N/A

Acronym	Definition	Chemical Abstracts Service (CAS) number
PCB	Polychlorinated biphenyl	Multiple
PDFA	Perfluorodecanoic acid	335-76-2
PE	Polyethylene	N/A
PentaBDE	Pentabromodiphenyl ether	32534-81-9
PET	Polyethylene terephthalate	25038-59-9
PFAA	Perfluoroalkyl acid	N/A
PFAS	Per- and polyfluoroalkyl substances	N/A
PFBA	Perfluorobutanoic acid	375-22-4
PFBS	Perfluorobutane sulfonic acid	375-73-5
PFCA	Perfluoroalkyl carboxylic acid	N/A
PFDeA	Perfluorodecanoic acid	N/A
PFHpA	Perfluoroheptanoic acid	375-85-9
PFHxA	Perfluorohexanoic acid	307-24-4
PFHxS	Perfluorohexane sulfonic acid	355-46-4
PFNA	Perfluorononanoic acid	375-95-1
PFOA	Perfluorooctanoic acid	335-67-1
PFOS	Perfluorooctane sulfonic acid	1763-23-1
POP	Persistent Organic Pollutant	N/A
PP	Polypropylene	N/A
PPO	Polyphenylene oxide	N/A
ppb	Parts per billion	N/A
ppm	Parts per million	N/A
ppt	Parts per trillion	N/A
PTFE	Polytetrafluoroethylene	9002-84-0
RCW	Revised Code of Washington	N/A
RDP	Resorcinol bis(diphenyl phosphate)	57583-54-7
REACH	Registration, Evaluation, Authorisation, and Restriction of Chemicals	N/A
RoC	Report on Carcinogens	N/A
SAR	Structure Activity Relationship	N/A
SB	Senate Bill	N/A
SCCP	Short chain chlorinated paraffins	85535-84-8
SCIL	Safer Chemicals Ingredient List	N/A
SCR	Senate Concurrent Resolution	N/A
SIN	Substitute It Now! List	N/A
SF	Senate File	N/A
SS	Safer States	N/A
SVHC	Substances of Very High Concern	N/A
TB	Technical Bulletin	N/A
TBB	2-Ethylhexyltetrabromobenzoate	183658-27-7

Acronym	Definition	Chemical Abstracts Service (CAS) number
TBBPA	Tetrabromobisphenol A	79-94-7
TBBP-TAZ	1,3,5-Triazine, 2,4,6-tris(2,4,6-tribromophenoxy)-	25713-60-4
TBPH	Bis(2-ethylhexyl) tetrabromophthalate	26040-51-7
TCEP	Tris(2-chloroethyl) phosphate	115-96-8
TCP	Tricresyl phosphate	1330-78-5
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin	1746-01-6
TDBPP	Tris(2,3-dibromopropyl) phosphate	126-72-7
TDCPP	Tris(1,3-dichloro-2-propyl) phosphate	13674-87-8
TEDX	The Endocrine Disruptors Exchange	N/A
TEQ	Toxic equivalents	N/A
TMBPF	Tetramethylbisphenol F	5384-21-4
TNBP	Tri-n-butyl phosphate	126-73-8
TPP	Triphenyl phosphate	115-86-6
TPU	Thermoplastic polyurethane	N/A
TRI	Toxics Release Inventory	N/A
TSCA	Toxic Substances Control Act	N/A
TURI	Toxics Use Reduction Institute (University of Massachusetts – Lowell)	N/A
UL	Underwriters Laboratories	N/A
USC	U.S. Code	N/A
UNEP	United Nations Environment Programme	N/A
V6	2,2-Bis(chloromethyl)trimethylene bis(bis(2-chloroethyl)phosphate)	38051-10-4
vH	Very High	N/A
WAC	Washington Administrative Code	N/A
WGK	Water Endangerment Class (German)	N/A
WHO	World Health Organization	N/A
WPI	Worcester Polytechnic Institute	N/A

Appendix B. Citation List

Overview

The following citation list was developed to meet the requirements outlined in RCW 70A.350.050[145] and 34.05.272.[146] It identifies the peer-reviewed science, studies, reports, and other sources of information used to support our identification of priority consumer products. The following are the types of sources used to support this report:

1. Peer review is overseen by an independent third party.
2. Review is by staff internal to Ecology.
3. Review by persons that are external to and selected by Ecology.
4. Documented open public review process that is not limited to invited organizations or individuals.
5. Federal and state statutes.
6. Court and hearings board decisions.
7. Federal and state administrative rules and regulations.
8. Policy and regulatory documents adopted by local governments.
9. Data from primary research, monitoring activities, or other sources, but that has not been incorporated as part of documents reviewed under other processes.
10. Records of best professional judgment of Ecology employees or other individuals.
11. Sources of information that do not fit into one of the other categories listed.

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Appendix C. Criteria for Safer

Introduction

Once hazardous chemicals are in consumer products, reducing exposure is up to the consumer. It is hard to predict how people will use consumer products and what they will do with the products when they are done. Hazardous chemicals in consumer products can result in those chemicals contaminating our communities, wildlife, and environmental resources.

If we can reduce the use of hazardous chemicals in consumer products by using safer alternatives, we have the opportunity to reduce exposure across the product lifecycle—from manufacturing to disposal or reuse. That means less exposure now and less cleanup later on.

RCW 70A.350[147] requires the Departments of Ecology and Health ("we") to identify safer alternatives to priority chemicals before proposing a restriction under the Safer Products for Washington program.[148]

Safer is defined in the law as "**less hazardous** to humans or the environment than the existing chemical or process." Risk is a combination of hazard and exposure. **To implement this law, we focus on reducing risk by reducing hazards.**

To determine whether alternative chemicals are safer than priority chemical classes, the Safer Products for Washington team developed the adaptable, hazard-based criteria outlined in this appendix.

Safer alternatives to priority chemicals may also be alternative products or processes that eliminate the need for alternative chemicals. In this case, alternatives cannot contain chemicals known to be in products during use at concentrations greater than 100 ppm that have known hazards of concern (such as known carcinogens, mutagens, or reproductive or developmental toxicants). We do not evaluate other chemicals found in both the priority product and the alternative because they do not change.

The criteria detailed in this appendix focus on how we identify safer alternative chemicals that function like priority chemicals. We will use the criteria to determine whether an alternative chemical is safer than the priority chemical class used in the priority product. The **minimum criteria for safer** is a baseline set of hazard criteria that define a first step toward reduced hazard. In most cases, alternatives that meet the minimum criteria for safer are less hazardous than the priority chemical class. In certain cases, however, an alternative may need to meet **additional criteria** for us to ensure it is less hazardous than the priority chemical class.

Our approach is based on the concept that "safer" is a spectrum of hazard, and our goal is continuous improvement toward more optimal chemicals (Figure 5). Even if an alternative is safer than a priority chemical, it is possible that there is still room for further improvement.

[147] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350
[148] https://www.ezview.wa.gov/site/alias__1962/37555/safer_products_for_washington.aspx

Figure 5. The spectrum of safer, showing progress from hazardous chemicals to optimal chemicals.

If you have questions about the criteria outlined here or about the Safer Products for Washington program, contact us at SaferProductsWA@ecy.wa.gov.

Outline

This appendix outlines how the Safer Products for Washington program will identify chemical alternatives that are safer than priority chemical classes. First, we outline our approach for identifying safer chemical alternatives. We then review the process we used to develop our criteria. The detailed criteria for safer include:

- Section 1.0 on data requirements.
- Section 1.1 overviewing the criteria for safer—including minimum, additional, and within-class criteria.
- Section 1.2 describing the hazard endpoints scoring.

Two supplements and one other appendix include additional information to support the criteria:

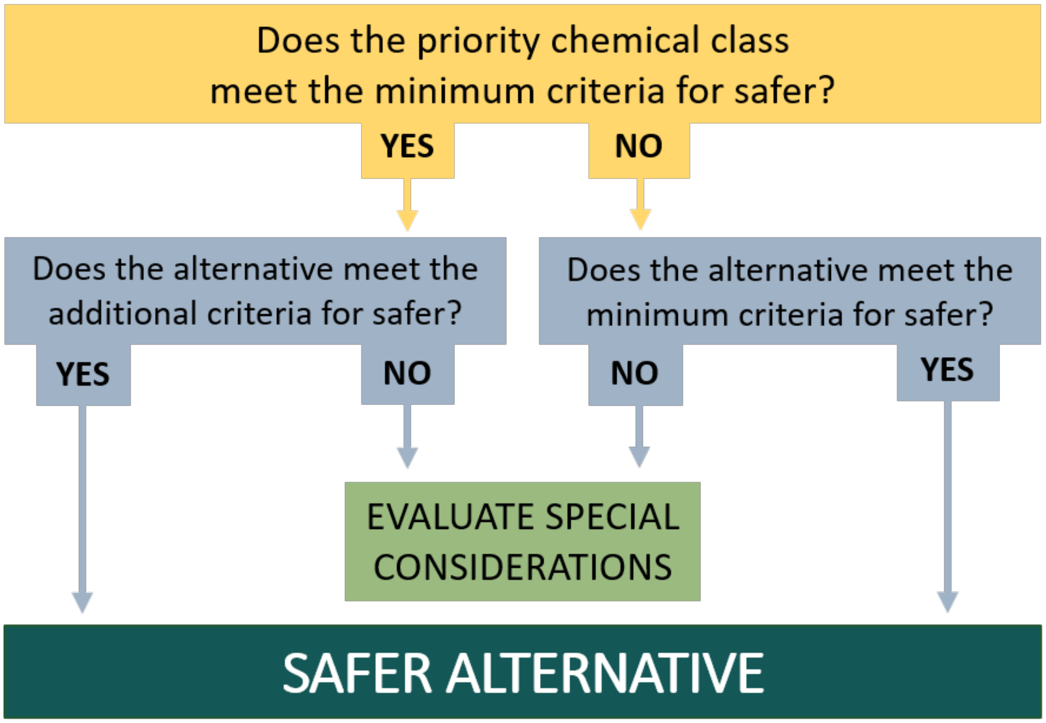
- Supplement 3 outlines the endpoint scoring approach in the GreenScreen® method.
- Supplement 4 includes a brief overview of each hazard assessment methodology we used to develop our criteria.
- Appendix A includes the references we reviewed to develop our criteria.

Approach for identifying safer chemical alternatives

We identify safer alternative chemicals to the priority chemical class based on whether they meet specific hazard criteria. Safer alternatives may also be **alternative products or processes**. Our criteria focus on how we identify safer **alternative chemicals**.

In this process, we evaluate the priority chemical class to determine whether it meets our minimum criteria for safer. This tells us whether the alternative chemical needs to meet the minimum or additional criteria for safer. If we identify an alternative chemical that meets the appropriate criteria for safer, it is a safer alternative. In some cases, alternative and priority chemical classes may have similar hazard levels, meaning we will include additional considerations in our evaluation. Figure 6 shows this process.

Figure 6. Overview of the general process used to determine whether alternatives are safer than the priority chemical class.



Criteria for safer—process overview

To identify safer alternatives, we need to determine whether the alternative chemical must meet the minimum or additional criteria for safer. To answer this question, we first determine if a priority chemical class meets or fails to meet our minimum criteria for safer. (See our explanation below for how we assess chemicals as a class.)

If a priority chemical class fails to meet our minimum criteria for safer, then the alternatives that do meet the minimum criteria will be considered safer. Conversely, if a priority chemical class meets our minimum criteria for safer, then we must find alternative chemicals that meet the additional criteria to be considered safer.

This process can be broken down as follows:

- Does the priority chemical class meet the minimum criteria for safer?
    - If no, then we ask, does the **alternative chemical meet or exceed the minimum criteria** for safer?
        - If yes, then it is safer.
        - If no, then we evaluate special considerations.
    - If yes, then we ask, does the **alternative chemical meet the additional criteria** for safer?
        - If yes, then it is a safer alternative.
        - If no, then we evaluate special considerations.

This approach assumes priority chemical classes will not meet the additional criteria for safer. It is unlikely that a priority chemical class would both qualify as a priority chemical in the law and meet the additional criteria for safer.

How do we assess chemical classes?

Through the Safer Products for Washington program, Ecology and Health have the authority to take action on classes of priority chemicals. Therefore, our process begins by determining whether the priority chemical class meets the minimum criteria for safer. We do this by considering hazard characteristics of chemicals within the priority chemical class. The Washington State Legislature identified the priority chemical classes for our first Safer Products for Washington cycle and included them in the statute.

There are many benefits to evaluating chemical classes as a whole as opposed to individual chemicals. Evaluating chemicals by class avoids the problem of treating chemicals with insufficient data as not hazardous. A class approach can prevent regrettable substitutions of other chemicals in the class with similar hazards. It can also protect against cumulative adverse impacts that can arise from exposure to multiple chemicals in the class. The National Academy of Sciences (The Academy) describes the benefits of a class-based approach to hazard evaluation further in its 2019 report on approaching flame retardants as a class (NAS, 2019).

The Academy (NAS, 2019) lays out four potential scenarios for assessing chemicals by class:

1. **Data rich chemicals**. In scenario 1, taking a class-based approach to a class of data rich chemicals is relatively straightforward.
2. **Data poor chemicals**. In scenario 2, all chemicals in the class are data poor. It is unlikely that priority chemicals will fall into this scenario because chemicals need some amount of data indicating hazard to be considered a priority chemical.
3. **A mix of data rich and data poor chemicals**. In scenario 3, there are sufficient data to assess at least one chemical in the class, but no data on other chemicals. The data available suggest that members of the class have similar biological activity. In this scenario, The Academy proposes an option for making a science-based policy decision to classify the class as potentially hazardous based on the data rich chemicals.
4. **Chemicals with variable or discordant data with response to biological activity (toxicological variability)**. In scenario 4, the data available suggest the class shows variable biological activity. Options in scenario 4 include making a policy decision, as described below.

The NAS report (NAS, 2019) focuses on identifying chemical classes for a cumulative risk assessment. This often requires an understanding of whether the chemicals in the class impact the same biological pathways, which can make grouping these chemicals challenging. In contrast, the Safer Products for Washington program aims to determine whether the chemical class meets or fails to meet our minimum criteria for safer. Therefore, using similar methods, we may come to different conclusions.

For example, the NAS determined that halogenated flame retardants need to be divided into subclasses in order to complete a risk assessment that meets CPSC requirements. However, NAS also states that halogenated flame retardants, "have several characteristics that could define them as a single class, including some physicochemical properties, their use as flame retardants, or generation of specific combustion byproducts. Those characteristics could define them as a single class for some decision contexts, but are not entirely workable for conducting a hazard or risk assessment under the CPSC regulations" (NAS, 2019).

RCW 70A.350[149] lays out a decision context focused on pollution prevention by reducing significant sources or uses of priority chemical classes when safer alternatives are feasible and available. We determined that within this decision context, it is possible to approach the classes as defined in the law provided they could be unified by structure, physiochemical properties, biology, or some combination thereof.

We made slight modifications to the NAS decision framework described above to fit the hazard-based approach of Safer Products for Washington. In this approach, we use the data rich chemicals within the class to determine whether the class meets or fails to meet our minimum criteria for safer. This informs whether alternatives need to meet the minimum or additional criteria to be considered safer.

Data rich chemicals have existing, third-party reviewed or publicly available hazard assessments that are compatible with our criteria for safer, or were evaluated by other government agencies or authoritative parties. Find more information about hazard assessments that may be compatible with our criteria for safer in Supplement 3 and Supplement 4.

We rely on the authoritative list compilation developed as part of the GreenScreen® Methodology (Supplement 4). GreenScreen® categorizes lists as authoritative or screening.

- Authoritative lists are derived mostly from government sources. In this report, we primarily rely on lists from the U.S., the United Nations, and the European Union.
- Screening lists are not used alone. We may use a screening list to support evidence from other sources.

To access these lists, we often use the GreenScreen® List Translator™ hazard screening approach. This approach uses a "lists of lists" to identify chemicals that authoritative bodies concluded have hazards that are likely consistent with a Benchmark-1 score.

Find more detail about how we use authoritative lists to assess data rich chemicals in the scoring for each hazard endpoint in Supplement 3. We then use the scenarios from the NAS report to extrapolate the information from the data rich chemicals to the class as a whole.

If the data rich chemicals in the class are similar (NAS Scenario 3) and fail to meet our minimum criteria for safer, we will make a science-based policy decision to classify the class as potentially hazardous based on the data rich chemicals. This means that the data poor chemicals within the class are potentially hazardous.

In some cases, there is toxicological variability (NAS Scenario 4) in the hazards within the class—where some chemicals in the class meet our minimum criteria for safer and other chemicals in

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

the class do not. In this instance, we use the within-class criteria (described below) to identify chemicals within the class that may be treated differently because they are safer. To determine whether alternatives need to meet the minimum or additional criteria, we consider the following options:

1. Making a conservative decision to classify the class based on the data rich hazardous chemicals and seek alternatives that meet the minimum criteria.
2. Making the determination that is best supported by data from chemicals in the class that have the potential to be found in the priority product.

In most cases, we will make the determination that is best supported by the chemicals potentially found in the product. However, in some cases there may be:

- Toxicological variability within the chemicals found in the products
- Mixtures of chemicals found in the products
- Concerns around breakdown or residual monomers in the products
- A lack of transparency around the chemicals used in the products

These are some examples of cases where we may make a conservative decision to consider the class potentially hazardous—despite the variability—and use the minimum criteria to identify safer alternatives. This approach helps avoid the pitfalls of assuming chemicals with no data are not hazardous and ensures the alternatives are safer than the priority chemical class.

Special considerations

Do we need to factor in exposure?

We only consider exposure factors if alternatives are not obviously safer based on hazard alone. When considering exposure, we ask whether the exposure routes or exposure potential could change the relevant hazards.

- If yes, then it may be a safer alternative.
    - Example: The priority chemical class does not meet our minimum criteria for safer. There is an alternative that also does not meet our minimum criteria for safer. The alternative fails because it is highly toxic when injected. We do not expect the alternative to be injected when used in the priority product. Reconsidering the hazard data with this exposure route deprioritized may make the alternative favorable for this specific product application.
    - Example: A priority chemical class does not meet our minimum criteria for safer. There is an alternative that meets our minimum criteria for safer, but it has an impurity that does not meet our minimum criteria for safer. By moving to the alternative, we reduce the concentration of chemicals in the product that do not meet our minimum criteria for safer from 10% (for the intentionally added priority chemical) to less than 1% (for the alternative with an impurity). This can be considered less hazardous and a safer alternative.
- If no, it is not a safer alternative.

We will seek alternatives with a significant reduction in hazard. An example of this would be a priority chemical class not meeting the minimum criteria and an alternative meeting the minimum criteria for safer. There may be some cases where the only alternative we identify has similar hazards to the priority chemical class. For example, both the priority chemical class and alternative meet the minimum criteria but fail to meet the additional criteria for safer. If the alternative is much less hazardous, differences in exposure are less important. However, if the alternative and priority chemical have similar hazards, exploring differences in exposure potential could help us determine whether the alternative is actually safer.

In these cases, we will evaluate potential exposure routes and chemical properties to determine whether specific hazards may be more or less relevant for a particular product-chemical combination. To determine which exposure routes (such as inhalation, dermal exposure, ingestion) or pathways (such as aquatic contamination) are more or less relevant, we will consider both product attributes and the chemical properties. The chemical properties will be based on the IC2 Guide (IC2, 2017) and the Cradle to Cradle Certified® Exposure Assessment methodology (C2CC®, 2020).

Considering which hazards are more or less relevant based on expected exposure routes and pathways will help us balance specific hazard trade-offs when an alternative and priority chemical show similar overall hazard levels. If no specific exposure routes or pathways help distinguish between a priority chemical class and an alternative with similar hazards, we will consider differences in the magnitude of exposure potential.

Differences in exposure magnitude could result from an alternative being chemically bound or encapsulated, or from a functional barrier that prevents exposure. Differences in leaching, migration, or off-gassing between the priority chemical class and the alternative could also influence exposure (C2CC®, 2020). The concentration or amount of the chemical used in the product may also influence the magnitude of exposure potential.

Do we consider chemical alternatives within the priority chemical class?

We will first seek alternatives outside the priority chemical class. We do this because many priority chemical classes have numerous unique chemicals that lack toxicological data but have sufficient structural similarity to suggest the toxicological concern would be present in the unstudied chemicals in the class. If we do not identify safer alternatives outside the priority chemical class, and if considerable variability in toxicity within the class suggests that some chemicals within the class may be safer alternatives, we will evaluate those chemicals using a set of "within-class" hazard criteria.

What are the "within-class" hazard criteria?

To be considered a safer alternative within the priority chemical class or excluded from the priority chemical class, a chemical must meet both the minimum or additional criteria for safer and the within-class criteria. We subject these chemicals and their known breakdown or transformation products to more protective requirements. This ensures that in addition to meeting the minimum or additional criteria for safer, data show these chemicals do not have the same toxicity or environmental fate concerns associated with the priority chemical class.

The within-class criteria adds data requirements for endpoints associated with the class and reduces the tolerance for chemicals within the class that are suspected of being carcinogens, reproductive or developmental toxicants, or endocrine disruptors (if those endpoints are associated with the priority class). It does not allow chemicals within the class to have high or very high persistence. Persistent chemicals are problematic because if we learn about hazards after contamination or exposure has occurred, they are difficult and expensive to clean up.

Replacing priority chemicals with another, less understood member of the class often leads to regrettable substitutions (Birnbaum & Bornehag, 2021; Chen et al., 2016; Cordner et al., 2016; Digangi et al., 2010; Eladak et al., 2015; EPA, 2017a, 2017b, 2021e; Vos, 2013). In cases where the replacement chemicals are persistent, widespread contamination to the environment and drinking water has occurred (McDonough et al., 2021). Avoiding persistent chemicals in classes of known hazardous chemicals is critical for pollution prevention. The within-class criteria is described in section 1.1 below.

Criteria development process

Ecology, in consultation with Health, developed the criteria for safer. To develop our criteria, we thoroughly reviewed existing methods for identifying safer chemicals and products that contain safer chemicals. In many cases, elements of existing criteria informed our process.

We developed our criteria based on existing hazard assessment criteria from EPA's Safer Choice and Design for the Environment (DfE) programs, and the GreenScreen® for Safer Chemicals Hazard Assessment Guidance (GreenScreen®). Learn more about these certification and labeling programs in Supplement 4.

All three frameworks rely on similar data sources—including the Globally Harmonized System (GHS)—for classifying information using a weight of evidence approach. We chose to build on these methods for many reasons, but three are central:

- Each framework developed transparent criteria using a stakeholder process.
- Guidance documents for alternatives assessments recommend them.
- They are used in published alternatives assessments conducted by (or on behalf of) Washington state or the Federal government.

EPA's Safer Choice Program certifies chemicals and products that meet its master criteria (EPA, 2012). EPA developed the Safer Chemical Ingredients List (SCIL) master criteria (adapted from Design for the Environment, EPA, 2015b) through an open stakeholder process. These criteria are publicly available, and the stakeholder process included a public comment period. Industry, non-governmental organizations (NGOs), and government stakeholders participated and provided input on the project scope, helped identify functional alternatives, and helped develop the report (EPA, 2016).

GreenScreen® built on EPA's Design for the Environment Criteria and developed a framework with input from a scientific advisory committee, with representation from academia, businesses, and NGOs (GreenScreen®, 2020). These criteria and scoring system are publicly available. A number of businesses, governments, and NGOs use GreenScreen® to promote the use of safer alternatives (GreenScreen®, 2018).

