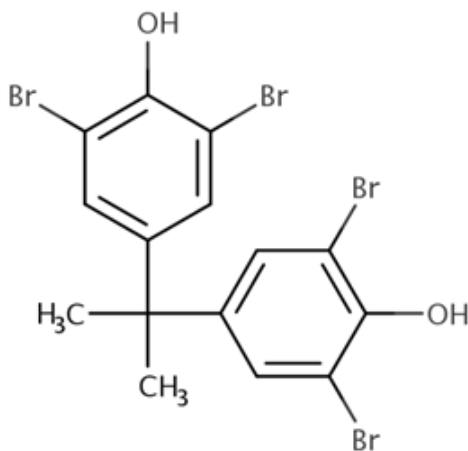




United States
Environmental Protection Agency

**Draft Risk Evaluation for
4,4'-(1-Methylethylidene)bis[2,6-dibromophenol]
(TBBPA)**

CASRN 79-94-7



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Docket

Supporting information can be found in the public docket, Docket ID [EPA-HQ-2018-0462](#).

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EXECUTIVE SUMMARY

Background

EPA evaluated the human health and environmental risks of 4,4'-(1-methylethylidene)bis[2,6-dibromophenol] (TBBPA) across its conditions of use (COUs) under section 6 of the Toxic Substances Control Act (TSCA). In August 2019, EPA designated TBBPA as a high-priority substance for TSCA evaluation and in August 2020 released the *Final Scope of the Risk Evaluation for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA); CASRN 79-94-7* ([U.S. EPA, 2020b](#)). This draft risk evaluation assesses human health risk to workers, including occupational non-users (ONUs¹), with and without personal protective equipment (PPE); consumers, including bystanders; and the general population exposed to environmental releases across its conditions of use (COUs) under TSCA, ranging from manufacture to disposal. It also assesses risk to the environment, including aquatic and terrestrial species.

The Agency has preliminarily determined that TBBPA presents an unreasonable risk of injury to human health and the environment under the COUs driven by significant contributions to risk from four COUs. Of the 24 COUs that EPA evaluated, 20 COUs were preliminarily determined *not* to significantly contribute to the unreasonable risk of injury of TBBPA to human health or the environment; 3 COUs significantly contribute to unreasonable risk due to inhalation to workers; and 1 COU significantly contributes to unreasonable risk to the environment. No COUs for TBBPA significantly contribute to unreasonable risk to ONUs; consumers, including bystanders; or the general population, including fenceline populations.

TBBPA is a white crystalline solid with a total production volume in the United States between 10 and 50 million pounds (lb