Guidance documents for alternatives assessments identify the SCIL, DfE, and GreenScreen® methods. The Interstate Chemical Clearinghouse (IC2) Guide for Alternatives Assessments (IC2 Guide) recommends the GreenScreen® methodology for hazard comparison (IC2, 2017).

GreenScreen® categorizes chemicals into four "Benchmark" scores.

- The lowest, **Benchmark 1**, identifies chemicals that should be avoided.
- **Benchmark 2** chemicals are considered safer than Benchmark 1 chemicals, earning the designation "use, but continue to search for safer substitutes."
- **Benchmark 3** chemicals are safer than Benchmark 2 chemicals and designated "use, but still opportunity for improvement."
- **Benchmark 4** chemicals are preferred, safer chemicals.

GreenScreen® also has a List Translator™ hazard screening approach that uses a "lists of lists" to identify chemicals that authoritative bodies concluded have hazards that would likely be consistent with a Benchmark 1 score.

Our minimum criteria for safer is based on the GreenScreen® Benchmark 2 criteria and our additional criteria for safer combines the SCIL master criteria and GreenScreen® Benchmark 3 criteria.

These methods are used by other government agencies, including:

- California Department of Toxic Substances Control (DTSC)'s Safer Consumer Products Program Alternatives Analysis Guide lists GreenScreen® and SCIL for hazard evaluation (DTSC, 2017).
- The National Research Council identified both GreenScreen® and DfE as methods for comparing hazards in their 2014 review of alternatives assessment frameworks (NRC, 2014).
- EPA's alternatives assessment guidance recommends using the hazard criteria that formed the basis for the SCIL (EPA, 2015e). Examples of published alternatives assessments using these criteria include BPA in thermal paper and flame retardants in flexible polyurethane foam, and printed circuit boards (EPA, 2011a; 2015c; 2015f; 2015g).
- Ecology and others often use the GreenScreen® scoring system in alternatives assessments. Examples from Ecology include assessments of alternatives to Deca-BDE in electronics and furniture (Ecology, 2008) and copper in boat paint (Northwest Green Chemistry & TechLaw, 2017).

The criteria

Sections 1.0 and 1.1 define our data requirements and hazard criteria. Our minimum data requirements contain the endpoints generally recognized as most significant.

The scoring of the hazard endpoints (very low, low, moderate, high, and very high) follows the process in the GreenScreen® methodology, which was adapted from EPA's DfE program and the GHS categorization (Supplement 4). In rare cases, we made minor modifications to the GreenScreen® scoring criteria, which we describe in Supplement 4.

1.0 Data requirements

1.0.1 Chemical hazard data requirements

For an alternative chemical to meet the minimum or additional criteria for safer, data must be present for the endpoints described in Table 52. Data requirements are aligned with the GreenScreen® methodology. We require data on carcinogenicity and mutagenicity. We require data on either reproductive or developmental toxicity. At least two of the following three endpoints are required: acute toxicity, systemic toxicity, and neurotoxicity. Skin or respiratory sensitization, acute aquatic toxicity or chronic aquatic toxicity, persistence, and bioaccumulation are required.

If an alternative is within the priority chemical class, our criteria do not allow data gaps for hazard endpoints known to be associated with the priority chemical class. Find more details on how we identify hazards associated with priority chemicals in the section on within-class hazard criteria.

For each required endpoint, at least one of the following must be available:

- Sufficient measured data on the chemical.
- Measured data on a suitable analog.
- Estimated data on the chemical or a suitable analog chemical.

We will consider data from the primary literature, authoritative sources, and government reports. We will manage conflicting studies using a strength of evidence approach. This approach is consistent with the GreenScreen® methodology. Find more information on the amount of data needed for each endpoint in Supplement 3.

Table 52. Minimum data requirements and potential exemptions to meet minimum or additional criteria for safer.

Hazard endpoint	Requirement
Carcinogenicity	Required
Mutagenicity/Genotoxicity	Required
Reproductive or Developmental Toxicity	Required
Endocrine Disruption	Not required
Acute Toxicity	Not always required*
Single or Repeat Systemic Toxicity	Not always required*
Single or Repeat Neurotoxicity	Not always required*

Hazard endpoint	Requirement
Skin or Respiratory Sensitization	Required
Skin or Eye Irritation	Not required
Acute or Chronic Aquatic Toxicity	Required
Persistence	Required
Bioaccumulation	Required

Note: * = Two out of these three endpoints require data.

1.0.2 Chemical concentration data requirements

This appendix describes our approach for evaluating intentionally added chemicals that serve the same function as priority chemicals. We are also concerned about residual monomers, known breakdown products, and impurities present in the product from chemicals that serve the function of priority chemicals. We describe our requirements for chemical concentration data below.

Current practices by SCIL and GreenScreen® inform the concentrations of alternatives we will consider. When we evaluate chemical alternatives, we are evaluating the following:

- All chemicals intentionally added to serve the function of the priority chemical class and their known breakdown/transformation products must meet our minimum or additional criteria for safer.
- Impurities and residual monomers of chemicals added to serve the function of priority chemicals when present at over 1,000 ppm must meet our minimum or additional criteria for safer.
- Impurities of chemicals added to serve the function of priority chemicals that are present between 100 – 1,000 ppm must not score high for carcinogenicity, mutagenicity, reproductive or developmental toxicity, or endocrine disruption (if data are available).

If we are evaluating a within-class alternative, we will consider chemicals present below 100 ppm. We are considering potentially lower concentrations of priority chemicals because we demonstrated that the presence of priority chemicals in priority products contributes to human and environmental exposure (Ecology, 2020a). If an alternative contains chemicals from the priority chemical class under evaluation, we evaluate the following:

- Priority chemicals present in the product above 100 ppm during the use phase must meet the minimum or additional criteria for safer and the within-class criteria for safer.
- Priority chemicals present below 100 ppm in the product during the use phase must meet the minimum or additional criteria for safer.

1.1 Criteria for safer

Moving toward safer chemicals is progressive. The criteria described below balance allowable persistence, bioaccumulation, and toxicity hazards with a goal of moving toward safer alternatives. If the priority chemical meets the minimum criteria for safer, then alternative chemicals must meet the additional criteria for safer.

Minimum criteria for safer

If the priority chemical class does not meet the minimum criteria for safer, alternative chemicals must meet the minimum criteria, described below, to be safer. The minimum criteria for safer is derived from GreenScreen® Benchmark 2 criteria for organic chemicals (Supplement 4). That means GreenScreen® Benchmark 1 chemicals and LT-1 chemicals do not meet our minimum criteria for safer. In order to meet the minimum criteria for safer, data is not required for all endpoints described below. See Table 52 for data requirements.

The criteria below describe the maximum allowable hazard traits for chemicals. Hazard traits are scored from low to high or very high. The scoring for each hazard endpoint can be found in Supplement 3.

- Carcinogenicity, mutagenicity, reproductive and developmental toxicity, and endocrine disruption must be moderate or lower.
- Persistence and bioaccumulation cannot both be very high.
- If any other human health or aquatic toxicity endpoints are very high, then persistence and bioaccumulation cannot both be high (Max Hazard Profiles 1 and 2, Table 53).
- If persistence is very high, then bioaccumulation cannot be very high and systemic toxicity (repeat exposure), neurotoxicity (repeat exposure), skin sensitization, and respiratory sensitization must all be moderate or lower, and acute toxicity, systemic toxicity (single exposure), neurotoxicity (single exposure), eye irritation, skin irritation, and acute and chronic aquatic toxicity cannot be very high. (Max Hazard Profile 3, Table 53).
- If bioaccumulation is very high, then persistence cannot be very high and systemic toxicity (repeat exposure), neurotoxicity (repeat exposure), skin sensitization, and respiratory sensitization must all be moderate or lower, and acute toxicity, systemic toxicity (single exposure), neurotoxicity (single exposure), eye irritation, skin irritation, and acute and chronic aquatic toxicity cannot be very high. (Max Hazard Profile 4, Table 53).

There will be some modifications to our criteria if we are evaluating inorganic chemicals as either priority chemicals or alternatives. In that case, the minimum criteria will be modified based on the GreenScreen® Benchmark 2 criteria for inorganic chemicals (Supplement 4).

Table 53. Highest allowable hazard profiles in our minimum criteria for safer. The maximum allowable hazard for human health and ecotoxicity endpoints in profiles with different persistence and bioaccumulation. Data are not required for all endpoints. (Minimum data requirements from section 1.0 apply.)

	Carcinogenicity	Genotoxicity/ Mutagenicity	Reproductive Toxicity	Developmental Toxicity	Endocrine Activity	Acute Toxicity	Systemic Toxicity (single)	Systemic Toxicity (repeat)	Neurotoxicity (single)	Neurotoxicity (repeat)	Skin Sensitization	Respiratory Sensitization	Skin Irritation	Eye Irritation	Acute Aquatic Toxicity	Chronic Aquatic Toxicity	Persistence (P)	Bioaccumulation (B)
Max Hazard Profile 1	M	M	M	M	M	vH	vH	vH	vH	vH	vH	vH	vH	vH	vH	vH	M	H
Max Hazard Profile 2	M	M	M	M	M	vH	vH	vH	vH	vH	vH	vH	vH	vH	vH	vH	H	M
Max Hazard Profile 3	M	M	M	M	M	H	H	M	H	M	M	M	H	H	H	H	H	vH
Max Hazard Profile 4	M	M	M	M	M	H	H	M	H	M	M	M	H	H	H	H	vH	H

Notes:

- M = moderate.
- H = high.
- vH = very high.

Additional criteria for safer

If the priority chemical class meets our minimum criteria for safer, alternative chemicals must meet the additional criteria, described below, to be safer. The additional criteria for safer is derived from GreenScreen® Benchmark 3 criteria and the SCIL master criteria (Supplement 4). Data is not required for all endpoints described below. See Table 52 for data requirements. The criteria below represents the maximum allowable hazards.

- Carcinogenicity, mutagenicity, and reproductive and developmental toxicity must be low or likely low, and endocrine disruption must be moderate or low.
- Neither persistence nor bioaccumulation can be very high.
- If acute aquatic toxicity is very high or systemic toxicity (repeat exposure), neurotoxicity (repeat exposure), skin sensitization, or respiratory sensitization is high or acute toxicity, systemic toxicity (single exposure), neurotoxicity (single exposure), eye irritation, skin irritation, or chronic aquatic toxicity is moderate, then persistence and bioaccumulation cannot both be moderate. (Max Hazard Profiles 1 and 2, Table 54).
- If either persistence or bioaccumulation is high, the other must be moderate or lower, and systemic toxicity (repeat exposure), neurotoxicity (repeat exposure), skin

sensitization, respiratory sensitization, acute toxicity, systemic toxicity (single exposure), neurotoxicity (single exposure), eye irritation, skin irritation, and acute and chronic aquatic toxicity must be low or likely low (Max Hazard Profiles 3 and 4, Table 54).

There will be some modifications to these criteria if we are evaluating inorganic chemicals as either priority chemicals or alternatives. In that case, the minimum criteria will be modified based on the GreenScreen® Benchmark 3 criteria for inorganic chemicals (Supplement 4).

In some cases, we will be evaluating a chemical that is data poor but has long-standing evidence of safe use. EPA's SCIL developed an approach to determining whether processing aids and additives can be listed.[150] Chemicals that meet the SCIL processing aids and additives criteria often are considered generic ingredients to products. They have chemical characteristics (such as simple acids or essential functionality in humans) that are indicative of low hazard and anecdotal evidence suggesting long-standing safe use. Chemicals listed on the SCIL as green circle or green half-circle processing aids and additives can be considered equivalent to meeting our additional criteria for safer, under the conditions described by EPA. The conditions described by EPA include pH limits for acids.

Table 54. Additional hazard criteria used to evaluate alternatives when priority chemicals meet the minimum criteria for safer. Data are not required for all endpoints. (Minimum data requirements from section 1.0 apply.)

	Carcinogenicity	Genotoxicity/ Mutagenicity	Reproductive Toxicity	Developmental Toxicity	Endocrine Activity	Acute Toxicity	Systemic Toxicity (single)	Systemic Toxicity (repeat)	Neurotoxicity (single)	Neurotoxicity (repeat)	Skin Sensitization	Respiratory Sensitization	Skin Irritation	Eye Irritation	Acute Aquatic Toxicity	Chronic Aquatic Toxicity	Persistence (P)	Bioaccumulation (B)
Max Hazard Profile 1	LL	L	L	L	M	H	H	M	H	M	M	M	H	H	vH	H	L	M
Max Hazard Profile 2	LL	L	L	L	M	H	H	M	H	M	M	M	H	H	vH	H	M	L
Max Hazard Profile 3	LL	L	L	L	M	L	L	L	L	L	L	L	L	L	L	L	H	M
Max Hazard Profile 4	LL	L	L	L	M	L	L	L	L	L	L	L	L	L	L	L	M	H

Notes:

- L = low.
- M = moderate.
- H = high.

[150] https://www.epa.gov/saferchoice/safer-choice-criteria-processing-aids-and-additives

- vH = very high.
- LL = indicates the chemical is likely low based on review of all available data (including chemical structure analogs) and that we identified no structural alerts.

Within-class criteria for safer

If the alternative is within the priority chemical class, it must meet the minimum or additional criteria **and** the within-class criteria (described below for priority chemicals present in the product during use at concentrations greater than 100 ppm).

- Alternatives within the class cannot have data gaps for hazards associated with the priority chemical class (see details on endocrine disruption below).
- If carcinogenicity, mutagenicity, reproductive or developmental toxicity, or endocrine disruption are associated with the priority chemical class, alternatives within the class must score low on these endpoints (see details on endocrine disruption below).
- If endocrine disruption is associated with the priority chemical class, but limited to a specific mechanism of action (such as anti-androgenicity or estrogenicity), data showing the within-class alternative does not share this mechanism may be sufficient—even if it is still not enough information to assign a GreenScreen® score for endocrine disruption.
- Alternatives within the class cannot be highly persistent or highly bioaccumulative.

Priority chemicals present in the product during use at concentrations less than 100 ppm must meet the minimum or additional criteria for safer.

Hazard endpoints are associated with the priority class if one or more chemicals within the class scores high or very high according to the GreenScreen® scoring methodology. We are considering the hazards of priority chemicals at lower concentrations than alternatives outside of the class because we know these product-chemical combinations are associated with human or environmental exposure and we aim to avoid regrettable substitutions.

1.2 Hazard endpoints scoring

GreenScreen® has defined criteria for very high, high, moderate, low, or very low for 18 hazard endpoints, building on GHS and EPA's DfE criteria. GHS is a globally recognized method for classifying chemical hazards (United Nations, 2011). Our criteria uses the GreenScreen® method to determine endpoint scores for required and available data with very few modifications. The two modifications are:

1. The addition of a "likely low" designation for carcinogenicity.
2. Designating chemicals that would pass the SCIL master criteria for reproductive and developmental toxicity as low for these endpoints. Find more information about scoring for each endpoint in Supplement 3 and additional endpoints in GreenScreen®, Annex 1[151] (Supplement 4).

[151] https://www.greenscreenchemicals.org/images/ee_images/uploads/resources/GreeScreen1.4-Annex1-1.18.pdf

Supplement 3. Endpoint scoring methodology

Group I human health endpoints

Carcinogenicity

Moderate or lower carcinogenicity means that according to the GHS the chemical is not a known or presumed carcinogen by any exposure route. We can identify known or presumed carcinogens by reviewing data or by presence on the lists specified in GreenScreen®, Annex 1[152] (Supplement 4). Moderate carcinogens, however, can be classified as a suspected carcinogen or have limited or marginal data in animals. Chemicals can only score low if there is evidence of lack of carcinogenicity. In a modification from the GreenScreen® scoring system, we propose scoring chemicals as "likely low" in some scenarios. If sufficient data does not exist to assign a low carcinogenicity score, but there is no reason to suspect carcinogenicity after review of all available experimental and modeling data (including structural analogs), we can accept the score as "likely low" rather than as a data gap.

Mutagenicity

Moderate or lower mutagenicity means that according to the GHS the chemical is not a known or presumed mutagen by any exposure route. We can identify known or presumed mutagens by reviewing data or by presence on the lists specified in GreenScreen®, Annex 1[153] (Supplement 4). Moderate mutagens, however, can be classified as a suspected mutagen or have limited or marginal data in animals. Chemicals can only score low if there is evidence that they do not cause chromosomal aberrations and gene mutations.

Reproductive toxicity

Moderate or lower reproductive toxicity means that according to the GHS the chemical is not a known or presumed reproductive toxicant by any exposure route. We can identify known or presumed reproductive toxicants by reviewing data or by presence on the lists specified in GreenScreen®, Annex 1[154] (Supplement 4). Moderate reproductive toxicants, however, can be classified as a suspected reproductive toxicant or have limited or marginal data in animals. Chemicals score low if there is evidence that they do not cause reproductive toxicity or if the effects observed occur at exposures greater than those required to pass the SCIL master criteria (shown in Table 55).

[152] https://www.greenscreenchemicals.org/images/ee_images/uploads/resources/GreeScreen1.4-Annex1-1.18.pdf
[153] https://www.greenscreenchemicals.org/images/ee_images/uploads/resources/GreeScreen1.4-Annex1-1.18.pdf
[154] https://www.greenscreenchemicals.org/images/ee_images/uploads/resources/GreeScreen1.4-Annex1-1.18.pdf

Table 55. If reproductive or developmental toxicity is observed at exposure above the guidance values in this table, a chemical can score low.

Route of administration	Guidance value
Oral (mg/kg/day)	250
Dermal (mg/kg/day)	500
Inhalation (vapor/gas) (mg/L/6h/day)	2.5
Inhalation (dust/mist) (mg/L/6h/day)	0.5

Developmental toxicity

Moderate or lower developmental toxicity means that, according to the GHS, the chemical is not a known or presumed developmental toxicant by any exposure route. We can identify known or presumed developmental toxicants by reviewing data or by presence on the lists specified in GreenScreen®, Annex 1[155] (Supplement 4). Moderate developmental toxicants, however, can be classified as a suspected developmental toxicant or have limited or marginal data in animals. Chemicals score low if there is evidence that they do not cause developmental toxicity or if the effects observed occur at exposures greater than those required to pass the SCIL master criteria (shown in Table 55).

Endocrine disruption

When data are available for endocrine disruption, we will evaluate it to determine whether there is evidence of endocrine activity and related human health effects (high), evidence of endocrine activity (moderate), or adequate data available including negative studies (low). We can identify known and suspected endocrine disruptors by reviewing data or by presence on the lists specified in GreenScreen®, Annex 1[156] (Supplement 4).

Group II human health endpoints

Acute mammalian toxicity

A very high score corresponds to the GHS Category 1 or 2 for any route of exposure. A high score corresponds to GHS Category 3 for any route of exposure. A moderate score corresponds to a GHS Category 4 for any route of exposure. In order to score low, the chemical must saftisfy one of the following:

- Correspond to a GHS Category 5.
- GHS must not classify the chemical, and adequate data must be available, including negative studies.

[155] https://www.greenscreenchemicals.org/images/ee_images/uploads/resources/GreeScreen1.4-Annex1-1.18.pdf
[156] https://www.greenscreenchemicals.org/images/ee_images/uploads/resources/GreeScreen1.4-Annex1-1.18.pdf

Table 56. Acute toxicity LD/LC_{50} for oral, dermal, and inhalation exposure corresponding to GHS Categories 1 through 5.

Classification criteria	Category 1	Category 2	Category 3	Category 4	Category 5
Oral LD50	≤ 5 mg/kg bw	> 5 and ≤ 50 mg/kg bw	> 50 and ≤ 300 mg/kg bw	> 300 and ≤ 2000 mg/kg bw	> 2000 mg/kg bw
Dermal LD50	≤ 50 mg/kg bw	> 50 and ≤ 200 mg/kg bw	> 200 and ≤ 1000 mg/kg bw	> 1000 and ≤ 2000 mg/kg bw	> 2000 mg/kg bw
Inhalation LC50 (4-hr.) gases	≤ 100 ppmV	> 100 and ≤ 500 ppmV	> 500 and ≤ 2500 ppmV	> 2500 and ≤ 20000 ppmV	> 20000 ppmV
Inhalation LC50 (4-hr.) vapors	≤ 0.5 mg/L	> 0.5 and ≤ 2.0 mg/L	> 2.0 and ≤ 10.0 mg/L	> 10.0 and ≤ 20.0 mg/L	> 20.0 mg/L
Inhalation LC50 (4-hr.) dusts and mists	≤ 0.05 mg/L	> 0.05 and ≤ 0.5 mg/L	> 0.5 and ≤ 1.0 mg/L	> 1.0 and ≤ 5.0 mg/L	> 5.0 mg/L

Systemic toxicity

- **Single exposures**
  - A very high score corresponds to the GHS Category 1 for any route of exposure. GHS Category 1 means that there is either a) significant toxicity in humans, based on reliable, good quality human case studies or epidemiological studies, or b) that there is presumed significant toxicity in humans based on animal studies, with significant or severe toxic effects relevant to humans at generally low exposures. Effects occur at the levels shown in Table 57.
  - For single exposure, a high score corresponds to GHS Category 2 for any route of exposure. GHS Category 2 means the chemical is presumed to be harmful to human health based on animal studies with significant toxic effects relevant to humans at generally moderate exposure (or human evidence in exceptional cases). Effects occur at the levels shown in Table 57.
  - A moderate score corresponds to a GHS Category 3 for any route of exposure. GHS Category 3 means that transient target organ effects occur. No specific doses are referenced, but the effects are alleviated once exposure stops.
  - In order to score low, GHS must not classify the chemical, and adequate data must be available, including negative studies.

Table 57. Repeat Exposure Guidance Values from GHS and corresponding scores.

Classification criteria	GHS Category 1	GHS Category 2	GHS not classified
Oral guidance value	< 300 mg/kg bw	> 300 and ≤ 2000 mg/kg bw	> 2000 mg/kg bw/day
Dermal guidance value	≤ 1000 mg/kg bw	> 1000 and ≤ 2000 mg/kg bw	> 2000 mg/Kg-bw/day

Classification criteria	GHS Category 1	GHS Category 2	GHS not classified
Inhalation vapors guidance value	≤ 10 mg/L	> 10 and ≤ 20 mg/L	> 20 mg/L
Inhalation dusts and mists guidance value	≤ 1.0 mg/L	> 1.0 and ≤ 5.0 mg/L	> 5.0 mg/L

- **Repeat exposure**
  - A high score for repeat exposure corresponds with a GHS Category 1. GHS Category 1 means that there is either a) significant toxicity in humans, from reliable, good quality human case studies or epidemiological studies, or b) that there is presumed significant toxicity in humans based on animal studies with significant or severe toxic effects relevant to humans at generally low exposures.
  - A moderate score for repeat exposure corresponds to a GHS Category 2. GHS Category 2 means the chemical is presumed to be harmful to human health, based on animal studies with significant toxic effects relevant to humans at generally moderate exposure (or human evidence in exceptional cases).
  - In order to score low, GHS must not classify the chemical, and it must have adequate data showing a lack of systemic toxicity. Table 58 shows guidance values for repeat exposure toxicity studies by GHS category and corresponding score.

Table 58. Repeat Exposure Guidance Values from GHS and corresponding scores.

Classification criteria	GHS Category 1 (high)	GHS Category 2 (moderate)	Low
Oral guidance value	≤ 10 mg/kg bw	>10 and ≤ 100 mg/kg bw	>100 mg/kg bw/day
Dermal guidance value	≤ 20 mg/kg bw	>20 and ≤ 200 mg/kg bw	>200 mg/Kg-bw/day
Inhalation vapors guidance value	≤ 0.2 mg/L	>0.2 and ≤ 1.0 mg/L	>1.0 mg/L
Inhalation dusts and mists guidance value	≤ 0.02 mg/L	>0.02 and ≤ 0.2 mg/L	>0.2 mg/L

Neurotoxicity

A very high score corresponds to the GHS Category 1 for any route of exposure. GHS Category 1 means that there is either a) significant toxicity in humans, from reliable, good quality human case studies or epidemiological studies, or b) that there is presumed significant toxicity in humans based on animal studies with significant or severe toxic effects relevant to humans at generally low exposures. A high score corresponds to GHS Category 2 for any route of exposure. GHS classifies Category 2 as “presumed to be harmful to human health based on animal studies with significant toxic effects relevant to humans at generally moderate exposure (or human evidence in exceptional cases).” A moderate score corresponds to a GHS Category 3 for any route of exposure. GHS Category 3 means that transient target organ effects occur. In order to score low, GHS must not classify the chemical, and adequate data must be available, including negative studies.

Skin and respiratory sensitization

High sensitization corresponds to a GHS Category 1A, meaning that there is high frequency of occurrence. A moderate score for sensitization corresponds to a GHS Category 1B, meaning there is low to moderate frequency of occurrence. In order for a chemical to score low, GHS must not classify the chemical, and adequate data and negative studies must be available.

Skin and eye irritation

Very high irritation corresponds to a GHS Category 1, meaning that there is irreversible damage. A high score for sensitization corresponds to a GHS Category 2A, meaning that the chemical is irritating. A moderate score corresponds to a GHS Category 2B meaning that the chemical is mildly irritating. In order for a chemical to score low, GHS must not classify the chemical, and adequate data and negative studies must be available.

Environmental fate and transport

Acute aquatic toxicity

Very high acute aquatic toxicity corresponds to a GHS Category 1 ($LC_{50} \leq 1.00$ mg/L). A high score for acute aquatic toxicity corresponds to a GHS Category 2 (LC_{50} between 1.00 and 10.0 mg/L). A moderate score corresponds to a GHS Category 3 (LC_{50} between 10.0 and 100 mg/L). In order for a chemical to receive a score of low, GHS must not classify the chemical, and adequate data and negative studies must be available.

Chronic aquatic toxicity

Very high chronic aquatic toxicity corresponds to an LC_{50} of less than 0.1 mg/L. A high score for chronic aquatic toxicity corresponds to an LC_{50} of 0.1 – 1.0 mg/L. A moderate score corresponds to an LC_{50} of 0.1 – 10 mg/L. In order for a chemical to score low, it must have an LC_{50} of greater than 10 mg/L.

Persistence

Persistence can be assessed by the half-life in the environment, the potential for long-range transport, and biodegradability. Very high persistence is characterized by half-lives greater than 5 days in air, 60 days in water, or 180 days in soil or sediment. High persistence is characterized by half-lives between 2 and 5 days in air, 40 and 60 days in water, and 60 and 180 days in soil or sediment. Moderate persistence is characterized by half-lives between 16 and 40 days in water and 16 and 60 days in soil or sediment. Low persistence means:

- The half-life is less than two days in air or less than 16 days in water or soil.
- The chemical meets the GHS definition of rapid degradability.
- The chemical is considered to “degrade rapidly” under EPA’s SCIL master criteria.

Very low persistence means the chemical meets the 1-day window in the ready biodegradation test (OECD).

Bioaccumulation

Bioaccumulation is based on the bioaccumulation factor (BAF), bioconcentration factor (BCF), log water octanol partitioning coefficient (Log Kow), biomonitoring data, and molecular properties. Table 59 shows the scoring from the GreenScreen® methodology for BCF/BAF and Log Kow (GreenScreen®, Annex 1[157] and Supplement 4). If there is data for multiple measures of bioaccumulation, we will use the highest score.

Table 59. Bioaccumulation measurements and scoring criteria from the GreenScreen® methodology.

Criteria	Very high	High	Moderate	Low	Very low
BCF or BAF	> 5000	> 1000 – 5000	> 500 – 1000	> 100 – 500	≤ 100
Log Kow	> 5.0	> 4.5 – 5.0	> 4.0 – 4.5	—	≤ 4

Notes:

- BCF = bioconcentration factor.
- BAF = bioaccumulation factor.
- Log Kow = water octanol partition coefficient.

[157] https://www.greenscreenchemicals.org/images/ee_images/uploads/resources/GreeScreen1.4-Annex1-1.18.pdf

Supplement 4. Existing hazard assessment methodologies

We relied on the following hazard assessment methodologies to develop our own approach.

GreenScreen® for Safer Chemicals Hazard Assessment Guidance (GreenScreen®)

GreenScreen® is a hazard assessment method[158] aimed at identifying safer alternatives. GreenScreen® categorizes chemicals into four benchmark scores. The lowest (Benchmark 1) identifies chemicals that should be avoided. Benchmark 2 chemicals are considered safer than Benchmark 1 chemicals, earning the designation "use, but continue to search for safer substitutes." Benchmark 3 chemicals are safer than Benchmark 2 chemicals—designated as "use, but still opportunity for improvement." Benchmark 4 chemicals are preferred, safer chemicals. We made a small modification to the carcinogenicity, and reproductive and developmental toxicity scoring described in GreenScreen® Appendix 1, but no other modifications.

EPA's Safer Choice program

The general requirements listed in the SCIL master criteria,[159] as applied by experts in the Safer Choice Program, are intended as a base set of criteria for all chemicals listed on the SCIL and ingredients in Safer Choice recognized products. For some products, there are additional criteria that can be applied, depending on the chemical function and product life cycle characteristics. These criteria make it possible for Safer Choice to ensure that chemicals in labeled products are among the safest in their functional classes and, without exception, cannot be listed carcinogens, mutagens, reproductive or developmental toxicants (CMRs), or persistent, bioaccumulative, and toxic chemicals (PBTs). Also, chemicals that release, degrade to, or form byproducts that are CMRs or PBTs will not be allowed.

Cradle to Cradle Certified® (C2CC®)

Cradle to Cradle Certified® (C2CC®) is a globally recognized way to identify safer consumer products. In order to be certified, products undergo rigorous evaluation for Material Health and other concerns. The C2CC® Material Health Standard Version 3.1 is the most relevant to the Safer Products for Washington program. C2CC® developed the criteria through an open stakeholder process and published the Material Health Certificate™ Standard.[160] Similar to the SCIL and GreenScreen® methodology, C2CC® is grounded in the GHS and includes additional information when available. The C2CC® Material Health Standard scores hazard endpoints as green (optimal chemicals), yellow (moderately problematic chemicals), and red (highly problematic chemicals—target for phase out). C2CC® also developed exposure parameters[161] that can be helpful when hazards cannot be avoided or reduced.

[158] https://www.greenscreenchemicals.org/images/ee_images/uploads/resources/GreeScreen1.4-Annex1-1.18.pdf
[159] http://www2.epa.gov/saferchoice/safer-choice-master-criteria-safer-chemical-ingredients
[160] https://www.c2ccertified.org/resources/detail/material-health-certificate-standard
[161] https://www.c2ccertified.org/resources/detail/exposure-assessment-methodology

Appendix D. Criteria for Feasible and Available

Overview of our criteria

Revised Code of Washington (RCW) 70A.350[162] requires Ecology and Health (jointly "we") to determine whether safer alternatives are "feasible and available" prior to restricting the use of a priority chemical. The statute that our Safer Products for Washington[163] program implements does not define feasible or available. Fortunately, a number of alternatives assessment frameworks and guidance documents provide insight to address "feasible" and "available."

Technical feasibility is often broken into two categories: functional use of the priority chemical and performance of the alternative (Jacobs et al., 2017). Characterizing how the priority chemical functions in the material or product defines the performance requirements for the alternative. Some experts propose considering whether certain priority chemicals represent an essential use (Cousins et al., 2019b). In some cases, a priority chemical may not be necessary for the product to function. Reducing or eliminating a chemical that is not functionally necessary may not require a complete feasibility evaluation.

Availability is included in a number of alternative assessment frameworks, including the Environmental Protection Agency (EPA)'s Design for the Environment Program (EPA, 2011a) and the Interstate Chemicals Clearinghouse Guide for Alternatives Assessment 2017 (IC2 Guide). The IC2 Guide outlines questions to determine whether an alternative is feasible and available. The guide offers multiple levels of complexity to meet different assessment needs.

Criteria development process

We based our process on the IC2 Guide because it provides a framework that aligns with others—such as the National Academy of Sciences (NRC, 2014)—while still offering enough flexibility to meet the requirements in RCW 70A.350.[164] The Interstate Chemicals Clearinghouse, a group of representatives from state and local governments, developed the IC2 Guide. Non-governmental organizations and businesses helped develop the guide as stakeholders (IC2 Guide 2017). Stakeholders participated through:

- Contributing to the initial scoping of the project.
- Reviewing each module in the guide.
- Three industry workshops.
- Two free webinars.
- A 60-day public comment period.

The IC2 Guide offers a number of modules—each with several levels of assessment that increase in detail—for identifying favorable alternatives. The levels allow the assessor to customize the approach to fit the purpose of the assessment.

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[162] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350
[163] https://www.ezview.wa.gov/site/alias__1962/37555/safer_products_for_washington.aspx
[164] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350

We selected a level 1 assessment to determine feasibility and availability. We will use two modules: performance and cost and availability . Level 1 assessments allow us to make a qualitative comparison between alternatives and the priority chemical. The purpose of this assessment is not to recommend one particular alternative but rather to eliminate alternatives that are infeasible or unavailable.

Criteria for feasible and available

To be **feasible**, an alternative must meet at least one of the following criteria:

- Already used for the application of interest or a similar application.
- Marketed for the application of interest or a similar application.
- Identified as feasible by an authoritative body.

To be **available**, an alternative must meet at least one of the following criteria:

- Currently used for the application of interest.
- Offered for sale at a price that is close to the current.

If needed, we will define "close to the current" on a case-by-case basis—relying on existing alternatives assessments and frameworks, as well as stakeholder input.

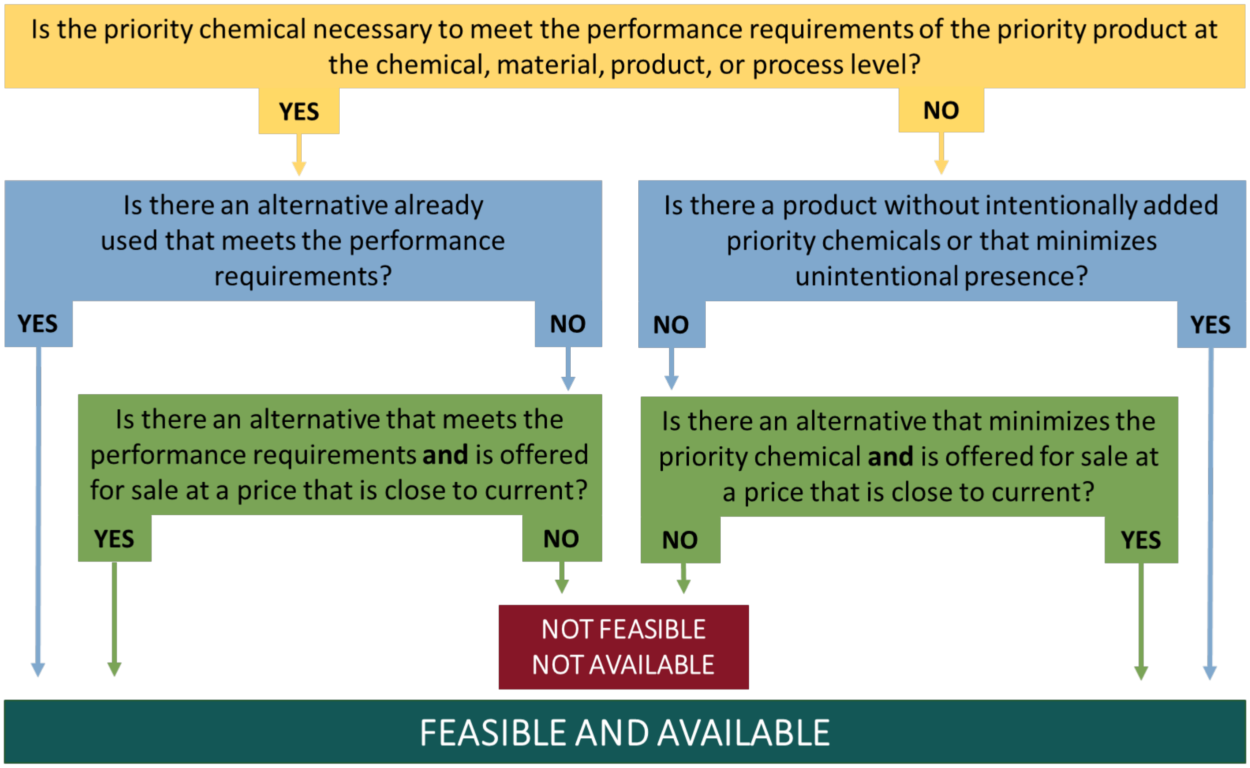
Examples of how to meet the criteria for feasible and available when looking for safer surfactants in detergent include:

- Identifying a detergent using an alternative surfactant.
- Identifying an alternative surfactant that is sold at a price similar to more hazardous surfactants using priority chemicals but is not currently used in detergent.

Figure 7 shows the process for identifying feasible and available alternatives.

- **Step 1** determines whether the priority chemical is necessary for meeting the performance needs of the product.
- **Step 2** determines whether the alternative is already in use. If it is, the alternative is feasible and available.
- If the alternative is not yet in use, **Step 3** determines whether the alternative could be used for the application of interest and whether it's offered for sale at a price that is close to the current.

Figure 7. Process for identifying feasible and available alternatives (modified from the level 1 performance and cost and availability modules from the IC2 guide).



Note: For an accessible text version of this graphic, see Supplement 5.

Step 1: Is the priority chemical necessary for meeting the relevant performance requirements of the priority product at the chemical, material, product, or process level?

We will identify performance requirements by characterizing the function the priority chemical serves at the chemical, material, product, or process level. For example:

- The priority chemical can impact performance at the **chemical level** by acting as a surfactant.
- Plasticizers—such as ortho-phthalates, which make plastic more flexible—impact performance at the **material level**.
- Performance requirements at the **product level** can include fire safety, which flame retardant chemicals could provide.
- Catalysts are chemicals that can impact performance at the **process level**.

We shared preliminary results from our work to identify safer, feasible, and available alternatives, and solicited feedback from stakeholders on our proposed definitions of the performance needs. Industry and manufacturers contributed valuable information about chemical and process requirements. The public and community groups shared useful insight about what concerns them and where additional public education and outreach is needed.

Input from a diverse group of stakeholders helps us not only set realistic expectations for alternatives but also understand over-engineering. Understanding the function the priority chemical serves tells us what the alternative needs to accomplish. In subsequent steps, we use performance requirements as a lens to evaluate alternatives.

If we identify relevant performance requirements associated with the priority chemical, we proceed to Step 2, where we identify alternatives that are already used and that meet the relevant performance requirements.

If we do not identify any relevant performance requirements associated with the priority chemical, we will determine that it is not functionally necessary. We then proceed to Step 2, where we identify products without intentionally added priority chemicals or that minimize unintentional presence.

Step 2: Determine whether there are alternatives already in use, or whether there are products without intentionally added priority chemicals or that minimize unintentional generation.

If the priority chemical provides a necessary function for the relevant performance requirements of the priority product, we will identify alternatives already in use that meet these requirements. Under RCW 70A.350,[165] an alternative can be a "chemical substitute or a change in materials or design that eliminates the need for a chemical alternative."

If the alternative is already in use, we will identify it as feasible and available. If not, we will proceed to Step 3.

If the priority chemical does not provide a necessary function, we will determine whether there is a product without intentionally added priority chemicals or that minimizes unintentional generation.

If the chemical is unintentionally generated, a safer alternative could be a product that minimizes the unintentional generation of the priority chemical. Unintentionally generated chemicals could be:

- Impurities or by-products from the manufacturing process.
- Contamination from source materials.
- Other chemicals unintentionally in the product.

If there is a product either without intentionally added priority chemicals or that minimizes unintentional generation, we will identify it as feasible and available. If not, we proceed to Step 3.

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

Step 3: Is there an alternative that could be used that is offered for sale at a price that is close to the current?

In this step, we assess whether alternatives not yet in use are feasible and available.

If the priority chemical provides a necessary function for the relevant performance requirements of the priority product, we will look for an alternative that could meet those requirements and is offered for sale at a price close to the current.

If the priority chemical is not necessary for meeting the relevant performance requirements of the priority product, we will look for alternative processes or material sources that minimize the priority chemical and are offered for sale at a price close to the current.

For an alternative chemical, alternative process, or alternative material that is not yet in use to be feasible, it must meet at least one of the following criteria:

- Other manufacturers use the alternative for a similar function.
- Similar products that are available on the commercial market use the alternative.
- Others market the alternative in promotional materials as providing the desired function within the application of interest.
- An authoritative body has identified the alternative as feasible.
- An authoritative body identified the alternative as favorable, with some indications that it might not perform as well, but the difference in performance is not crucial to the product.
- An authoritative body identified the alternative as unfavorable, i.e., not a viable alternative based on performance. However, modifications to the process could make the alternative feasible.
- An authoritative body identified the alternative as unfavorable, but the application is not identical to the application of interest, and the process or product can be modified to accommodate the alternative.

If the alternative process is feasible, we will then determine whether it is available. In order to determine whether feasible alternatives that are not yet in use are available, we will consider whether they are offered for sale at a price close to the current. An example could be an alternative surfactant that is sold at a price similar to more hazardous surfactants containing priority chemicals but is not currently used in detergent.

If needed, we will define “close to the current” on a case-by-case basis—relying on existing alternatives assessments and frameworks and with stakeholder feedback. If the alternative is feasible and the price is close to the current, we will identify it as feasible and available.

Supplement 5. Accessible flowchart information

The process for identifying whether a safer alternative is feasible and available, outlined in Figure 7, is as follows:

- **Step 1**: Is the priority chemical necessary to meet the performance requirements of the priority product at the chemical, material, product, or process level?
    - If yes, move to **Step 2** and ask: Is there an alternative already used that meets the performance requirements?
        - If yes, the alternative is feasible and available.
        - If no, move to **Step 3** and ask: Is there an alternative that meets the performance requirements and is offered for sale at a price that close to the current?
            - If yes, the alternative is feasible and available.
            - If no, the alternative is not feasible or available.
    - If no, move to **Step 2** and ask: Is there a product without intentionally added priority chemicals or that minimizes unintentional presence?
        - If yes, the alternative is feasible and available.
        - If no, move to **Step 3** and ask: Is there an alternative that minimizes the priority chemical and is offered for sale at a price that is close to current?
            - If yes, the alternative is feasible and available.
            - If no, the alternative is not feasible or available.

Appendix E. Safer Certifications

Section 1. Overview of how we identify safer alternatives

Safer chemical alternatives must meet our criteria for safer. Chemical alternatives are used to function like priority chemicals. They are identified based on the relevant performance requirements of the priority product. Some hazard assessment methodologies and product certifications assess chemicals or products against criteria as or more stringent than our own. These existing assessments and certifications can be an efficient way for us to identify safer alternatives.

The use of certification or labeling programs is not a requirement. We can assess alternatives against our criteria for safer to determine whether they are safer. However, it makes sense for us to start our evaluation using existing hazard assessments and certification standards that meet our criteria for safer and have transparent and independent review processes.

There are many instances where existing hazard assessment methodologies already evaluated products and chemicals, and some alternatives have certifications or labels. Building on existing work leverages efforts and minimizes the need for businesses to share confidential business information with us.

This appendix identifies existing hazard assessment methodologies and certification standards (section 2) that meet our transparency and independence requirements (section 3) and our criteria for safer (sections 4 through 9). These hazard assessment methodologies and certification standards can be used to identify safer alternatives in other chapters of this report.

Section 2. Hazard assessment methodologies and certification standards reviewed in this document

We identified six hazard assessment methodologies or certification standards that meet our transparency and independence requirements (described below) and have designations for chemicals or products that meet or are likely to meet our criteria for safer. This is a continuous process—more certification standards and hazard assessment methodologies may be added to this list over time.

Included in this evaluation

1. GreenScreen® Benchmark 2, 3, 4 chemicals and GreenScreen® Certified Products
    - GreenScreen® Benchmark 2 chemicals meet the minimum criteria for safer. Some Benchmark 2 chemicals also meet the additional criteria for safer. Benchmark 3 and 4 chemicals meet both the minimum and additional criteria for safer.
    - Some GreenScreen® certified products meet the minimum and additional criteria for safer.
2. TCO Certified Products

    - TCO Certified products meet the minimum criteria for safer if the chemicals under consideration are alternative flame retardants, plasticizers, or process solvents.
3. EPA Safer Chemical Ingredients List (SCIL) and Safer Choice Products
    - Chemicals evaluated against the master criteria and safer choice products with chemicals evaluated against the master criteria meet the minimum and additional criteria for safer. Some chemicals evaluated using functional class criteria will meet our minimum criteria for safer, but others will not.
4. Cradle to Cradle Certified® (C2CC®) products with Silver, Gold, or Platinum Material Health Certificates™
    - Silver, Gold, or Platinum Material Health Certificates™ may meet our minimum criteria for safer. Additional information on unreported ingredients, exposure, persistence, and bioaccumulation may be required to meet our criteria for safer.
5. ChemFORWARD Chemicals in bands A, B, and C
    - ChemFORWARD Bands A and B likely meet our minimum and additional criteria for safer. ChemFORWARD Band C meets our minimum criteria for safer. Confirmation that chronic or acute aquatic toxicity is assessed may be necessary.
6. Scivera GHS+ Green, Yellow/Green, and Yellow chemicals
    - GHS+ Green chemicals meet our minimum and additional criteria for safer.
    - GHS+ Yellow/Green and Yellow meet our minimum criteria for safer.

Section 3. Transparency and independence requirements

Existing hazard assessments or product certification standards can be used to identify alternatives that meet our minimum or additional criteria for safer—as long as the transparency and independence requirements described below are met. These requirements ensure that the hazard assessment includes the chemicals used to function like priority chemicals and their known breakdown products and impurities. They also make sure the hazard assessment is conducted in a reproducible and unbiased manner. Assessments and standards must have:

- Transparent criteria for evaluation.
- Qualified third-party assessors.
- A clear process in place for becoming and remaining certified to promote objectivity and reproducibility.

Ingredient transparency

Hazard assessments must include all chemicals intentionally added to function like priority chemicals, their breakdown products and impurities (down to 100 ppm), and residual monomers (down to 1,000 ppm). Manufacturers must disclose this information to third-party evaluators.

Criteria transparency

Hazard assessments must have publicly available criteria for assessing chemical hazards that meet our minimum data requirements. The criteria must have defined scoring measures to allow us to determine whether it meets or exceeds our criteria for safer.

Third-party assessors

Hazard assessments must have a qualified third-party review process. For example, a manufacturer discloses chemical information to a qualified assessor who completes the assessment and sends it to a qualified third-party reviewer. (If there is no third-party reviewer associated with the hazard assessment method, but the entire hazard assessment can be shared with Ecology—potentially through a confidential business information agreement—it can still be considered.)

To be deemed qualified, third-party assessors and reviewers must have:

- Expertise in toxicology, chemistry, and biology.
- Experience in accessing and interpreting all required chemical, health, and environmental hazard information.

The assessor must have demonstrated competency, using data from human epidemiology studies, animal models, in vitro models, and quantitative structural activity relationship models for toxicity and chemical hazard assessment.

Transparency in the assessment process

Hazard assessment methods must have a publicly available process for how chemicals and products are evaluated, when the evaluation was completed, and the expiration date (if applicable). The required steps can vary but must include ingredient or chemical disclosure and third-party evaluation. If the hazard assessment certifies a product, there must be a defined duration of the certification and requirements for recertification if the product formulation changes.

Data requirements

In order to determine whether the existing hazard assessment method or product standard meets our criteria for safer, we need to know the data requirements and hazard endpoints assessed. Hazard assessment methods must evaluate the endpoints required by our criteria for safer. They must have data requirements as or more stringent than those outlined in our criteria for safer (based on GreenScreen® Benchmark 2 data requirements).

Hazard criteria

To meet our criteria for safer, the hazard assessment method or product standard must have hazard criteria as or more stringent than our criteria for safer. Chemicals must be scored for each of the required hazard endpoints in a way that is consistent with or translatable to our scoring system. The overall scores of chemicals used to function like priority chemicals must meet our minimum or additional criteria for safer. In some cases, existing hazard assessments may meet most, but not all, of our criteria. In those cases, we can work with the manufacturer and third-party assessor to confirm the remaining details needed.

Section 4. GreenScreen® Assessment for Chemicals and GreenScreen® Certified™ Products

GreenScreen® for Safer Chemicals Hazard Assessment Guidance v 1.4 is a hazard assessment method aimed at identifying safer alternatives. GreenScreen® categorizes chemicals into four benchmark scores.

- The lowest, Benchmark 1, identifies chemicals that should be avoided.
- Benchmark 2 chemicals are considered safer than Benchmark 1 chemicals, earning the designation "use, but continue to search for safer substitutes."
- Benchmark 3 chemicals are safer than Benchmark 2 chemicals and designated "use, but still opportunity for improvement."
- Benchmark 4 chemicals are the preferred, safer chemicals.

Benchmark U chemicals do not meet the minimum data requirements to be scored. Resource 1 in Supplement 6 describes the scoring in more detail.

GreenScreen® Certified™ is a product certification program that evaluates several product types using the GreenScreen® method. The criteria for the GreenScreen® Certified™ standard is different for each product, but in some cases, it may meet our criteria for safer. See Supplement 6 for the standards for GreenScreen® Certified™ textiles (Resource 2) and furniture and fabrics (Resource 3).

4.1 Ingredient Transparency

GreenScreen® Chemical Assessments

A GreenScreen® assessment fully assesses the chemical of concern along with known breakdown products. Impurities and residual monomers at concentrations between 100 – 1000 ppm are assessed for carcinogenicity, mutagenicity, and reproductive and developmental toxicity—and fully assessed if present in concentrations greater than 1000 ppm. This meets our ingredient transparency requirement.

GreenScreen® Certified™

For GreenScreen® Certified™ assessments, the level of ingredient transparency varies by certification level.

- Under the Certified Standard for Textile Chemicals (V.2.1), manufacturers of Silver, Gold, and Platinum products must report each intentionally added substance and each impurity present at or above 0.01% by mass (100 ppm) (Resource 2).
- The GreenScreen® Standard for Furniture and Fabrics (V.1.0) requires disclosure of intentionally added chemicals and impurities, residual monomers, and catalysts present over 100 ppm to obtain Gold+ and Silver+ certifications (Resource 3).

Both the Textile Standard (Silver, Gold, and Platinum) and the Furniture and Fabrics Standard (Silver+ and Gold+) meet our ingredient transparency requirement.

4.2 Criteria transparency

GreenScreen® chemical assessments

The GreenScreen® scoring methodology can be found in Resource 1 and on the GreenScreen® website.[166]

GreenScreen® Certified™

The Textile Certification (V.2.1) and the Furniture and Fabrics (V.1.0) Standard are publicly available and fully transparent (Resources 2 and 3).

4.3 Third-party assessors

GreenScreen® chemical assessments

We will only accept GreenScreen® assessments conducted by licensed profilers. Manufacturers provide data to licensed profilers, who complete the GreenScreen® assessment. GreenScreen® profilers are organizations that must have:

- Expertise in toxicology, chemistry, and biology.
- Experience in accessing and interpreting all required chemical, health, and environmental hazard information.
- Demonstrated expertise in the GreenScreen® method.

If a redacted GreenScreen® is submitted to Ecology, the unredacted version must have been reviewed by a qualified third party (separate from the manufacturer and assessor). Clean Production Action collected a list of licensed profilers[167] with expertise in toxicology, training in the GreenScreen® method, and GreenScreen® Certified™ assessments.

GreenScreen® Certified™

GreenScreen® Certified™ products have been assessed by licensed GreenScreen® profilers[168] and verified by Clean Production Action. The process for certification is publicly available and described in annex 2 of the standard for each product certification (Resources 2 and 3).

[166] https://www.greenscreenchemicals.org/learn/guidance-and-method-documents-downloads
[167] https://www.greenscreenchemicals.org/certified/service-providers
[168] https://www.greenscreenchemicals.org/certified/service-providers

4.4 Transparency in the process

GreenScreen® chemical assessments

GreenScreen® chemical assessments are conducted by a licensed profiler with expertise in toxicology and training in the GreenScreen® method. These policies are publicly available on the GreenScreen® website.[169] GreenScreen® Benchmark 1 assessments do not expire but may be updated. GreenScreen® Benchmark U, 2, 3, and 4 assessments are valid for five years.

GreenScreen® Certified™

Product certifications have transparent, publicly available processes and renewal requirements (annex 2 of Resources 2 and 3). Both the Textile Chemicals Standard (V.2.1) and the Furnishing and Fabrics Standard (V.1.0) describe the terms and conditions for certifications. Certifications are valid for five years and require an annual renewal (Resources 2 and 3). During the annual renewal, manufacturers must attest that there have been no changes to the product's chemical composition. If there have been changes, reassessment may be necessary.

4.5 Data Requirements:

GreenScreen® chemical assessments

GreenScreen® Benchmark 2, 3, and 4 scores meet our data requirements. Data requirements for the hazard endpoints are shown in Table 60 below. The chemical being evaluated is fully assessed and impurities, residual monomers, and known breakdown products at concentrations between 100 – 1,000 ppm are assessed for carcinogenicity, mutagenicity, and reproductive and developmental toxicity—and fully assessed if present in concentrations over 1,000 ppm.

Table 60. Sufficient data to assign a score as described in the Safer Products for Washington safer criteria is required for the following endpoints.

Hazard Endpoint	Requirement
Carcinogenicity	Required
Mutagenicity/Genotoxicity	Required
Reproductive or Developmental Toxicity	Required
Endocrine Disruption	Not required
Acute Toxicity	Not always required*
Single or Repeat Systemic Toxicity	Not always required*
Single or Repeat Neurotoxicity	Not always required*
Skin or Respiratory Sensitization	Required
Skin or Eye Irritation	Not required
Acute or Chronic Aquatic Toxicity	Required
Persistence	Required
Bioaccumulation	Required

Note: * = Two out of these three endpoints require data.

[169] https://www.greenscreenchemicals.org/assess/gs-professionals

GreenScreen® Certified

GreenScreen® Certified™ Silver and Gold textiles evaluate chemicals using the GreenScreen® assessment method and require data to meet, at minimum, GreenScreen® Benchmark 2 requirements (Resource 2). These requirements (described above), meet our data requirements.

- Furniture and Fabrics Certification (V.1.0): GreenScreen® Certified™ Gold+ furniture and fabrics evaluate chemicals using the GreenScreen® assessment method and require data to meet, at minimum, GreenScreen® Benchmark 2 requirements (Appendix 3). While GreenScreen® Certified™ Silver+ furniture and fabrics meet our ingredient transparency standard, they are assessed against a comprehensive restricted substance list in lieu of a GreenScreen® assessment. Therefore, data on hazard endpoints is not required and the Silver+ certification does not meet our data requirements (Resource 3).
- Textile Chemicals (V.2.1): GreenScreen® Certified Gold and Platinum textile chemicals have been evaluated against chemicals using the GreenScreen® assessment method and require data to meet, at minimum, GreenScreen® Benchmark 2 (Gold) or GreenScreen® Benchmark 3 (Platinum) requirements.

4.6 Hazard Criteria

GreenScreen® Chemical Assessments

GreenScreen® Benchmark 2 chemicals meet our minimum criteria for safer and Benchmark 3 and 4 chemicals meet our additional criteria for safer. Some Benchmark 2 chemicals may meet the additional criteria for safer, but it depends on the combination of hazards present. GreenScreen® scores chemicals as very low, low, moderate, high, or very high largely based on criteria in the Globally Harmonized System for the Classification and Labeling of Chemicals (GHS).

Our scoring system of individual hazard endpoints is derived from GreenScreen® and described in detail in the criteria for safer. Because we derived our scoring system from the GreenScreen® method, chemicals that score low, moderate, or high in GreenScreen® will score the same in our criteria.

Table 61 shows the maximum possible hazard scores for Benchmark 2 chemicals. This scoring meets our minimum criteria for safer by eliminating chemicals with high hazards for carcinogenicity, mutagenicity, reproductive or developmental toxicity, and endocrine disruption or high concerns over persistence and bioaccumulation.

Table 62 shows the maximum possible hazard scores for Benchmark 3 chemicals. Benchmark 3 and 4 chemicals meet our additional criteria for safer by requiring data that shows they are not carcinogenic, mutagenic, reproductive or developmental toxicants, or endocrine disruptors. It also further reduces acceptable persistence and bioaccumulation concerns.

Table 61. Scoring matrix for GreenScreen® Benchmark 2 chemicals. Data is not required for all endpoints. (See Table 60 for data requirements.)

	Carcinogenicity	Genotoxicity/ Mutagenicity	Reproductive Toxicity	Developmental Toxicity	Endocrine Activity	Acute Toxicity	Systemic Toxicity (single)	Systemic Toxicity (repeat)	Neurotoxicity (single)	Neurotoxicity (repeat)	Skin Sensitization	Respiratory Sensitization	Skin Irritation	Eye Irritation	Acute Aquatic Toxicity	Chronic Aquatic Toxicity	Persistence (P)	Bioaccumulation (B)
Max Hazard Profile 1	M	M	M	M	M	vH	vH	vH	vH	vH	vH	vH	vH	vH	vH	vH	M	H
Max Hazard Profile 2	M	M	M	M	M	vH	vH	vH	vH	vH	vH	vH	vH	vH	vH	vH	H	M
Max Hazard Profile 3	M	M	M	M	M	H	H	M	H	M	M	M	H	H	H	H	H	vH
Max Hazard Profile 4	M	M	M	M	M	H	H	M	H	M	M	M	H	H	H	H	vH	H

Table 62. Scoring matrix for GreenScreen® Benchmark 3 chemicals. Data is not required for all endpoints. (See Table 60 for data requirements.)

	Carcinogenicity	Genotoxicity/ Mutagenicity	Reproductive Toxicity	Developmental Toxicity	Endocrine Activity	Acute Toxicity	Systemic Toxicity (single)	Systemic Toxicity (repeat)	Neurotoxicity (single)	Neurotoxicity (repeat)	Skin Sensitization	Respiratory Sensitization	Skin Irritation	Eye Irritation	Acute Aquatic Toxicity	Chronic Aquatic Toxicity	Persistence (P)	Bioaccumulation (B)
Max Hazard Profile 1	L	L	L	L	L	H	H	M	H	M	M	M	H	H	H	H	M	L
Max Hazard Profile 2	L	L	L	L	L	H	H	M	H	M	M	M	H	H	H	H	L	M
Max Hazard Profile 3	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	M
Max Hazard Profile 4	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	M	H

GreenScreen® Certified™ products

- Furniture and Fabrics Certification: GreenScreen® Certified™ Gold+ requires all chemicals be Benchmark 2 or higher. This meets our minimum criteria for safer.
- Textile Chemicals Certification: GreenScreen® Certified™ Gold requires all chemicals be Benchmark 2 or higher. This meets our minimum criteria for safer. GreenScreen® Certified™ Platinum requires all chemicals be Benchmark 3 or higher. This meets our additional criteria for safer.

4.7 Conclusion

GreenScreen® chemical assessments

GreenScreen® Benchmark 2 chemicals meet our minimum criteria for safer. GreenScreen® Benchmark 3 and 4 chemicals meet our additional criteria for safer.

GreenScreen® Certified™

GreenScreen® Certified™ Textile Chemicals Gold (V.2.1) meet our minimum criteria for safer and GreenScreen® Certified™ Textile Chemicals Platinum meet our additional criteria for safer. GreenScreen® Certified™ Gold+ furniture and fabrics (V.1.0) meet our minimum criteria for safer. This is summarized in Table 63 below.

Table 63. GreenScreen® Benchmark scores and certifications that meet our minimum or additional criteria for safer.

Assessment or certification	Ingredient transp.	Criteria transp.	Third-party review	Process transp.	Data req.	Minimum criteria for safer	Additional criteria for safer
GreenScreen® Benchmark 2	X	X	X	X	X	X	
GreenScreen® Benchmark 3	X	X	X	X	X	X	X
GreenScreen® Benchmark 4	X	X	X	X	X	X	X
GreenScreen® Certified™ Gold+ (fabric and furniture)	X	X	X	X	X		
GreenScreen® Certified™ Gold (textile chemicals)	X	X	X	X	X	X	
GreenScreen® Certified™ Platinum (textile chemicals)	X	X	X	X	X	X	X

Notes:

- transp. refers to transparency.
- req. refers to requirements.

Section 5. TCO Certified

TCO Certified is a global sustainability certification for electronic products, including computers, mobile devices, display products, and data center products. Criteria include reduction of hazardous substances, including flame retardants, in addition to social responsibility, energy reduction, sustainability, and others to move toward a circular economy.

TCO Development updates its criteria regularly with newer and more protective "generations," or versions. TCO Certified uses the GreenScreen® methodology (see Section 4 of this document for more information) to identify safer alternatives for the functions identified on the TCO Certified Accepted Substance List. The certification criteria is updated every three years, but the list of accepted substances is updated more often. Compliance with criteria is independently verified during the certificate's full validity period. TCO Certified is a Type 1 third-party certification in accordance with ISO 14024.

5.1 Ingredient transparency

TCO Certified does not require manufacturers to fully disclose all ingredients and will not meet ingredient transparency requirements for every application. However, in TCO Certified generation 8, plasticizers and flame retardants are fully disclosed and must score GreenScreen® Benchmark 2 or higher. TCO Certified generation 9 includes process chemicals in addition to plasticizers and flame retardants, and these have been added to the TCO Certified Accepted Substance List.

The TCO Certified Accepted Substance List[170] can be found in Supplement 6 (Resource 4). Although we do not know all the ingredients, we know that for specific chemical functions (plasticizer, flame retardant, and process chemicals) the chemical used must be one of the chemicals found on the accepted substance list. This meets our criteria for transparency when we are looking for alternatives for specific functions.

If additional functional groups are added, such as industrial cleaners, then those would also meet our transparency criteria. Because these chemicals are evaluated using the GreenScreen® method, breakdown products and impurities are evaluated down to 100 ppm and residual monomers are evaluated down to 1,000 ppm.

[170] https://tcocertified.com/accepted-substance-list/

5.2 Criteria transparency

TCO Certified has transparent criteria for each product type. Find the certification documents in Supplement 6 (Resource 5). The hazard criteria used to evaluate flame retardants, plasticizers, and process chemicals is the GreenScreen® method described above. This method evaluates data on 18 hazard endpoints and scores each endpoint using a standard scoring system. GreenScreen® Benchmark 2 chemicals meet our minimum criteria for safer. GreenScreen® Benchmark 3 and 4 chemicals meet our additional criteria for safer.

5.3 Third-party assessors

The accepted substance list is comprised of chemicals that have been evaluated using the GreenScreen® method by a third-party Licensed GreenScreen® Profiler. Authorized GreenScreen® profilers have been trained in the GreenScreen® method and have expertise in toxicology, chemistry, and biology. TCO Development reviews the GreenScreen® reports. Flame retardants, plasticizers, and process chemicals that are not on the TCO Certified Accepted Substance List may be assessed by a Licensed GreenScreen® Profiler and added to the TCO Certified Accepted Substance List if they are Benchmark 2 or higher.

5.4 Transparency in the process for continuing to be certified or labeled

TCO Development provides publicly available guidance on their website[171] for companies interested in obtaining certifications. After becoming certified, each brand is reviewed on an annual basis, including spot checks and retesting.

5.5 Data requirements

TCO Certified requires chemicals on the accepted substance list to be GreenScreen® Benchmark 2 or higher. GreenScreen® Benchmark 2 chemicals meet our data requirements, as described above.

5.6 Hazard criteria

TCO Certified requires chemicals on the accepted substance list to be GreenScreen® Benchmark 2 or higher. GreenScreen® Benchmark 2 meets our minimum criteria for safer (see more in Section 4). Since the certification does not reveal if the flame retardants or plasticizers used in the products are Benchmark 2 or 3, certified products do not meet our additional criteria without further assessment.

5.7 Conclusion

TCO Certified products meet the minimum criteria for alternatives to flame retardants or plasticizers. As the TCO Certified Accepted Substance List grows, other functions like process chemicals may also meet our minimum criteria.

[171] https://tcocertified.com/step-by-step-guide-for-brands/

Table 64. TCO Certified products meet the minimum criteria for safer alternatives to flame retardants or plasticizers.

Certification	Ingredient transp.	Criteria transp.	Third-party assessors	Process trans.	Data req.	Minimum criteria	Additional criteria
TCO Certified*	X	X	X	X	X	X	

Notes:

- * = For plasticizers and flame retardants.
- transp. refers to transparency.
- req. refers to requirements.

Section 6. Safer Chemical Ingredients List and Safer Choice Products

EPA manages the Safer Chemical Ingredients List (SCIL) and Safer Choice Labeling program to identify chemicals and products that are safer. SCIL contains chemicals that have been thoroughly evaluated and are found to meet specific hazard criteria. The Safer Choice label is an EPA program that identifies safer products after thoroughly reviewing their ingredients for hazards.

The general requirements listed in the Safer Choice Master Criteria[172] (Resource 6), as applied by EPA technical experts, are intended as a base set of criteria for most chemicals listed on SCIL and ingredients in Safer Choice recognized products. For some products, there are functional-class criteria that are applied instead of the master criteria. The functional-class criteria allow for the identification of "best in class" options but are not held to the data requirements of the master criteria.

6.1 Ingredient transparency

Chemicals listed on SCIL are assessed as well as any known breakdown products or residual monomers present at concentrations greater than 100 ppm.

In Safer Choice products, all intentionally added chemicals are assessed, though chemicals for specific functions are only assessed against their specific functional-class criteria. Impurities, residual monomers, and known breakdown products are assessed at concentrations greater than 100 ppm.

6.2 Criteria transparency

The SCIL master criteria can be found in Supplement 6 (Resource 6) and online. All Safer Choice products have ingredients that meet the SCIL master criteria or relevant functional-class criteria.

[172] http://www2.epa.gov/saferchoice/safer-choice-master-criteria-safer-chemical-ingredients

6.3 Third-party assessors

SCIL chemicals and Safer Choice products are assessed by third parties and reviewed by EPA staff. Third-party profilers must have appropriate staff to perform hazard assessments, including those with training in toxicology, chemistry, and biology. The qualification requirements[173] are publicly available. They must be able to:

- Assess and interpret diverse toxicological and environmental information.
- Assess and manage chemical, health, and environmental hazard information.
- Demonstrate skill at using EPA and other physical-chemical and environmental estimation models and software.
- Securely handle proprietary business information.

6.4 Transparency in the process for continuing to be certified or labeled

EPA established a clear, publicly available process for getting a chemical evaluated on SCIL[174] and getting products evaluated for Safer Choice.[175] The process includes ingredient transparency, third-party assessors, and entering into an agreement with the Safer Choice program for continued improvement of environmental and human health benefits.

6.5 Data requirements

The SCIL master criteria meets our data requirements. SCIL identifies chemicals as Green Circle, Green Half-Circle, or Yellow Triangle based on the types of data available to assess hazards. Green Circle and Green Half-Circle chemicals meet the SCIL criteria based on experimental and modeled data. Additional data would strengthen the confidence of the analysis for Green Half-Circle chemicals. Yellow Triangle chemicals have data gaps or are associated with hazards that do not meet the master criteria.

Table 65 shows the endpoints required for green circle and green half-circle chemicals evaluated against the master criteria. In order to meet the master criteria, sufficient data to assign a score using the scoring method described in Section 5.2.3 is required for the endpoints in Table 65. Sufficient data include authoritative lists, and experimental and modeled data.

Table 65. Required endpoints for chemicals meeting the SCIL master criteria

Hazard Endpoint	Requirement
Carcinogenicity	Required
Mutagenicity/Genotoxicity	Required
Reproductive or Developmental Toxicity	Required
Endocrine Disruption	Not required
Acute Toxicity	Required
Systemic Toxicity	Repeat exposure is required

[173] https://www.epa.gov/sites/production/files/2014-01/documents/third_party_profiler_qualifications.pdf
[174] https://www.epa.gov/saferchoice/how-list-chemical-safer-chemical-ingredients-list
[175] https://www.epa.gov/saferchoice/steps-get-safer-choice-label-your-product

Hazard Endpoint	Requirement
Neurotoxicity	Repeat exposure is required
Skin or Respiratory Sensitization	Required
Skin or Respiratory Irritation	Not required
Eye Irritation	Not required
Aquatic Toxicity	Acute aquatic toxicity is required
Persistence	Required
Bioaccumulation	Required

Some SCIL chemicals are assessed against functional criteria and not the master criteria. SCIL chemicals evaluated against functional criteria may meet the data requirements for our criteria for safer—they are evaluated on a case-by-case basis.

The functional class criteria can be found in Supplement 6 (Resource 7). We evaluated the processing aids and additives criteria, polymer criteria, solvent criteria, and preservative criteria. In some cases green circles and green half-circle chemicals can meet our minimum or additional criteria for safer.

The Safer Choice processing aids and additives meet our minimum and additional criteria for safer. The processing aids and additives criteria apply to chemicals with long-standing histories of safe use that are typically considered commodity or generic chemicals. Chemicals that meet this functional class must not be carcinogens, mutagens, reproductive toxicants, or PBTs. There are eleven subgroups within this functional class. Each subgroup has additional conditions of use chemicals must meet. When using the processing aids and additives functional class criteria, we confirmed that the chemical met the additional considerations for the subgroup, such as pH limits for acids. See our criteria for safer for more information.

The Safer Choice polymer criteria meets our minimum criteria, except for the allowance for PFAS in floor finishes. Floor finishes are not currently a priority product. Both the polymer and its degradation products must not be carcinogens, mutagens, reproductive toxicants, or PBTs. The polymer is also assessed for acute mammalian toxicity, repeated dose systemic toxicity, skin sensitization, aquatic toxicity, persistence, and bioaccumulation (EPA, 2015b).

The Safer Choice functional criteria for solvents, fragrances, and for preservatives and additives may meet our minimum criteria with additional information. These criteria consider a number of relevant hazard endpoints but do not address all endpoints our criteria for safer requires. The Safer Choice solvent criteria considers carcinogenicity, neurotoxicity, acute toxicity, reproductive and developmental toxicity, repeat dose toxicity, persistence, bioaccumulation, and aquatic toxicity (EPA, 2009b). Other information may be used to confirm mutagenicity and sensitization to meet our criteria.

Safer Choice products contain chemicals assessed against the master criteria or the functional class criteria. Therefore, if we know the function of the chemical alternatives in safer choice products, we can determine which criteria they have been evaluated against and whether those criteria meet our minimum or additional criteria.

6.6 Hazard criteria

Chemicals that pass the SCIL master criteria correspond to low or moderate hazards using our scoring system, derived from the GreenScreen® methodology (Table 66). Green Circle and Green Half-Circle chemicals meet the SCIL master criteria. Yellow Triangle and Grey Square chemicals do not meet the SCIL master criteria. The highest allowable hazards under the SCIL master criteria correspond to a hazard profile that meets our minimum and additional criteria for safer.

Table 66. Scoring matrix for chemicals that pass the SCIL master criteria.

	Carcinogenicity	Genotoxicity/Mutagenicity	Reproductive Toxicity	Developmental Toxicity	Endocrine Activity	Acute Toxicity	Systemic Toxicity (repeat)	Neurotoxicity (repeat)	Skin Sensitization	Respiratory Sensitization	Acute Aquatic Toxicity	Persistence	Bioaccumulation
Max Hazard Profile 1	LL	L	L	L	M	L	L	L	L	L	vH	vL	M
Max Hazard Profile 2	LL	L	L	L	M	L	L	L	L	L	L	M	M

Note: LL (likely low) indicates that there is no data to suspect that the chemical is carcinogenic, but there is insufficient data to assign a score of L.

Carcinogenicity

Chemicals that are known, presumed (Category 1), or suspected (Category 2) human carcinogens under GHS do not pass the SCIL master criteria. Chemicals with limited or marginal evidence of carcinogenicity in animals also do not pass the SCIL master criteria. Our criteria allow for chemicals with limited or marginal evidence of carcinogenicity in animals, if they are not very persistent and not very bioaccumulative.

The SCIL master criteria do not require evidence of lack of carcinogenicity but exhaust all sources of data gathering and modeling. If any source of data indicates carcinogenicity, the chemical will not pass the SCIL master criteria. Therefore, even though chemicals that pass the SCIL master criteria may not score low in our criteria, they would not score high or moderate. We assign this a value of “likely low.” The SCIL master criteria meet our minimum and additional criteria for carcinogenicity.

Mutagenicity and genotoxicity

Chemicals considered mutagens or genetic toxicants do not pass the SCIL master criteria. Evidence of mutagenicity *in vitro* and/or *in vivo* means a chemical will fail to meet the SCIL master criteria. Mutagenicity and genotoxicity effects include:

- Heritable germ cell mutagenicity (including gene mutation and chromosome mutation).
- Germ cell genetic toxicity.
- Somatic cell mutagenicity or genetic toxicity.

Our criteria allow for suspected mutagens that have limited or marginal data in animals. The SCIL master criteria meet our minimum and additional criteria for mutagenicity.

Reproductive and developmental toxicity

Chemicals do not pass the SCIL master criteria if they:

- Are listed as known or suspected reproductive or developmental toxicants using the GHS criteria.
- Demonstrate adverse effects at doses at or below the values in Table 67.

Our criteria does not allow for chemicals that are known reproductive or developmental toxicants but does allow for suspected reproductive or developmental toxicants. The SCIL master criteria for reproductive and developmental toxicity meet our minimum and additional criteria.

Table 67. Lowest Observable Effects Levels that pass the SCIL master criteria for reproductive and developmental toxicity by exposure route.

Exposure route	Guidance value
Oral	250 mg/kg-bw/day
Dermal	500 mg/kg-bw/day
Inhalation (vapor/gas)	2.5 mg/L/6h/day
Inhalation (dust/mist)	0.5 mg/L/6h/day

Endocrine disruption

Chemicals can pass the SCIL master criteria with a data gap for endocrine disruption. However, if data is available showing endocrine disruption and an adverse health outcome (such as cancer), the chemical will not pass the SCIL master criteria.

Chemicals with evidence of endocrine disruption and adverse health outcomes score high in our criteria and do not pass the SCIL master criteria. The SCIL master criteria meet our minimum and additional criteria for endocrine disruption.

Acute toxicity

Chemicals that pass the SCIL master criteria have LD_{50} greater than the guidance values in Table 68. These values correspond to an acute toxicity score of low using our criteria. Under certain circumstances, we allow for chemicals with very high acute toxicity in our criteria. The SCIL master criteria meet our minimum and additional criteria for acute toxicity.

Table 68. LD_{50} must be greater than the GHS Guidance Values to pass the Safer Chemical Ingredient criteria for acute toxicity.

Exposure route	Guidance value
Oral	2,000 mg/kg-bw/day
Dermal	2,000 mg/kg-bw/day
Inhalation (vapor/gas)	20 mg/L/6h/day
Inhalation (dust/mist)	5 mg/L/6h/day

Systemic toxicity

SCIL master criteria use guidance values from 90-day repeat exposure studies to determine whether chemicals meet the systemic toxicity criteria. Table 69 shows GHS guidance values for 90-day repeat exposure studies. Effects above these guidance values correspond to low systemic toxicity using our scoring system. Our minimum criteria allow for chemicals with high systemic toxicity. The SCIL master criteria meet our minimum and additional criteria for systemic toxicity.

Table 69. Lowest Observable Effects Levels must be greater than the GHS guidance values to pass the Safer Chemical Ingredient criteria for repeat exposure systemic toxicity.

Exposure route	Guidance value
Oral	100 mg/kg-bw/day
Dermal	200 mg/kg-bw/day
Inhalation (vapor/gas)	1.0 mg/L/6h/day
Inhalation (dust/mist)	0.2 mg/L/6h/day

Neurotoxicity

SCIL master criteria evaluate neurotoxicity based on the same criteria as the repeat exposure studies for systemic toxicity. GHS guidance values for 90-day repeat exposure studies must exceed those shown in Table 69. These guidance values correspond to low neurotoxicity using our scoring system. Our criteria allow for high repeat exposure neurotoxicity. The SCIL master criteria meet our minimum and additional criteria for neurotoxicity.

Skin and respiratory sensitization

GHS Category 1A and 1B skin and respiratory sensitizers fail to meet the SCIL master criteria. Category 1A reflects a high frequency of occurrence or sensitization rate in humans. Category 1B reflects a low to moderate frequency of occurrence or sensitization rate in humans. These GHS categories correspond to high and moderate sensitizers in our scoring system. Our criteria allow for moderate and high sensitizers. The SCIL master criteria meet our minimum and additional criteria for skin and respiratory sensitization.

Aquatic toxicity, persistence, and bioaccumulation

In order to meet the SCIL master criteria, a chemical that is an acute aquatic toxicant (i.e., the concentration that is lethal or effective or inhibitory in 50% of the test subjects [L/E/IC50] is < 100 ppm), must biodegrade rapidly and not be bioaccumulative (see Table 70, rows 1 through 3). If a chemical has low aquatic toxicity (Table 70, line 4), then its half-life must be less than 60 days. Our criteria for safer consider chemicals with half-lives shorter than 60 days as moderately persistent. Moderately persistent chemicals can meet our criteria for safer. A bioconcentration factor of less than 1,000 correlates to moderate or lower bioaccumulation. Moderately bioaccumulative chemicals can meet our criteria for safer. The SCIL master criteria meet our minimum and additional criteria for bioaccumulation and persistence.

Table 70. Persistence and aquatic toxicity criteria for the Master Criteria. Bioaccumulation potential must always be < 1000 (BCF or BAF).

Scenario	Acute aquatic toxicity (L/E/IC50)	Persistence (measured by biodegradation test without degradation products of concern)
Scenario 1	If ≤ 1ppm	Then may be acceptable if the chemical meets the 10 day window of biodegradation
Scenario 2	If > 1 ppm and ≤ 10 ppm	Then the chemical must meet the 10 day window for biodegradation
Scenario 3	If > 10 ppm and < 100 ppm	Then the chemical must reach the pass level within 28 days
Scenario 4	If ≥ 100ppm	Then the chemical need not reach the pass level within 28 days. Half-life must be < 60 days.

Notes:

- The concentration that is lethal or effective or inhibitory in 50% of the test subjects (L/E/IC50).
- Bioconcentration factor (BCF).
- Bioaccumulation faction (BAF).

Safer Choice products

Safer Choice products contain chemicals evaluated against SCIL master criteria or functional-class criteria. Some chemicals evaluated using functional-class criteria will meet our minimum criteria for safer, but others will not. Therefore, if we are assessing a Safer Choice product as a potential alternative, we will need to consider the function of the alternative chemicals to determine whether they have been evaluated against hazard criteria that meets our minimum or additional criteria for safer.

6.7 Conclusion

Chemicals on SCIL that have been evaluated against the master criteria meet our minimum and additional criteria for safer. Safer Choice products and chemicals evaluated against functional criteria may meet our minimum and additional criteria for safer.

Table 71. SCIL that have been evaluated against the master criteria and some Safer Choice Products meet our ingredient transparency, data requirements, and minimum and additional criteria for safer.

Designation	Ingredient transp.	Criteria transp.	Third-party review	Process transp.	Data req.	Minimum criteria for safer	Additional criteria for safer
SCIL* Green Circle	X	X	X	X	X	X	X
SCIL* Green Half-Circle	X	X	X	X	X	X	X
Safer Choice Products**	X	X	X	X	X	X	X

Notes:

- * = For chemicals that have been evaluated against the master criteria.
- ** = If the chemicals used for the function of priority chemicals have been evaluated against the master criteria, Safer Choice products meet our data requirements. Chemicals evaluated using functional criteria will be assessed on a case-by-case basis.
- transp. refers to transparency.
- req. refers to requirements.

Section 7. Cradle to Cradle® Certification Program

Cradle to Cradle Certified® (C2CC®) is a globally recognized way to identify safer consumer products. In order to be certified, products undergo rigorous evaluation for Material Health in addition to Material Reuse, Renewable Energy and Carbon Management, Water Stewardship, and Social Fairness. Products are assigned a level based on their lowest scoring category (Bronze, Silver, Gold, or Platinum).

This analysis only includes the Material Health category. This analysis discusses the C2CC® Material Health Standard V 3.1. Version 4.0 was released in March 2021 and will be used to evaluate future products that have been assessed with this newer version. The criteria were developed through a stakeholder process and are available in Appendix 8. Similar to the SCIL and GreenScreen® methodology, the C2CC® Material Health Standard is grounded in the GHS and includes additional information when available.

7.1 Ingredient disclosure

For products with Gold or Platinum Material Health Certificates™, all intentionally added chemicals are assessed. Impurities and known breakdown products are assessed at concentrations greater than 100 ppm. Residual monomers are assessed at concentrations greater than 1000 ppm. (In the next version of the Material Health Standard, Version 4.0, residual monomers will be assessed at concentrations greater than 100 ppm.)

Products with Silver Material Health Certificates™ have 95% of ingredients assessed. If we can confirm that the chemicals used to function like priority chemicals are included in the 95% of ingredients assessed, products with Silver Material Health Certificates™ would meet our transparency criteria.

7.2 Criteria transparency

The C2CC® Material Health Standard V 3.1 and V 4.0 can be found in Supplement 6 (Resource 8) and online.

7.3 Third-party assessors

Chemicals and products are assessed by accredited third parties and reviewed by Cradle to Cradle Products Innovation Institute (C2CPII). Find third-party assessment bodies on the Cradle to Cradle website.[176] Assessment bodies have expertise in toxicology, chemistry, and biology and have been accredited to use the C2CC® assessment methodology. In addition to reviewing the assessments conducted by third parties, C2CC® also audits their assessors to ensure method consistency and compliance. The assessment scheme[177] and third-party assessor process follow ISO standards 19011 and 17065, which provide guidance to certification bodies and audit management systems.

7.4 Transparency in the process for continuing to be certified or labeled

Manufacturers work with C2CC® and a third-party assessor to disclose product ingredients and formulations. The assessor evaluates the chemicals in the product using the Material Health Standard. If the requirements are met, the product can be certified. Recertification is necessary every two years. The assessment scheme is based on ISO standards 19011 and 17065 to support an unbiased and fair certification process.[178]

7.5 Data requirements

The chemical assessment guidance used for the C2CC® Gold, Platinum, Silver, and Bronze Material Health Certificates™ meet our data requirements. For Silver and Bronze Certified products, we must confirm the certification assessed the chemicals replacing priority chemicals. For chemicals evaluated, C2CC® considers the hazard endpoints shown in Table 72. For each endpoint, experimental data, modeled data, or authoritative sources are used.

When data from multiple sources are conflicting, the most conservative finding is used, unless there is compelling reason to do otherwise from a weight of evidence approach. The specific types of data required are discussed for each endpoint in Section 7.6. It is important to note that products with C2CC® Silver Material Health Certificates™ are not required to disclose all ingredients. If the chemicals used to replace priority chemicals are included in the analysis, they are evaluated against chemical hazard data requirements that meet our data requirements.

[176] https://www.c2ccertified.org/get-certified/find-an-assessor
[177] https://cdn.c2ccertified.org/resources/certification/policy/POL_Cert_Scheme_v1.3__040520.pdf
[178] https://cdn.c2ccertified.org/resources/certification/policy/POL_Cert_Scheme_v1.3__040520.pdf

Two differences in the data requirements between C2CC® and our criteria are how they address environmental toxicity (aquatic toxicity, persistence, and bioaccumulation) and carcinogenicity. Our criteria require data on aquatic toxicity. C2CC® allows for a data gap for aquatic toxicity, if persistence and bioaccumulation are low and water solubility is low. This data gap allowance is acceptable for a chemical being assessed against our criteria because chemicals with low persistence and bioaccumulation can have very high aquatic toxicity and still meet our minimum criteria for safer.

Similarly, if aquatic toxicity is low, C2CC® allows data gaps or very high scores for persistence and bioaccumulation in V3.1. This scenario does not meet our criteria for safer. Therefore, we will require follow-up data from the C2CC® assessor—which we request from the manufacturer—confirming that the chemicals used to function like priority chemicals have data for persistence and bioaccumulation and are not very persistent and very bioaccumulative. This declaration is discussed further below (Section 7.6).

C2CC® Material Health Standard V4.0 will no longer allow for very persistent and very bioaccumulative chemicals in Gold and Platinum products. C2CC® requires a thorough investigation into carcinogenicity. Chemicals that are known or suspected carcinogens are scored “red” and are not allowed in products with Gold or Platinum Material Health Certificates™. Chemicals with equivocal or marginal evidence of carcinogenicity score “yellow” and can be found in products with Gold or Platinum Material Health Certificates™.

In order to score “green,” a chemical must have evidence of lack of carcinogenicity from a long-term cancer bioassay. This requirement is more stringent than our requirement to score “low” for carcinogenicity. Thus, chemicals that would score “low” using our scoring system may be considered data gaps in C2CC®. Therefore, we allow chemicals with data gaps for carcinogenicity as long as there has been a thorough analysis of all available data, including structural analogs, to confirm that the chemical is likely not moderately or highly carcinogenic. We allow chemicals with this type of analysis to score “likely low.”

Table 72. Sufficient data to assign a score using the scoring method described in our criteria for safer is required for the following endpoints.

Hazard endpoint	Requirement
Carcinogenicity	Required^
Mutagenicity/Genotoxicity	Required
Reproductive or Developmental Toxicity	Required
Endocrine Disruption	Not required
Acute Toxicity	Required
Systemic Toxicity	Acute or repeat exposure is required
Neurotoxicity	Not required
Skin or Respiratory Sensitization	Required
Skin or Respiratory Irritation	Required
Eye Irritation	Required
Aquatic Toxicity	Required*
Persistence	Required
Bioaccumulation	Required

Notes:

- * = Some exemptions based on persistence, bioaccumulation, and water solubility.
- ^ = Sufficient analysis is conducted to score "likely low" in our criteria, even if data is limited or not available.

7.6 Hazard criteria

In general, products that are C2CC® Silver, Gold, or Platinum are likely to meet our minimum criteria. However, there are some differences in ingredient transparency (Silver only) and how exposure and very persistent and very bioaccumulative chemicals are handled for all products certified using the Material Health Standard V3.1. We can leverage the existing C2CC® evaluation to identify products that are likely safer and then follow up with assessors to document that the exposure, persistence, and bioaccumulation meet our criteria.

C2CC® scores chemicals from green (optimal chemicals) to red (hazardous chemicals) for each endpoint and then uses a scoring structure to assign an overall score to each chemical. For products to receive Gold and Platinum Material Health Certificates™, all chemicals must score yellow (moderately problematic chemicals with one or more moderate hazard endpoints) or green (optimal chemicals), which generally correspond to moderate or low using our criteria (Table 73).

For products with Silver Material Health Certificates™, 95% of the chemicals must score yellow or green for carcinogenicity, mutagenicity, and reproductive and developmental toxicity endpoints. The remaining chemicals may be nondisclosed (grey) or red. If we can confirm that the chemicals used to function like priority chemicals are included in the analysis and did not score red, products with Silver Material Health Certificates™ will also meet our criteria.

There are two differences between our minimum criteria for safer and the C2CC® Material Health Standard criteria. First, C2CC® V3.1 allows very persistent and very bioaccumulative chemicals to score yellow (Table 73, Max Hazard Profile 3). Therefore, products certified using

V3.1 or earlier with C2CC® Silver, Gold, and Platinum Material Health scores will only meet our minimum criteria for safer if they have additional documentation from the third-party assessor declaring that no very persistent and very bioaccumulative chemicals were used for the function of the priority chemical. In V4.0 of the Material Health Standard, very persistent and very bioaccumulative chemicals will score red.

Second, exposure potential can change the Material Health score of chemicals. Chemicals that do not pass our minimum criteria for safer (which score red or gray) can be allowed in products with Silver, Gold, or Platinum Material Health Certificates™ if exposure potential is not plausible for all use and end-of-use scenarios. To ensure the alternative is truly less hazardous, we will require an additional declaration from the third-party assessor that the product does not contain any red or gray chemicals for the function of the priority chemicals.

Table 73. Scoring matrix for chemicals intentionally added, impurities and breakdown products present at > 100 ppm, and residual monomers present at > 1,000 ppm in C2CC® Gold or Platinum products. Data is not required for all endpoints.

	Carcinogenicity	Genotoxicity/ Mutagenicity	Reproductive Toxicity	Developmental Toxicity	Endocrine Activity	Acute Toxicity	Systemic Toxicity (single)	Systemic Toxicity (repeat)	Neurotoxicity (single)	Neurotoxicity (repeat)	Skin Sensitization	Respiratory Sensitization	Skin Irritation	Eye Irritation	Aquatic Toxicity	Persistence	Bioaccumulation
Max Hazard Profile 1	LL	L/M	L/M	L/M	M	M	H	M	H	M	L	L	M	M	vH	H	vL
Max Hazard Profile 2	LL	L/M	L/M	L/M	M	M	H	M	H	M	L	L	M	M	M	vH	L
Max Hazard Profile 3*	LL	L/M	L/M	L/M	M	M	H	M	H	M	L	L	M	M	L	vH	vH

Notes:

- LL (likely low) indicates that there is no data to suspect the chemical is a Group I human health toxicant, but there is insufficient data to assign a score of L.
- L/M indicates that the scoring system between ChemFORWARD and our criteria is different, and it is not possible to determine whether chemicals score moderate or low without more information.
- * indicates the profile does not meet our minimum criteria for safer.

Carcinogenicity

In scoring the chemical, the assessor considers data from peer-reviewed sources, authoritative lists, and structural alerts. For C2CC® to score a chemical yellow or green, it must not be a known or suspected carcinogen. Limited, equivocal, or conflicting evidence of carcinogenicity leads to a yellow score. In order to be scored green, the chemical must have a negative, two year cancer bioassay. Data from multiple sources is integrated using both the weight of evidence and strength of evidence approaches, defined by the GHS.[179]

Data from multiple sources is integrated using both the weight of evidence and strength of evidence approaches, defined by the GHS. The C2CC® Gold and Platinum Material Health Certificate™ allows data gaps for carcinogenicity. The burden of data needed to score green is much higher than the data needed to score yellow or red—some chemicals that would score low in our criteria may score yellow or be considered a data gap by C2CC®. Therefore, while we cannot assign a score of low, we can conclude that products with the Gold or Platinum Material Health Certificate™ do not contain any high or moderate carcinogens. Chemicals scoring yellow would be considered "likely low" in our criteria, and chemicals scoring green would be considered low in our criteria. Chemicals in Gold or Platinum products would score yellow or green and meet our minimum criteria for safer.

Genotoxicity

Genotoxicity (called mutagenicity in C2CC® V3.1) is assessed solely based on empirical evidence. In the C2CC® V3.1 Material Health Assessment methodology, structural models are not applicable to genotoxicity, and in the absence of empirical data a chemical will score grey and will not be eligible to meet our criteria for safer.

In order to score green, a chemical must not induce aberrations of chromosomes or aberrations of their segregation in in vitro systems. If only one of these lines of evidence is present and the finding is negative, the chemical will score yellow. For example, if an Ames assay is negative and no other data are available, or if there is conflicting findings from the same endpoint (such as one study found a positive result and another found a negative result). A chemical will score red if there are positive results in eukaryotic or prokaryotic mutagenic assays. Yellow chemicals cannot induce point mutations but may have data gaps for chromosomal aberration and segregation. This corresponds to a score of moderate in our criteria.

For a chemical to score green, it must not be classified by GHS as Category 1A, 1B, or 2. It must not induce aberrations of chromosomes, segregation errors in in vitro systems, or point mutations. This would correspond to a score of low in our criteria. Chemicals in Gold or Platinum products would score yellow or green and meet our minimum criteria for safer.

[179] https://unece.org/ghs-rev3-2009

Reproductive and developmental toxicity

For a chemical to score yellow or green by C2CC®, it must not be a known or suspected reproductive or developmental toxicant. Using our criteria, a chemical with suspected reproductive or developmental toxicity would score moderate. Chemicals with equivocal or marginal evidence score yellow in C2CC® and moderate in our criteria. Chemicals that exhibit no adverse effects in sexual function, fertility, or the development of an embryo or fetus, based on human or animal studies, will score green in C2CC® and low in our criteria. Therefore, chemicals with yellow reproductive and developmental toxicity scores by C2CC® score moderate to low in our criteria and meet our minimum criteria for safer. Chemicals that score green in C2CC® would score low in our criteria. Chemicals in Gold or Platinum products would score yellow or green and meet our minimum criteria for safer.

Endocrine disruption

For a chemical to score yellow or green by C2CC®, it cannot show evidence of endocrine disruption that is linked to an adverse health outcome. This aligns with our minimum criteria for safer. Chemicals that score green in C2CC® have adequate data supporting both no endocrine activity and no adverse health effects linked to endocrine activity. Chemicals scoring green in C2CC® would score low in our criteria. Chemicals scoring yellow in C2CC® may have evidence of endocrine activity that is not linked to an adverse health effect. Chemicals scoring yellow would score moderate in our criteria. Chemicals in Gold or Platinum products would score yellow or green and meet our minimum criteria for safer.

Acute toxicity

C2CC® uses the guidance values identified by the GHS to score chemicals for acute toxicity for oral, dermal, and inhalation exposure routes. Our minimum criteria also relies on guidance values for scoring acute toxicity. Chemicals categorized by GHS in Category 1, 2, or 3 (LD_{50} in Table 74) are red in C2CC® and do not meet our criteria for safer. Chemicals that score yellow (GHS Category 4) score moderate in our criteria. Chemicals that score green in the C2CC® (GHS Categories 4 and 5) score moderate or low in our criteria. Our criteria allow for chemicals to have very high acute toxicity in some scenarios. Chemicals in Gold or Platinum products would score yellow or green and meet our minimum criteria for safer.

Table 74. Acute toxicity lethal doses categorized by GHS for oral, dermal, and inhalation exposures.

Classification criteria	Category 1	Category 2	Category 3	Category 4	Category 5
Oral LD50	≤ 5 mg/kg bodyweight	> 5 and ≤ 50 mg/kg bodyweight	> 50 and ≤ 300 mg/kg bodyweight	> 300 and ≤ 2000 mg/kg bodyweight	> 2000 mg/kg bodyweight
Dermal LD50	≤ 50 mg/kg bodyweight	> 50 and ≤ 200 mg/kg bodyweight	> 200 and ≤ 1000 mg/kg bodyweight	>1000 and ≤ 2000 mg/kg bodyweight	> 2000 mg/kg bodyweight
Inhalation LC50 (4-hr.) Gases	≤ 100 ppmV	> 100 and ≤ 500 ppmV	> 500 and ≤ 2500 ppmV	> 2500 and ≤ 20000 ppmV	> 20000 ppmV

Classification criteria	Category 1	Category 2	Category 3	Category 4	Category 5
Inhalation LC50 (4-hr.) Vapors	≤ 0.5 mg/L	>0.5 and ≤ 2.0 mg/L	>2.0 and ≤ 10.0 mg/L	>10.0 and ≤ 20.0 mg/L	>20.0 mg/L
Inhalation LC50 (4-hr.) Dusts and Mists	≤ 0.05 mg/L	>0.05 and ≤ 0.5 mg/L	>0.5 and ≤ 1.0 mg/L	> 1.0 and ≤ 5.0 mg/L	>5.0 mg/L

Systemic toxicity

C2CC® uses the guidance values identified by the GHS to score chemicals for systemic toxicity for oral, dermal, and inhalation exposure routes. For single exposure, chemicals score red if there are effects following single exposures at doses lower than the GHS Category 1 guidance values. This corresponds to a score of very high in our criteria. A chemical scores yellow if there are effects after single exposures at doses that fall within the guidance values for GHS Category 2. This corresponds to a score of high in our criteria. Chemicals score green if they are not classified by GHS or have effects following single exposures greater than the values shown in Table 75. This corresponds to a score of moderate or lower in our criteria. Chemicals in Gold or Platinum products would score yellow or green and meet our minimum criteria for safer.

Table 75. Single exposure systemic toxicity lowest observable adverse effects levels categorized by GHS for oral, dermal, and inhalation exposures.

Classification criteria	GHS Category 1	GHS Category 2	GHS not Classified
Oral Guidance Value	< 300 mg/kg bodyweight	> 300 and ≤ 2000 mg/kg bodyweight	> 2000 mg/kg bw/day
Dermal Guidance Value	≤ 1000 mg/kg bodyweight	> 1000 and ≤ 2000 mg/kg bodyweight	> 2000 mg/Kg-bw/day
Inhalation Vapors Guidance Value	≤ 10 mg/	> 10 and ≤ 20 mg/L	> 20 mg/L
Inhalation Dusts and Mists Guidance Value	≤ 1.0 mg/L	> 1.0 and ≤ 5.0 mg/L	> 5.0 mg/L

For repeated dose toxicity, chemicals that score red in C2CC® have repeat exposure effects at exposures lower than the Category 1 GHS guidance values shown in Table 74. This corresponds to a score of very high in our criteria. Chemicals score yellow if they show effects after repeat exposures that fall within the guidance values for GHS Category 2, shown in Table 74. This corresponds to a score of high in our criteria. Chemicals that are green in C2CC® have only shown effects after repeat exposures greater than the “GHS Not Classified” values shown in Table 76. These correspond to moderate or lower scores in our criteria.

Table 76. Repeat exposure systemic toxicity lowest observable adverse effects levels categorized by GHS for oral, dermal, and inhalation exposures.

Classification Criteria	GHS Category 1	GHS Category 2	GHS not Classified
Oral Guidance Value	≤ 10 mg/kg bodyweight	> 10 and ≤ 100 mg/kg bodyweight	> 100 mg/kg bw/day

Classification Criteria	GHS Category 1	GHS Category 2	GHS not Classified
Dermal Guidance Value	≤ 20 mg/kg bodyweight	> 20 and ≤ 200 mg/kg bodyweight	>200 mg/Kg-bw/day
Inhalation Vapors Guidance Value	≤ 0.2 mg/	> 0.2 and ≤ 1.0 mg/L	> 1.0 mg/L
Inhalation Dusts and Mists Guidance Value	≤ 0.02 mg/L	> 0.02 and ≤ 0.2 mg/L	> 0.2 mg/L

Neurotoxicity

C2CC® uses the guidance values identified by the GHS to score chemicals for neurotoxicity for oral, dermal, and inhalation exposure routes. For single exposure, chemicals score red if they show effects following single exposures lower than the GHS Category 1 guidance values. This corresponds to a score of very high in our criteria. A chemical scores yellow if there are effects following single exposure at doses that fall within the guidance values for GHS Category 2. This corresponds to a score of high in our criteria. Chemicals score green if they are not classified by GHS or only show effects at doses greater than the values shown in Table 72. This corresponds to a score of moderate or lower in our criteria. Chemicals in Gold or Platinum products would score yellow or green and meet our minimum criteria for safer.

For repeated dose toxicity, chemicals that score red in C2CC® show effects following repeat exposure at does lower than the Category 1 GHS guidance values shown in Table 74. This corresponds to a score of very high in our criteria. Chemicals score yellow if there are effects following repeat exposure at doses that fall within the guidance values for GHS category 2, shown in Table 74. This corresponds to a score of high in our criteria. Chemicals score green in C2CC® if there are only effects following repeat exposure at doses greater than the "GHS Not Classified" values shown in Table 74. These correspond to moderate or lower score in our criteria.

Skin and respiratory sensitization

Chemicals score red in C2CC® if they are classified as GHS Category 1A or 1B. In our criteria, a GHS classification of 1A corresponds to a score of high, and a classification of 1B corresponds to a score of moderate. A score of yellow in C2CC® would likely also score moderate in our criteria. Both C2CC® and our criteria require adequate data and negative studies to score low.

Aquatic toxicity

C2CC® scores acute aquatic toxicity such that GHS categories 1 and 2 correspond to red scores, and GHS category 3 corresponds to yellow scores. This aligns with our scoring criteria for very high (GHS category 1), high (GHS category 2), and moderate (GHS category 3). In the GHS, categories are based on the 96 hour LC50 of less than 1 mg/L being very high, 1 – 10 mg/L being high, 10 – 100 mg/L being moderate, and greater than 100 mg/L being low.

Chronic aquatic toxicity is also scored similarly between C2CC® and our minimum criteria. A NOEC (No Observed Effect Concentration) below 1 mg/L scores red in C2CC® and high/very high in our minimum criteria for safer. A NOEC between 1 – 10 mg/L scores yellow in C2CC® and moderate in our minimum criteria for safer.

Persistence

To score green for persistence in C2CC®, a chemical must have a half-life less than 30 days in water or less than 90 days in soil. These values correspond to moderate or high scores in our criteria. In order to score yellow for persistence, a chemical must have a half-life between 30 and 60 days in water and between 90 and 180 days in soil. Red chemicals have half-lives greater than 60 days in water and greater than 180 days in soil. Red chemicals are equivalent to very high, yellow chemicals are equivalent to high/moderate, and green chemicals are equivalent to moderate or low in our minimum criteria for safer.

Bioaccumulation

A bioconcentration factor (BCF) greater than 500 scores red in C2CC® and moderate or higher for bioaccumulation in our criteria. Chemicals scoring yellow in C2CC® have BCFs between 100 and 500, which corresponds to a score of low in our criteria. In order to score green in C2CC®, the chemical must have a BCF less than 100, which corresponds to a score of very low in our criteria.

Overall environmental fate score

C2CC® manages allowable environmental hazards by combining aquatic toxicity, persistence, and bioaccumulation hazards into a single risk flag. Chemicals in products with Gold or Platinum Material Health Certificates™ cannot have red or gray environmental risk flags. That means there are trade-offs between persistence, bioaccumulation, and aquatic toxicity. As shown in Table 77, if persistence is high, bioaccumulation and aquatic toxicity must be lower and vice versa.

In order have a yellow or green environmental risk flag, aquatic toxicity, persistence, and bioaccumulation are considered together. Chemicals scoring green or yellow must have the scores for aquatic toxicity, persistence, and bioaccumulation shown in Table 77.

Table 77. Maximum aquatic toxicity, persistence, and bioaccumulation score for chemicals found in products with C2CC® Platinum or Gold Material Health Certificates™.

Aquatic toxicity	Persistence	Bioaccumulation
Red or Gray	Green	Green
Yellow	Red or Gray	Yellow
Yellow	Yellow	Red or Gray
Green*	Red or Gray*	Red or Gray*

Note: * = the score does not meet our minimum criteria for safer.

Using the scoring from our criteria, this means that a chemical that is very high or high (or has a data gap) for aquatic toxicity must not have very high persistence and must be very low for bioaccumulation to be used in products with Gold or Platinum Material Health Certificates. If a chemical has very high persistence and bioaccumulation is moderate or higher, it must have low aquatic toxicity.

C2CC® allows for chemicals with very high persistence and very high bioaccumulation to score yellow, if aquatic toxicity is low. This last scenario does not meet our minimum criteria for safer. However, we can confirm with the C2CC® assessor that the chemicals used to function like priority chemicals are not very persistent and very bioaccumulative, and leverage the rest of the C2CC® analysis to identify safer alternatives.

7.7 Conclusion

Products with C2CC® Silver, Gold, or Platinum Material Health scores are likely to meet our minimum criteria for safer (based on the Material Health Standard V3.1, shown in Table 78) with supplemental documentation.

Table 78. C2CC® Material Health Certificate™ levels that meet, or are likely to meet, our ingredient transparency and data requirements and our minimum criteria for safer.

Assessment or certification	Ingredient transparency	Criteria transparency	Third-party review	Process transparency	Data requirements	Minimum criteria for safer
Material Health Certificate™ Silver	Possibly	X	X	X	X	X*^
Material Health Certificate™ Gold	X	X	X	X	X	X*
Material Health Certificate™ Gold	X	X	X	X	X	X*

Notes:

- * = Indicates that the certificate will only meet our criteria for safer if we can confirm that the chemical is not very persistent and very bioaccumulative and no adjustments have been made for exposure potential.
- ^ = Indicates that the certification will only meet our criteria for safer if we can confirm that the chemicals used to function like priority chemicals are included in the analysis, and did not score red or gray.

Section 8. ChemFORWARD

ChemFORWARD is a nonprofit that developed a method for assessing chemicals using the C2CC® Material Health Assessment Methodology, which is part of the product certification system. C2CC® only certifies at the product level. ChemFORWARD uses the C2CC® Material Health Assessment Methodology (currently V3.1, Supplement 6, Resource 8) to assess and report the results at the chemical level. C2CC® is currently updating the Material Health Assessment Methodology to Version 4.0. As these updates become available, ChemFORWARD will also update methods. Assessments cited in this report were evaluated using standard 3.1.

For a review of the C2CC® scoring methodology, please see Section 7.3. ChemFORWARD assessments are conducted by a qualified third-party assessor and then verified by a toxicologist approved by the program. All exchanges and changes between the assessor and verifier are tracked and can be used to resolve any potential conflicts.

8.1 Ingredient disclosure

The ChemFORWARD guidance evaluates chemicals. Impurities, known breakdown products, and residual monomers are assessed at concentrations at or above 100 ppm.

8.2 Criteria transparency

The ChemFORWARD guidance references the C2CC® Material Health Standard V3.1 to score individual endpoints and chemicals. Modifications to the C2CC® Material Health Standard can be found in Supplement 6, Resource 9.

8.3 Third-party assessors

ChemFORWARD has an assessment verification program that ensures the quality of the chemical hazard assessments. Assessors have expertise in chemistry and toxicology as well ChemFORWARD and C2CC®. After a chemical is assessed, there is a third-party verification process, which includes a set of procedures for a technical peer review and a technical challenge process. After this process, a chemical is listed in their database as verified. Verifiers are toxicology experts qualified by ChemFORWARD to review hazard assessments. Find the policies and procedures for third-party verification in Supplement 6, Resource 10.

8.4 Transparency in the process for continuing to be certified or labeled

ChemFORWARD assessments are valid for three years and have clear expiration dates. There is also a transparent process for challenging the findings.

8.5 Data requirements

The ChemFORWARD guidance references the C2CC® Material Health Standard V3.1 scoring system. The data requirements are the same as C2CC® and are described in Section 7.3. ChemFORWARD requires data for all the endpoints required to meet our minimum and additional criteria for safer.

8.6 Hazard criteria

ChemFORWARD uses the C2CC® Material Health Standard V 3.1 to score individual endpoints by exposure route and chemicals. Modifications can be found in Resource 8. The modifications primarily describe the deviations from the C2CC® assessment for using exposure to assess risk. Since ChemFORWARD is chemical specific, not product specific, exposure is considered differently.

In order to meet our minimum criteria for safer, the hazard scores cannot be adjusted for exposure. ChemFORWARD does not adjust chemical hazard scores for exposure. ChemFORWARD only uses exposure adjustments to interpret data gaps. In most cases, the allowable data gaps meet the data requirements in our criteria for safer. However, ChemFORWARD allows for a data gap for carcinogenicity—similar to C2CC®. Our minimum criteria allows for moderate carcinogens, and our additional criteria allows for chemicals that lack long-term cancer studies (but have no structural alerts or marginal evidence of carcinogenicity).

The only allowable data gap in the ChemFORWARD method that does not meet our data requirements is the allowance for aquatic toxicity data gaps when water solubility is low (less than 0.001 mg/l). Similar to the C2CC® method, if we only rely on a final score from ChemFORWARD, we would need to confirm that there is data for aquatic toxicity.

The scoring for each endpoint is described in Section 7 of this document (C2CC® method). Table 79 shows how each ChemFORWARD Band would score using our criteria.

Table 79. The maximum hazard profile for each ChemFORWARD Band. Scores shown in this table reflect the maximum hazards allowable under different ChemFORWARD Bands, scored using our criteria.

	Carcinogenicity	Genotoxicity/Mutagenicity	Reproductive Toxicity	Developmental Toxicity	Endocrine Activity	Acute Toxicity	Systemic Toxicity (single)	Systemic Toxicity (repeat)	Neurotoxicity (single)	Neurotoxicity (repeat)	Skin Sensitization	Respiratory Sensitization	Skin Irritation	Eye Irritation	Aquatic Toxicity	Persistence	Bioaccumulation
Max Hazard Profile Band A	L	L	L	L	L	L	M	M	M	M	L	L	L	L	L	M	vL
Max Hazard Profile Band B	LL	L	L	L	L	L	M	M	M	M	L	L	L	L	L	M	vL
Max Hazard Profile Band C	LL	L/M	L/M	L/M	M	M	H	M	H	M	L	L	M	M	vH	H	vL
Max Hazard Profile Band C	LL	L/M	L/M	L/M	M	M	H	M	H	M	L	L	M	M	M	vH	L
Max Hazard Profile Band C	LL	L/M	L/M	L/M	M	M	H	M	H	M	L	L	M	M	M	H	vH

Notes:

- LL (likely low) indicates that there is no data to suspect the chemical is a Group I human health toxicant, but there is insufficient data to assign a score of L.
- L/M indicates that the scoring system between ChemFORWARD and our criteria is different, and it is not possible to determine whether chemicals score moderate or low without more information.
- These ChemFORWARD Bands will likely meet our minimum or additional criteria for safer.

ChemFORWARD Band A

All hazard endpoints must score green according to the C2CC® scoring method described above. Green scores in the C2CC® method correspond to moderate and low scores in our criteria. Chemicals in band A meet our minimum criteria for safer. Provided exposure adjustments have not been made for aquatic toxicity, chemicals in band A will also meet our additional criteria for safer.

ChemFORWARD Band B

All hazard endpoints score green in C2CC®, which correspond to moderate and low scores in our criteria. The main difference between bands A and B is that for chemicals in band B, there are no long-term cancer studies. These chemicals would score "likely low" in our scoring method. Chemicals in band B meet our minimum criteria for safer. Provided exposure adjustments have not been made for aquatic toxicity, chemicals in band B will also meet our additional criteria for safer.

ChemFORWARD Band C

Some hazard endpoints are yellow, which correspond to a mix of green, yellow, and red scores in our criteria. Provided exposure adjustments have not been made for aquatic toxicity, chemicals in band C will meet our minimum criteria for safer.

8.7 Conclusion

Chemicals with ChemFORWARD Bands A, B, and C likely meet our minimum criteria for safer. ChemFORWARD Bands A and B likely meet our additional criteria for safer.

Table 80. ChemFORWARD assessments that meet our minimum or additional criteria for safer.

Assessment	Ingredient transp.	Criteria transp.	Third-party review	Process transp.	Data req.	Minimum criteria for safer	Additional criteria for safer
Band A	X	X	X	X	X	X	X*
Band B	X	X	X	X	X	X	X*
Band C	X	X	X	X	X	X*	

Notes:

- * = Indicates that the assessment will only meet our criteria for safer if we can confirm that there were no exposure potential adjustments for data gaps in aquatic toxicity.
- transp. refers to transparency.
- req. refers to requirements.

Section 9 Scivera GHS+

Scivera's GHS+ evaluation is built on EPA's Design for the Environment Criteria,[180] the National Academy of Sciences' guide for selecting chemical alternatives,[181] and the United Nation's Globally Harmonized System (GHS) for the Classification and Labeling of Chemicals.[182] Chemicals are binned into color groups based on the evaluation of 20 hazard endpoints and four physical/chemical properties. In 2018, Scivera GHS+ was accepted for chemical hazard assessments within the Electronic Product Environmental Assessment Tool (EPEAT) Standard[183] (NSF/ANSI 426, IEEE 1680, UL110) by the Green Electronics Council.

9.1 Ingredient disclosure

Scivera GHS+ assesses chemicals and transformation products. Scivera includes information made available for all intentionally added chemicals at any concentration, residuals, impurities, or other unintentional contaminants at concentrations greater than 100 ppm. If sufficient data is available to determine that relevant environmental transformation products are feasible and cause for higher concern than the parent compound, Scivera adjusts the overall hazard category score based on the higher hazard rating of the environmental transformation product.

9.2 Criteria transparency

The Scivera GHS+ methodology[184] is publicly available online, including the scoring framework.[185] Find the scoring criteria in Supplement 6, Resources 11 and 12.

9.3 Third-party assessors

Chemicals are evaluated in-house through Scivera, by their team of board-certified toxicologists. While Scivera has an internal quality assurance and quality control process, there is no third-party review. If a manufacturer and Scivera agree to share the full evaluation with Ecology, Scivera GHS+ would meet our requirement for a third-party review.

9.4 Transparency in the process for continuing to be certified or labeled

Scivera GHS+ verified hazard assessments have been reviewed by a board-certified toxicologist. Hazard assessments do not expire but are periodically reviewed and updated—the date of the assessment and any subsequent updates are available upon request.

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[180] https://www.epa.gov/saferchoice/alternatives-assessment-criteria-hazard-evaluation
[181] https://www.nap.edu/catalog/18872/a-framework-to-guide-selection-of-chemical-alternatives
[182] https://www.unece.org/trans/danger/publi/ghs/ghs_rev07/07files_e0.html
[183] https://www.epa.gov/greenerproducts/electronic-product-environmental-assessment-tool-epeat
[184] https://www.scivera.com/ghsplus/
[185] https://www.scivera.com/scivera-ghsplus-framework/

9.5 Data requirements

Chemicals scored as green, green/yellow, or yellow overall meet our data requirements. Sufficient data to assign a score using the methods described in our criteria for safer are required for the endpoints shown in Table 81.

Table 81. Sufficient data to assign a score using the scoring method described in our criteria for safer is required for the following endpoints.

Hazard Endpoint	Requirement
Carcinogenicity	Required
Mutagenicity/Genotoxicity	Required
Reproductive or Developmental Toxicity	Required
Endocrine Disruption	Required*
Acute Toxicity	Required for oral, dermal, and inhalation*
Systemic Toxicity	Required for single and repeat dose*
Neurotoxicity	Required for single and repeat dose*
Skin and Respiratory Sensitization	Required*
Eye and Respiratory Irritation	Required*
Acute or Chronic Aquatic Toxicity	Required*
Persistence	Required
Bioaccumulation	Required

Note: * = No more than three data gaps allowed for green/yellow or yellow chemicals, no data gaps allowed for green chemicals.

9.6 Hazard criteria

Chemicals that have been evaluated using Scivera GHS+ that are categorized as green meet our minimum and additional criteria. Chemicals categorized as yellow/green meet our minimum criteria for safer (Table 82). It is possible that chemicals evaluated as yellow will meet our minimum criteria for safer. The scoring of chemical endpoints for green/yellow chemicals and green chemicals is shown below. We used the "worst-case" example of a chemical categorized for each color and then scored it using our scoring method.

Table 82. Scoring matrix for chemicals in the green/yellow category. Data is not required for all endpoints.

	Carcinogenicity	Genotoxicity/ Mutagenicity	Reproductive Toxicity	Developmental Toxicity	Endocrine Activity	Acute Toxicity	Systemic Toxicity (single)	Systemic Toxicity (repeat)	Neurotoxicity (single)	Neurotoxicity (repeat)	Dermal Sensitization	Respiratory Sensitization	Skin Irritation	Eye Irritation	Aquatic Toxicity	Persistence	Bioaccumulation
Green	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L

	Carcinogenicity	Genotoxicity/ Mutagenicity	Reproductive Toxicity	Developmental Toxicity	Endocrine Activity	Acute Toxicity	Systemic Toxicity (single)	Systemic Toxicity (repeat)	Neurotoxicity (single)	Neurotoxicity (repeat)	Dermal Sensitization	Respiratory Sensitization	Skin Irritation	Eye Irritation	Aquatic Toxicity	Persistence	Bioaccumulation
Yellow/green	L	L	L	L	L	M	M	M	M	M	M	M	M	M	M	M	M
Yellow/green	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	L
Yellow/green	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H
Yellow	M	M	M	M	M	vH	vH	H	vH	H	H	H	vH	vH	vH	M	H
Yellow	M	M	M	M	M	vH	vH	H	vH	H	H	H	vH	vH	vH	H	M
Yellow	M	M	M	M	M	H	H	M	H	M	M	M	H	H	H	vH	M
Yellow	M	M	M	M	M	H	H	M	H	M	M	M	H	H	H	M	vH

Carcinogenicity

In order for a chemical score of yellow, yellow/green, or green, it must score moderate or low for carcinogenicity in the Scivera GHS+ system. In order to score moderate or low, it cannot be a known or presumed carcinogen. GHS Category 2, suspected carcinogens, correspond to a score of moderate in both our system and the Scivera GHS+ system. Limited, equivocal, or conflicting evidence of carcinogenicity leads to a moderate score in both systems as well and can be based on experience and modeling data.

In order to score low (and be categorized as green), a chemical must have data showing lack of carcinogenicity. Negative modeling data must be accompanied by negative mutagenicity and repeated dose systemic toxicity. This follows our identification of chemicals as “likely low” based on modeling data. Carcinogenicity scores of moderate or low in Scivera GHS+ would score similarly in our criteria and meet our minimum (moderate) or additional (low) criteria for safer.

Genotoxicity

To score low, a chemical must have experimental evidence that it is not genotoxic. Modeling data can be used to supplement this determination, but experimental data is necessary to score low. If a chemical is moderate, it may be suspected of causing heritable mutations in human germ cells through experimental and modeled data. In order to meet our minimum criteria, chemicals cannot be known or presumed mutagens, but they may be suspected mutagens. In order to meet our additional criteria, chemicals must have evidence that they are not mutagenic. Thus, chemicals that score moderate using the Scivera GHS+ system meet our minimum criteria, and those scoring low using the Scivera GHS+ system meet our additional criteria.

Reproductive and developmental toxicity

For a chemical to score moderate in Scivera GHS+, it must not be a known or presumed reproductive or developmental toxicant. Suspected reproductive toxicants are scored moderate using the Scivera GHS+ system. That corresponds to a moderate score in our system and meets our minimum criteria. To score low using the Scivera GHS+ system, there must be experimental evidence of lack of reproductive or developmental toxicity. This aligns with our score of low and meets our additional criteria for safer.

Endocrine disruption

In order for a chemical to score moderate or low using the Scivera GHS+ system, it cannot have evidence of endocrine disruption that is linked to an adverse health outcome (scoring high). Our minimum criteria also does not allow for chemicals with endocrine disruption linked to adverse health impacts. Chemicals with moderate endocrine disruption may have endocrine activity, but the activity is not linked to high scores for other human health endpoints. This aligns with our definition for moderate endocrine disruption and meets our minimum and additional criteria for safer.

Acute toxicity

Scivera GHS+ uses the guidance values identified by the GHS to score chemicals for acute toxicity (Table 68, above). Our criteria also relies on GHS guidance values for scoring acute toxicity. Chemicals categorized by GHS in Category 1, 2, or 3 (LD_{50} in Table 68, above) are high or very high in Scivera GHS+ and high or very high in our criteria.

Chemicals that score moderate or low in Scivera GHS+ (GHS Categories 4 and 5) also score moderate or low in our criteria. Chemicals with very high acute toxicity can meet our minimum criteria, and those with high acute toxicity can meet our additional criteria for safer in some scenarios—depending on scores for other endpoints.

Systemic toxicity

Scivera GHS+ uses the guidance values identified by the GHS to score chemicals for systemic toxicity (Tables 69 and 70). These are the same guidance values our criteria rely on. For chemicals to score moderate or low in our criteria and Scivera GHS+, they must be either classified in GHS Category 3 or not classified by GHS for single exposures. For repeated exposure, chemicals must be classified in categories 1, 2, or not classified by GHS. The guidance values from the GHS are shown in Table 69 and Table 70 above.

Our minimum criteria allows for chemicals with very high systemic toxicity (single and repeat exposure) in some scenarios—depending on scores for other endpoints. Our additional criteria allows for chemicals with high systemic toxicity (single exposure) and moderate systemic toxicity (repeat exposure) in some scenarios—depending on scores for other endpoints.

Neurotoxicity

Scivera GHS+ uses the guidance values identified by the GHS to score chemicals for single and repeat exposure neurotoxicity. Our criteria also relies on the GHS guidance values.

A very high score for single exposure neurotoxicity corresponds to the GHS Category 1 for any route of exposure. A high score for single exposure neurotoxicity corresponds to GHS Category 2 for any route of exposure. A moderate score for single exposure neurotoxicity corresponds to a GHS Category 3 for any route of exposure. To score low for single exposure neurotoxicity, GHS must not classify the chemical, and adequate data must be available, including negative studies.

For repeat exposure neurotoxicity, a high score corresponds to GHS Category 1 for any route of exposure. A moderate score for repeat exposure neurotoxicity corresponds to GHS Category 2 for any route of exposure. A low score corresponds to GHS "Not Classified" for any route of exposure.

Scivera GHS+ and our criteria scoring methods align. Chemicals that score as very high (single and repeat exposure) can meet our minimum criteria, and those that score as high (single exposure) or moderate (repeat exposure) can meet our additional criteria for safer in certain scenarios—depending on scores for other endpoints.

Skin and respiratory sensitization

Chemicals that score high in our criteria and Scivera GHS+ are categorized as 1A for skin or respiratory sensitization, according to the GHS. In both our criteria and Scivera GHS+, chemicals that score 1B for skin and respiratory sensitization are considered moderate. Chemicals that score as very high for skin and respiratory sensitization can meet our minimum criteria, and those that score as moderate for skin and respiratory sensitization can meet our additional criteria for safer in certain scenarios—depending on scores for other endpoints.

Acute and chronic aquatic toxicity

Scivera GHS+ uses the GHS guidance values to score acute and chronic aquatic toxicity (Table 83). Very high acute aquatic toxicity corresponds to a GHS Category 1 ($LC_{50} \leq 1$ mg/L). A high score for acute aquatic toxicity corresponds to a GHS Category 2 (LC_{50} between 1 and 10 mg/L). A moderate score corresponds to a GHS Category 3 (LC_{50} between 10 and 100 mg/L). In order for a chemical to receive a score of low, GHS must not classify the chemical, adequate data and negative studies must be available, and the LC_{50} must be greater than 100 mg/L.

Very high chronic aquatic toxicity corresponds to an LC_{50} of less than 0.1 mg/L. A high score for chronic aquatic toxicity corresponds to an LC_{50} of 0.1 – 1.0 mg/L. A moderate score corresponds to an LC_{50} of 0.1 – 10 mg/L. For a chemical to score low, it must have an LC_{50} of greater than 10 mg/L.

Our minimum criteria allows for chemicals that score as very high for acute and chronic aquatic toxicity, provided persistence and bioaccumulation are not also very high. Our additional criteria allows for chemicals that score as very high for acute aquatic toxicity in certain scenarios—depending on scores for other endpoints.

Table 83. Acute and chronic aquatic toxicity from GHS and corresponding scores.

	GHS Category 1	GHS Category 2	GHS Category 3 and 4	GHS Category "Not Classified"
Acute (LC/EC_{50})	≤ 1mg/L	> 1mg/L and ≤ 10mg/L	> 10mg/L and ≤ 100mg/L	> 100mg/L
Chronic (LC/EC_{50})	≤ 0.1mg/L	> 0.1mg/L and ≤ 1mg/L	> 1mg/L and ≤ 10 mg/L Poorly soluble with no acute toxicity at solubility and BCF ≥ 500 or log K_{ow} ≥ 4	> 10mg/L

Persistence and bioaccumulation

Persistence and bioaccumulation are scored using the criteria described in Tables 84 and 85 below. The Scivera GHS+ scoring system for persistence and bioaccumulation aligns with our criteria. Chemicals that score as very high for persistence or bioaccumulation can meet our minimum criteria, and chemicals that score as high for persistence or bioaccumulation can meet our additional criteria in certain scenarios—depending on scores for other endpoints.

Table 84. Persistence scoring criteria Scivera GHS+.

	Very high	High	Moderate	Low
Soil/Sediment	> 180 days	60 to 180 days	16 to 60 days	< 16 days
Water	> 60 days	40 to 60 days	16 to 40 days	< 16 days
Air	> 5 days	2 to 5 days	N/A	< 2 days
Biodegradability BOD (5 day) /COD ratio	< 0.2 not biodegradable	0.2 – 0.4 slowly biodegradable	0.4 – 0.5 average biodegradable	> 0.5 easily biodegradable

Notes:

- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)

Table 85. Bioaccumulation scoring criteria Scivera GHS+.

Criteria	Very High	High	Moderate	Low
BCF or BAF	> 5000	> 1000 – 5000	> 500 – 1000	> 100 – 500
Log Kow	> 5.0	> 4.5 – 5.0	> 4.0 – 4.5	—

9.7 Conclusion

Chemicals that are Scivera GHS+ green meet our additional criteria for safer. Chemicals that are Scivera GHS+ green/yellow meet our minimum criteria and may meet our additional criteria. Chemicals that are GHS+ yellow meet our minimum criteria. Chemicals that are GHS+ red do not meet our minimum criteria.

Table 86. Scivera GHS+ assessments that are likely to meet our criteria for safer.

Assessment	Ingredient transp.	Criteria transp.	Third-party review	Process transp.	Data req.	Minimum Criteria for Safer	Additional Criteria for Safer
Scivera GHS+ green	X	X	X	X	X	X	X
Scivera GHS+ green/yellow	X	X	X	X	X	X	X
Scivera GHS+ yellow	X	X	X	X	X	X	

Notes:

- transp. refers to transparency.
- req. refers to requirements.

Supplement 6. Reference resources

- Resource 1: GreenScreen® Benchmark Scores[186]
- Resource 2: GreenScreen® Certified™ Standard for Textiles[187]
- Resource 3: GreenScreen® Certified™ Standard for Furniture and Fabrics:[188]
- Resource 4: TCO Certified Accepted Substance List[189]
- Resource 5: TCO Certification Process[190]
- Resource 6: Safer Chemical Ingredients List Master Criteria[191]
- Resource 7: Safer Chemical Ingredients Functional/Product Class Criteria[192]
- Resource 8: C2CC® Material Health Standard V 3.1[193] and C2CC® Material Health Standard V 4.0[194]
- Resource 9: ChemFORWARD Hazard Assessment Methodology:[195]
- Resource 10: ChemFORWARD third-party methods[196]
- Resource 11: Scivera GHS+ framework[197]
- Resource 12: Scivera GHS+ Scoring Criteria[198]

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186 https://www.greenscreenchemicals.org/learn/guidance-and-method-documents-downloads

187 https://www.greenscreenchemicals.org/images/ee_images/uploads/resources/GSCTextileChemicalsStandard_v2.0_FINAL_20201026_.pdf

188 https://www.greenscreenchemicals.org/images/ee_images/uploads/resources/GreenScreen_Certified_Furniture_Fabric_v1_20201001.pdf

189 https://tcocertified.com/accepted-substance-list/

190 https://tcocertified.com/certification-documents/

191 https://www.epa.gov/saferchoice/safer-choice-master-criteria-safer-chemical-ingredients

192 https://www.epa.gov/saferchoice/standard#tab-2

193 https://cdn.c2ccertified.org/resources/certification/guidance/MTD_Material_Health_Assessment_FINAL_030220.pdf

194 https://cdn.c2ccertified.org/resources/certification/Changes_to_the_MHAM_for_use_in_v4_Assessments_031221.pdf

195 https://static1.squarespace.com/static/60611efa464a766c6a812834/t/6079aecfeb6014570c723579/1618587343513/C2CC%2BChemical%2BRating%2BGuidance%2Bv1.2.docx%2B%281%29.pdf

196 https://static1.squarespace.com/static/60611efa464a766c6a812834/t/606e5077eacda90026d19290/1617842296193/Verification+Program+Description+v1.1.pdf

197 https://www.scivera.com/ghsplus/

198 https://www.scivera.com/scivera-ghsplus-framework/

Appendix F. Existing Laws, Regulations, and Restrictions

Tables 87 through 91 describe existing regulations and voluntary actions to reduce priority chemicals in consumer products. We reviewed actions from other nations, as well as actions at the U.S. federal and state levels. In some cases, we supplemented the information with voluntary actions taken by retailers. The existing regulations and voluntary efforts in Tables 87 through 91 could provide insight during potential rulemaking. Below, we highlight relevant example regulations or voluntary actions for each chemical-product combination.

Flame retardants

Electronic equipment (plastic device casings): Other states and nations restrict the use of organohalogen flame retardants in electric and electronic enclosures, or are proposing such restrictions (Table 87). Organohalogen flame retardants were restricted in electronic products in Europe in March 2021. The European Commission's Ecodesign for Electronic Displays regulation prohibits the "use" of organohalogen flame retardants in all electronic displays with a screen area greater than 100 square centimeters. Delaware's proposed HB 77 provides insights on details, including:

- Proposing a concentration limit of greater than 0.1% organohalogen flame retardants.
- Defining electronic enclosures as "the plastic housing that encloses electronic components."
- Exempting resale of electronic products.

Recreational polyurethane foam products: We did not identify any regulations from other states or nations specific to flame retardants in recreational polyurethane products. However, California regulations on flame retardants in other polyurethane products might be applicable to recreational polyurethane foam products because they:

- Restrict flame retardants (encompassing all current priority chemical flame retardants) at concentrations greater than 0.1%.
- Exempt resale of polyurethane products.

Table 87. Existing regulations and voluntary actions for flame retardants in consumer products. The references from states fall within the citation category 5, and the reference to the EU falls within citation category 11. The citation categories are described in Appendix B.

Entity	Year	Regulation or policy	Requirements and standards	Source
California	2018	CA BPC §§19100-19104[199]	On or after January 1, 2020, prohibits the manufacture, sale, or distribution of children's products, mattresses, and upholstered furniture with over 1,000 ppm flame retardants. Penalty $1,000 – $2,000.	CA State Code
California	2017	22 CA ADC §69511.1[200]	As of July 1, 2017, identifies children's foam-padded sleeping products containing TDCPP and TCEP. Entities must notify consumers before purchase.	CA Administrative Code
Delaware	2021–still pending, last amendment proposed Jan. 11, 2022[1]	HB 77[201]	Would prohibit the manufacture, sale, and distribution of **electronic enclosures** with over 0.1% organohalogen. Exempts resale. Amendment HA1 would makes Act consistent with California law, changes the effective date to July 1, 2023.	DE General Assembly
EU	2019	Commission Regulation (EU) 2019/2021[202]	As of March 1, 2021, prohibits the use of halogenated flame retardants in **enclosures and stands of electronic displays**. Must label components containing flame retardants.	EU
Hawaii	2004	HRS §332D-2[203]	On or after January 1, 2006, prohibits the manufacture, processing, or distribution of products with over 0.1% pentaBDE or octaBDE.	HI State Code

199 https://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=BPC&division=8.&title=&part=&chapter=3.&article=5.5.

200 https://govt.westlaw.com/calregs/Document/I774D7EED0BC4473887D37480AA122155?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default)

201 https://legis.delaware.gov/BillDetail?LegislationId=48303

202 https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1576033291584&uri=CELEX:32019R2021

203 https://www.capitol.hawaii.gov/hrscurrent/Vol06_Ch0321-0344/HRS0332D/HRS_0332D-0002.htm

Entity	Year	Regulation or policy	Requirements and standards	Source
Illinois	2005	410 ILCS 48[204]	Effective July 1, 2005, prohibits the manufacture, sale, or distribution of products with over 0.1% pentaBDE or octaBDE. Penalties $10,000 – $25,000. Manufacture replacement service parts. Recycled.	IL Compiled Statutes
Maine	2021	38 MRS §1609-A[205]	Effective January 1, 2019, prohibits the manufacture, sale, or distribution of new upholstered furniture, electronic components, and casings of electronic components with flame retardants. Exempts resale.	ME Revised Statutes
Maine	2017	MRS §1609-A[206]	Effective January 1, 2019, prohibits the manufacture, sale, or distribution of upholstered furniture with over 0.1% flame retardants. Exempts resale.	ME Revised Statutes
Maryland	2020	Md. Code Ann., Health §24-306.1[207]	Effective January 1, 2021, prohibits the manufacture, sale, or distribution of children's products, mattresses, upholstered furniture, and re-upholstered furniture with over 0.1% flame retardant chemical by mass. Exempts resale. Penalty $2,500 – $10,000.	MD Code Annotated
Maryland	2010	Md. Code Ann., Environment §6-1201.1[208]	Beginning December 31, 2010, prohibits the manufacture, sale, and distribution of mattresses, residential upholstered furniture, and **electronic equipment** containing decaBDE. Exempts service parts. Exempts resale. Exempts recycled products in compliance with federal law. Exempts transportation and military equipment.	MD Code Annotated

[204] https://www.ilga.gov/legislation/ilcs/ilcs3.asp?ActID=2707&ChapterID=35
[205] https://legislature.maine.gov/legis/statutes/38/title38sec1609-A.html
[206] https://legislature.maine.gov/legis/statutes/38/title38sec1609-A.html
[207] https://mgaleg.maryland.gov/mgawebsite/Laws/StatuteText?article=ghg&section=24-306.1&enactments=False&archived=False
[208] https://mgaleg.maryland.gov/mgawebsite/Laws/StatuteText?article=gen&section=6-1202.1&enactments=False&archived=False

Entity	Year	Regulation or policy	Requirements and standards	Source
Massachusetts	2021	Mass. Gen. Laws Chapter 21A, §28 (2020)[209]	Effective April 1, 2021, prohibits the manufacture, sale, or distribution of bedding, carpeting, children's products, residential upholstered furniture with over 1,000 ppm flame retardants (TDCPP, TCEP, antimony trioxide, HBCD, TBPH, TBB, chlorinated paraffins, TCPP, PentaBDE, OctaBDE, TBBPA). Penalty $100 – $50,000. Includes CAS numbers.	MA General Laws
Michigan	2003	MCL 324.14722[210]	Effective June 1, 2006, prohibits the manufacture, processing, or distribution of products with over 0.1% pentaBDE. Penalty $2,500 – $25,000. Recycling. Replacement parts.	MI Compiled Laws
Minnesota	2019	MINN. STAT. 325F.07 (2021)[211]	Effective July 1, 2021, prohibits the manufacture, sale, or distribution of children's products, residential upholstered furniture, residential and business textiles, mattress, and children's products with more than 1,000 ppm any organohalogenated flame retardants. Exempts resale.	Minnesota Statutes 2021

[209] https://malegislature.gov/Bills/191/H4900
[210] http://legislature.mi.gov/doc.aspx?mcl-324-14722
[211] https://www.revisor.mn.gov/statutes/cite/325F.071

Entity	Year	Regulation or policy	Requirements and standards	Source
Nevada	2021	2021 Statutes of Nevada Chapter 112[212] To be codified in Chapter 459 of Nevada Revised Statutes	Effective July 1, 2022, prohibits the knowing manufacture, sale, and distribution of children's products, upholstered residential furniture, residential textiles, business textiles, or mattresses with over 1,000 ppm flame retardants. Penalty $1,000. Exempts resale.	2021 Statutes of Nevada (81st Session)
New York	2021	N.Y. Environmental Conservation Law Chapter 43-B, Article 37, Title 10[213]	Beginning January 1, 2024, prohibits the manufacture, sale, and distribution of furniture, mattresses, and **electronic displays** with flame retardants. Defines electronic display. Intentionally added. Exempts electronic components and electronic casings of the components. Manufacturer reports annually.	Consolidated Laws of New York
Rhode Island	2020	R.I. Gen. Laws §23-26-3.1[214]	Beginning January 1, 2020, prohibits manufacture, knowing sale, offer for sale, or distribution of residential upholstered bedding or furniture containing 1,000 ppm non-polymeric organohalogen flame retardant. Exempts products sold or in use before effective date.	State of Rhode Island General Laws
Vermont	2009	9 V.S.A. Chapter 80[215]	Effective July 1, 2010, bans the sale and distribution of all products with over 0.1% flame retardants octaBDE and pentaBDE. Bans the sale of mattresses and furniture with decaBDE. Bans children's products and upholstered furniture with TCEP and TDCPP effective January 1, 2014. Bans the manufacture, sale, and distribution of **TVs and computers with a plastic housing** with more than 0.1% decaBDE effective July 1, 2012. Exempts resale.	Vermont Statutes Annotated

[212] https://www.leg.state.nv.us/Statutes/81st2021/Stats202105.html#Stats202105_CH112
[213] https://www.nysenate.gov/legislation/laws/ENV/A37T10
[214] http://webserver.rilegislature.gov//Statutes/TITLE23/23-26/23-26-3.1.htm
[215] https://legislature.vermont.gov/statutes/fullchapter/09/080

Entity	Year	Regulation or policy	Requirements and standards	Source
Washington	2016	RCW 70A.430.030[216]	Beginning July 1, 2017, prohibits the manufacture, sale, and distribution of children's products and residential furniture with flame retardants (TDCPP, TCEP, decaDBE, HBCD, additive TBPPA).	Revised Code of Washington
Washington	2007	RCW 70A.405[217]	Prohibits the manufacture, sale, and distribution of some products with flame retardants PBDEs and mattresses with decaBDE after January 1, 2008. Restricts the sale of televisions, computers, and residential upholstered furniture with decaBDE by January 1, 2011.	Revised Code of Washington
Washington	2004	Executive Order 04-01[218]	Begin implementing plan to phase out PBDEs no later than July 1, 2005.	Washington Governor's Office

Note: 1 = The Delaware General Assembly is scheduled to adjourn June 30, 2022.

[216] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.430.030
[217] https://apps.leg.wa.gov/billsummary/?BillNumber=1024&Year=2007&Initiative=false
[218] https://www.digitalarchives.wa.gov/governorlocke/eo/eo_04-01.htm

PCBs

Paints and printing inks: We did not identify any relevant regulations specific to PCBs in paints and printing inks. Intentional use of PCBs is broadly restricted under the Toxic Substances Control Act (Table 88). EPA restricts inadvertent PCBs in products to an average annual concentration of less than 25 ppm (40 CFR Section 761.3).

Table 88. Existing regulations and voluntary actions for PCBs in consumer products. These references fall within the citation category 5, described in Appendix B.

Entity	Year	Regulation or policy	Requirements and standards	Source
U.S.	2020	40 CFR 761[219]	40 CFR 761.20. Components with greater than or equal to 50 ppm must be totally enclosed. 40 CFR 761.3. Excluded manufacturing process—a manufacturing process in which quantities of PCBs have a concentration less than 25 ppm annual average and 50 ppm maximum. Inadvertently generated PCBs. 40 CFR 761.3. Excluded PCB products—PCB materials with over 50 ppm.	Code of Federal Regulations
U.S.	1977	15 U.S.C. §2605(e)[220]	Except as otherwise provided, prohibits the manufacture of any PCB by January 1, 1979 and the distribution in commerce of PCBs by July 1, 1979.	United States Code
Washington	2014	RCW 36.26.280[221]	Establishes a procurement policy avoiding PCBs.	Revised Code of Washington

PFAS

Carpet and rugs: Vermont, Maine, and California all restrict the intentional use of PFAS in carpets and rugs. Massachusetts and New York have proposed restrictions (Table 89). These regulations:

- Would restrict PFAS as a class in carpets and rugs with total fluorine concentrations greater than 1 ppm (Massachusetts).
- Would exempt resale of carpets and rugs (many states).

Aftermarket stain and water-resistance treatments: Vermont and Maine restrict intentionally added PFAS in aftermarket treatments, and Massachusetts has a proposed restriction (Table 89). These regulations and potential regulations:

[219] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-R/part-761
[220] http://uscode.house.gov/view.xhtml?path=/prelim@title15/chapter53&edition=prelim
[221] https://apps.leg.wa.gov/billsummary/?BillNumber=6086&Year=2013&Initiative=false

- Restrict PFAS as a class in aftermarket treatments (for fabric products) with total fluorine concentrations greater than 1 ppm (Massachusetts).

Leather and textile furniture and furnishings: We did not identify any existing regulations on PFAS in leather and textile furniture and furnishings (Table 89). Massachusetts has a pending bill that would:

- Restrict PFAS as a class in upholstered furniture with total fluorine concentrations greater than 0.1 ppm.
- Exempt resale of products.

Table 89. Existing regulations and voluntary actions for PFAS in consumer products. The references from states fall within citation category 5 and the references from retailers (Home Depot, IKEA, Lowe's, and Target) fall within citation category 11. The citation categories are described in Appendix B.

Entity	Year	Regulation or policy	Requirements and standards	Source
California	2017	22 CA ADC §69511.4[222]	Effective July 1, 2021, identifies **carpets and rugs** containing PFAS as priority products. Entities must notify consumers before purchase.	CA Administrative Code
Colorado	2020	C.R.S. 8-20-206.5[223] C.R.S. 25-5-1311[224]	Effective June 29, 2020, establishes PFAS reporting, establishes and funds a PFAS takeback program, and charges a fee to manufacturers of fuel products.	Colorado Revised Statutes
Connecticut	2021	Public Law 21-191[225] To be codified at Chapter 446z C.G.S. §22a-903a and Chapter 446d §22a-255h, §22a-255i, and §22a-255k	Prohibits the use of firefighting foam with PFAS. Establishes a PFAS takeback program. Prohibits the manufacture, sale, and distribution with intentionally added PFAS.	Connecticut General Assembly

222 https://govt.westlaw.com/calregs/Document/I5EA7EB36284B46BC94CE79E601B63D4D?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default)#co_anchor_I004CAFBB81B049B283B76F48EB601A5F
223 https://law.justia.com/codes/colorado/2020/title-8/article-20/section-8-20-206-5/
224 https://law.justia.com/codes/colorado/2020/title-25/article-5/section-25-5-1311/
225 https://www.cga.ct.gov/2021/act/Pa/pdf/2021PA-00191-R00SB-00837-PA.PDF

Entity	Year	Regulation or policy	Requirements and standards	Source
Home Depot	2019	Home Depot[226]	Home Depot excludes PFOA and PFOS from indoor wall-to-wall **carpet**.	Home Depot
IKEA	2016	IKEA[227]	IKEA banned PFAS, including **carpets, and leather and textile furnishings**.	IKEA
Illinois	2021	415 ILCS 170[228]	Beginning January 1, 2022, prohibits use of Class B firefighting foam that contains PFAS and requires notice of discharge. On or after January 1, 2025, prohibits sale and distribution for use within the state of PFAS-containing Class B firefighting foam.	IL Compiled Statutes
Lowe's	2020	Lowe's[229]	All indoor residential **carpet and rugs**, and **fabric protection sprays** are free of PFAS chemicals.	Lowe's
Maine	2021	38 MRS §1614[230]	Beginning January 1, 2023, requires manufacturers to report products with intentionally added PFAS. Prohibits the sale and distribution of **carpet or rugs** and **fabric treatment** with intentionally added PFAS. Exempts resale. Manufacturers of PFAS products must submit written notification. Department may request certificate of compliance.	ME Revised Statutes
Maine	2020	32 MRS §1733[231]	Authorizes the Department of Environmental Protection to prohibit the manufacture, sale, and distribution of food packaging with intentionally added PFAS no sooner than January 1, 2022.	ME Revised Statutes

[226] https://corporate.homedepot.com/sites/default/files/Chemical Strategy - Update 061918.pdf
[227] https://www.ikea.com/us/en/life-at-home/safer-life-at-home-puba448f210
[228] https://www.ilga.gov/legislation/ilcs/ilcs3.asp?ActID=4187&ChapterID=36
[229] https://corporate.lowes.com/our-responsibilities/corporate-responsibility-reports-policies/lowes-safer-chemicals-policy
[230] https://legislature.maine.gov/legis/statutes/38/title38sec1614.html
[231] https://legislature.maine.gov/legis/statutes/32/title32sec1733.html

Entity	Year	Regulation or policy	Requirements and standards	Source
Maryland	2021	Md. Code Ann., Health §21-259.2[232]	On or after January 1, 2025, prohibits knowingly manufacturing, selling, and distributing cosmetics with intentionally added PFAS, phthalates, and other chemicals.	Md. Code Annotated
Massachusetts	2021—still pending, last action taken February 17, 2022[1]	House 2350[233]	Would prohibit the manufacture, sale, and distribution of child passenger restraints, cookware, **fabric treatments**, personal care products, **rugs and carpets**, and **upholstered furniture** with intentionally added or not PFAS over 1 ppm. Exempts resale. Manufacturers must test.	MA Legislature
Michigan	2021—still pending, last action taken March 10, 2021[2]	SB 0127[234]	Would require consumer notification if consumer products or packaging contain PFAS. Penalty $1,000 – $10,000. Put warning label on products. Manufacturer notifies seller.	Michigan Legislature
Michigan	2021—still pending, last action taken July 14, 2021	HB 5250[235]	Would prohibit the manufacture, sale, and distribution of food packaging with intentionally added PFAS, bisphenols, and phthalates. Incidental presence.	Michigan Legislature
Minnesota	2021—still pending, last action taken January 28, 2021[3]	SF 373[236]	Would prohibit the manufacture, distribution, and use of food packaging with intentionally added PFAS and bisphenols. Defines "incidental presence." Would require companies to develop a certificate of compliance.	Minnesota Legislature

[232] http://mgaleg.maryland.gov/mgawebsite/Legislation/Details/hb0643?ys=2021rs
[233] https://malegislature.gov/Bills/192/HD2994
[234] http://www.legislature.mi.gov/(S(uzi0avrbuvblgfs2hafb22kc))/mileg.aspx?page=GetObject&objectname=2021-SB-0217
[235] http://www.legislature.mi.gov/(S(o2kjjdqtoupgjqp2re1nthlf))/mileg.aspx?page=GetObject&objectname=2021-HB-5250
[236] https://www.revisor.mn.gov/bills/bill.php?view=chrono&f=SF373&y=2021&ssn=0&b=senate#actions

Entity	Year	Regulation or policy	Requirements and standards	Source
Nevada	2021	2021 Statutes of Nevada Chapter 112[237] To be codified in Chapter 459 of Nevada Revised Statutes	Effective July 1, 2022, prohibits the knowing manufacture, sale, and distribution of children's products, upholstered residential furniture, residential textiles, business textiles, or mattresses with over 1,000 ppm flame retardants. Prohibits the use of firefighting foam with PFAS. Penalty $1,000. Exempts resale.	2021 Statutes of Nevada (81st Session)
New York	2021—still pending, last action taken Feb. 14, 2022[4] Note: Senate bill is the one that is proceeding	Senate Bill 5027[238] Assembly Bill A9279[239]	Would prohibit the sale of **carpets** with PFAS after December 31, 2024. Would establish requirements for minimum post-consumer content. Establishes statewide stewardship program.	New York State Senate
New York	2021—still pending, last action taken Jan. 5, 2022 (on both bills)	Senate Bill 6291[240] Assembly Bill A7063[241]	Would prohibits the use of PFAS in common apparel. Defines "intentionally added."	New York State Senate
North Carolina	2021—still pending, last action taken April 7, 2021[5]	Senate Bill 638[242]	Would prohibit the manufacture, sale, and distribution of any product with PFAS. All products. Penalty $5,000 – $200,000.	North Carolina General Assembly
Target	2020	Target goals[243]	Bans long-chain perfluorinated alkyl compounds in products imported on or after September 25, 2020, including **leather and textile furnishings**. Removes added perfluorinated chemicals (PFC's) from **textile products** by 2022.	Target

[237] https://www.leg.state.nv.us/Statutes/81st2021/Stats202105.html#Stats202105_CH112
[238] https://www.nysenate.gov/legislation/bills/2021/S5027
[239] https://www.nysenate.gov/legislation/bills/2021/a9279
[240] https://www.nysenate.gov/legislation/bills/2021/S6291
[241] https://www.nysenate.gov/legislation/bills/2021/a7063
[242] https://www.ncleg.gov/BillLookUp/2021/S638
[243] https://corporate.target.com/corporate-responsibility/planet/chemicals

Entity	Year	Regulation or policy	Requirements and standards	Source
Vermont	2021	18 V.S.A. Chapter 33[244] 18 V.S.A. Chapter 33A[245] 18 V.S.A. Chapter 33B[246] 18 V.S.A. Chapter 33C[247]	Effective July 1, 2022, prohibits the manufacture, sale, and distribution of Class B firefighting foam, food packaging, **rugs and carpets**, **aftermarket treatments**, and ski wax with intentionally added PFAS. Provides for resale exemptions and certificates of compliance.	Vermont Statutes Annotated
Vermont	2021—still pending, last action taken Jan. 13, 2021[6]	House 27[248]	Would require manufacturers of food packaging, personal care products, and clothing with PFAS, to include a health and safety warning.	Vermont General Assembly
Washington	2018	RCW 70A.222.070[249]	No sooner than January 1, 2022, prohibits the manufacture and sale of food packaging with intentionally-added PFAS if Department of Ecology determines safer alternatives are available.	Revised Code of Washington

Notes:

- 1 = The Massachusetts Legislature meets full-time. The next session starts in January 2023.
- 2 = The Michigan Legislature meets full-time and will likely adjourn *sine die* on December 31, 2022.
- 3 = The Minnesota Legislature is scheduled to adjourn sometime in late May 2022.
- 4 = The New York State Legislature is scheduled to adjourn June 2, 2022.
- 5 = The North Carolina General Assembly will likely adjourn in December 2022, but no *sine die* date is currently set.
- 6 = The 2022 Vermont General Assembly currently has no scheduled *sine die* date.

[244] https://legislature.vermont.gov/statutes/fullchapter/18/033
[245] https://legislature.vermont.gov/statutes/fullchapter/18/033A
[246] https://legislature.vermont.gov/statutes/fullchapter/18/033B
[247] https://legislature.vermont.gov/statutes/fullchapter/18/033C
[248] https://legislature.vermont.gov/bill/status/2022/H.27
[249] https://app.leg.wa.gov/RCW/default.aspx?cite=70a.222.070

Bisphenols

Food and drink cans: We did not identify any existing restrictions on bisphenols as a class in food and drink can linings (Table 90). However, we did identify two pending regulations which:

- Propose restricting the intentional use of bisphenols as a class in food packaging (MI, pending).
- Propose a restriction level of 0.1 ppb for chemicals within the bisphenols class in similar products (PA, pending).

Thermal paper: We did not identify any existing restrictions on bisphenols as a class in thermal paper (Table 90). We did identify a number of restrictions on thermal paper (or receipt paper) with BPA. The EU restricts BPA in thermal paper products at concentrations equal or higher than 0.02% by weight (EU).

Alkylphenol ethoxylates

Laundry detergent: California DTSC identified laundry detergent containing NPEs as a priority product, and is currently in the pre-regulatory phase. The EU (Annex XVII) restricts NP and NPEs at concentrations greater than 0.1% by weight in various products, including cleaning products.

Table 90. Existing regulations and voluntary actions for phenolic compounds (BPA and APEs) in consumer products. The references from states fall within the citation category 5 and the reference from the EU falls within citation category 11. The citation categories are described in Appendix B.

Entity	Year	Regulation or policy	Requirements and standards	Source
Connecticut	2011	Chapter 416 C.G.S. §21a-12e[250]	Effective October 1, 2013, prohibits the manufacture, sale, or distribution of **thermal receipt paper** with BPA.	Connecticut General Statutes
Connecticut	2009	Chapter 416 C.G.S. §21a-12b[251]	Effective October 1, 2011, prohibits the manufacture, sale, and distribution of reusable food and **beverage containers**, infant formula, and baby food containers with BPA. Allows one year to sell inventory.	Connecticut General Statutes
EU	2016	Commission Regulation (EU) 2016/2235[252]	Beginning January 2, 2020, restricts BPA in **thermal paper** in a concentration equal to or greater than 0.02% by weight.	EU

[250] https://www.cga.ct.gov/current/pub/chap_416.htm
[251] https://www.cga.ct.gov/current/pub/chap_416.htm#sec_21a-12b
[252] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R2235&from=EN

Entity	Year	Regulation or policy	Requirements and standards	Source
EU	2016	Commission Regulation (EU) 2016/26[253]	Beginning February 3, 2021, restricts NPE in **domestic cleaning products** in concentrations equal to or greater than 0.1% by weight.	EU
Illinois	2019	415 ILCS 5/22.61[254]	Beginning January 1, 2020, prohibits the manufacture of thermal paper with BPA for sale in the state. Beginning January 1, 2020, prohibits the distribution or use of **business and banking paper** with BPA. Exempts paper made before effective date. Exempts recycled material.	IL Combined Statutes
Maryland	2011	Md. Code Ann., Health §24-304[255]	On or after January 1, 2012, prohibits the manufacture, sale, and distribution of infant formula containers with over 0.5 ppb BPA. Requires use of safer alternatives.	MD Code Annotated
Minnesota	2021—still pending, last action taken Jan. 28, 2021[1]	SF 373[256]	Would prohibits the manufacture, distribution, and use of **food packaging** with intentionally added PFAS and bisphenols. Defines "intentionally added." Would require companies to develop certificate of compliance.	Minnesota Legislature
Minnesota	2009	MINN. STAT. 325F.172[257] 325F.173[258] 325F.174[259] 325F.175[260] (2021)	Beginning January 1, 2010, prohibits sale of children's products containing BPA. Beginning August 1, 2014, prohibits the manufacture, sale, and distribution of children's empty bottles or cups with BPA. Beginning August 1, 2015, prohibits sale of infant formula, baby food, or toddler food in containers with intentionally-added BPA. Exempts resale of used children's products.	2021 Minnesota Statutes

253 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0026&from=FR
254 https://ilga.gov/legislation/ilcs/ilcs4.asp?DocName=041500050HTit%2E+V&ActID=1585&ChapterID=36&SeqStart=30300000&SeqEnd=39900000
255 https://mgaleg.maryland.gov/mgawebsite/Laws/StatuteText?article=ghg&section=24-304&enactments=False&archived=False
256 https://www.revisor.mn.gov/bills/bill.php?view=chrono&f=SF373&y=2021&ssn=0&b=senate#actions
257 https://www.revisor.mn.gov/statutes/cite/325F.172
258 https://www.revisor.mn.gov/statutes/cite/325F.173
259 https://www.revisor.mn.gov/statutes/cite/325F.174
260 https://www.revisor.mn.gov/statutes/cite/325F.175

Entity	Year	Regulation or policy	Requirements and standards	Source
New York	2021—still pending, last action taken Jan. 5, 2022	Senate 417[261]	Would prohibits the distribution and use of **business paper** with BPA. Require replacement with safer alternative. Report alternatives to agency. Form an advisory committee to study recycling.	New York State Senate
Pennsylvania	2021—still pending, last action taken Feb. 26, 2021[2]	HB 684[262]	Would prohibit the manufacture, sale, and distribution of infant containers with over 0.1 ppb BPA.	Pennsylvania State Legislature
Pennsylvania	2010	HR 94[263]	Urges Congress and FDA to encourage reduced use of BPA in plastic **food containers and bottles**. Encourages FDA to prohibit the importation, sale, and advertising of polycarbonate baby bottles. House resolution supports safer alternatives.	Pennsylvania State Legislature
Vermont	2021	18 V.S.A. Chapter 33A[264]	Effective July 1, 2023, allows the Department of Health to regulate intentionally added bisphenols and phthalates. Allows the Attorney General to request a certificate of compliance.	Vermont Statutes Annotated
Vermont	2014	18 V.S.A. Chapter 38A[265]	Authorizes agency to adopt rules prohibiting the sale or distribution of consumer products with priority chemicals, including BPA and phthalates.	Vermont Statutes Annotated
Vermont	2010	18 V.S.A. §1512[266]	Beginning July 1, 2012, prohibits the manufacture, sale, or distribution of formula in containers, jars, and cans, baby food in containers, jars, and cans, and reusable food and **beverage containers** with BPA.	Vermont Statutes Annotated

Notes:

- 1 = The Minnesota Legislature is scheduled to adjourn sometime in late May 2022.
- 2 = The Pennsylvania State Legislature is scheduled to adjourn *sine die* on November 30, 2022.

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[261] https://www.nysenate.gov/legislation/bills/2021/S417
[262] https://www.legis.state.pa.us/cfdocs/billinfo/billinfo.cfm?syear=2021&sind=0&body=H&type=B&bn=684
[263] https://www.legis.state.pa.us/CFDOCS/Legis/PN/Public/btCheck.cfm?txtType=PDF&sessYr=2009&sessInd=0&billBody=H&billTyp=R&billNbr=0094&pn=1692
[264] https://legislature.vermont.gov/statutes/fullchapter/18/033A
[265] https://legislature.vermont.gov/statutes/fullchapter/18/038A
[266] https://legislature.vermont.gov/statutes/section/18/029/01512

Ortho-phthalates

Vinyl flooring*:* We did not identify any regulations on ortho-phthalates in vinyl flooring products (Table 91). Washington state restricts the use of specific ortho-phthalates in children's products at concentrations greater than 1,000 ppm (individually or combined). There are also voluntary actions to reduce ortho-phthalate use in vinyl flooring. In 2016, many major flooring retailers prohibited the use of ortho-phthalates as additive plasticizers in vinyl flooring products.

A challenge in regulating ortho-phthalates in vinyl flooring is the presence of ortho-phthalates from recycled materials. Pre- and post-consumer vinyl flooring products can be recycled into new vinyl flooring products. Recycling brings many benefits, but post-consumer vinyl flooring products can introduce ortho-phthalates into new products that use alternative plasticizers. However, some manufacturers are finding ways to promote recycling and reduce ortho-phthalate exposure. Tarkett's post-consumer vinyl flooring recycling program screens recycled materials for ortho-phthalates (based on manufacture date) to help avoid reintroducing ortho-phthalates into new vinyl flooring products (Table 91).

Personal care and beauty products: We did not identify any restrictions on ortho-phthalates as a class in personal care and beauty products. California and Maryland both restrict the intentional addition of two ortho-phthalates, DBP and DEHP, in cosmetic products. Retailers and others have taken voluntary actions to reduce the use of ortho-phthalates more broadly in personal care and beauty products (Table 91). Many voluntary efforts to reduce ortho-phthalates in these products do not strive for 100% reduction, recognizing the presence of trace contaminants.

Table 91. Existing regulations and voluntary actions for phthalates in consumer products. The references from states fall within the citation category 5, and the references from the EU and retailers (Home Depot, Lowe's, Menards, Target, and Tarkett) fall within citation category 11. The citation categories are described in Appendix B.

Entity	Year	Regulation or policy	Requirements and standards	Source
California	2020	CA HSC §111792[267]	Requires **cosmetic** manufacturers to report to the state lists of chemicals, flavors, and fragrances in their products. The state must maintain a website with this info. Manufacturers report priority chemicals to the state.	CA State Code

267 https://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=HSC&division=104.&title=&part=5.&chapter=7.&article=3.5.

Entity	Year	Regulation or policy	Requirements and standards	Source
Canada	2019	Cosmetic Ingredient Hotlist[268]	**Cosmetics** sold in Canada must not contain DEHP.	Health Canada / Santé Canada
EU	2019	Commission Regulation (EU) 2019/1966[269]	After June 11, 2019, bans certain phthalates in **cosmetic products**.	EU
Home Depot	2016	Home Depot[270]	Home Depot excludes ortho-phthalates as added plasticizers in **vinyl flooring**.	Home Depot
Lowe's	2020	Lowe's[271]	All **vinyl flooring** is free of ortho-phthalates.	Lowe's
Maine	2019	32 MRS §1733[272]	Beginning January 1, 2022, prohibits sale of food packaging containing inks, dyes, pigments, coatings, plasticizers, or other additives that contain intentionally-added phthalates. Authorizes state to require a certificate of compliance.	ME Revised Statutes
Maryland	2021	Md. Code Ann., Health §21-259.2[273]	Effective January 1, 2025, prohibits knowingly manufacturing, selling, and distributing **cosmetics** with intentionally added PFAS, phthalates, and other chemicals.	MD Code Annotated
Menards	2015	Menards specs[274]	Menards sells many **vinyl flooring** products that are described as "all components are ortho-phthalate free."	Menards
Michigan	2021—still pending, last action taken July 14, 2021	HB 5250[275]	Would prohibit the manufacture, sale, and distribution of food packaging with intentionally added PFAS, bisphenols, and phthalates. Defines "incidental presence."	Michigan Legislature

[268] https://www.canada.ca/en/health-canada/services/consumer-product-safety/cosmetics/cosmetic-ingredient-hotlist-prohibited-restricted-ingredients/hotlist.html
[269] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32019R1966
[270] https://corporate.homedepot.com/sites/default/files/Chemical Strategy - Update 061918.pdf
[271] https://corporate.lowes.com/our-responsibilities/corporate-responsibility-reports-policies/lowes-safer-chemicals-policy
[272] https://legislature.maine.gov/legis/statutes/32/title32sec1733.html
[273] http://mgaleg.maryland.gov/mgawebsite/Legislation/Details/hb0643?ys=2021rs
[274] https://www.menards.com/main/flooring-rugs/vinyl-flooring/vinyl-plank-flooring/designers-image-trade-click-lock-5-88-x-37-floating-vinyl-plank-flooring-18-11-sq-ft-ctn/cl1038-2/p-1444432043736.htm
[275] http://www.legislature.mi.gov/(S(o2kjjdqtoupgjqp2re1nthlf))/mileg.aspx?page=GetObject&objectname=2021-HB-5250

Entity	Year	Regulation or policy	Requirements and standards	Source
Minnesota	2021—still pending, last action taken Jan. 28, 2021[1]	SF 373[276]	Would prohibit the manufacture, distribution, and use of food packaging and ink with intentionally added phthalates. Defines "incidental presence." Would require companies to develop a certificate of compliance.	Minnesota Legislature
New York	2021—still pending, last action taken Jan. 5, 2022	Assembly Bill A02155[277]	Would prohibit the manufacture, sale, distribution, and use of **nail polish** and nail hardener with phthalates.	New York State Assembly
Target	2020	Target progress report[278]	Target achieved formulating beauty and personal care products without phthalates by 2020.	Target
Tarkett	2021	Tarkett recycling[279]	Tarkett developed a post-consumer vinyl flooring recycling program that screens materials for phthalates (based on manufacture date) to reduce the reintroduction of phthalates to vinyl flooring products made from recycled materials.	Tarkett
Vermont	2021	18 V.S.A. Chapter 33A[280]	Effective July 1, 2023, allows the Department of Health to regulate intentionally added bisphenols and phthalates. Allows the Attorney General to request a certificate of compliance.	Vermont Statutes Annotated
Vermont	2014	18 V.S.A. Chapter 38A[281]	Authorizes agency to adopt rules prohibiting the sale or distribution of consumer products with priority chemicals, including BPA and phthalates.	Vermont Statutes Annotated

Note: 1 = The Minnesota Legislature is scheduled to adjourn sometime in late May 2022.

[276] https://www.revisor.mn.gov/bills/bill.php?view=chrono&f=SF373&y=2021&ssn=0&b=senate#actions
[277] https://nyassembly.gov/leg/?bn=A2155&term=2021
[278] https://corporate.target.com/_media/TargetCorp/csr/pdf/2021_corporate_responsibility_report.pdf
[279] https://professionals.tarkett.com/en_EU/node/recycling-used-homogeneous-flooring-13311
[280] https://legislature.vermont.gov/statutes/fullchapter/18/033A
[281] https://legislature.vermont.gov/statutes/fullchapter/18/038A

Appendix G. Exemptions

Under the Safer Products for Washington program, Ecology will not identify the following as priority consumer products:

- Plastic shipping pallets manufactured prior to 2012;
- Food or beverages;
- Tobacco products;
- Drug or biological products regulated by the United States food and drug administration;
- Finished products certified or regulated by the federal aviation administration or the department of defense, or both, when used in a manner that was certified or regulated by such agencies, including parts, materials, and processes when used to manufacture or maintain such regulated or certified finished products;
- Motorized vehicles, including on and off-highway vehicles, such as all-terrain vehicles, motorcycles, side-by-side vehicles, farm equipment, and personal assistive mobility devices; and
- Chemical products used to produce an agricultural commodity, as defined in RCW 17.21.020.[282]

Ecology may identify the packaging of products listed above as priority consumer products.

For an electronic product identified by Ecology as a priority consumer product under this section, the department may not make a regulatory determination under RCW 70A.350.040[283] to restrict or require the disclosure of a priority chemical in an inaccessible electronic component of the electronic product.

[282] https://app.leg.wa.gov/RCW/default.aspx?cite=17.21.020
[283] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.040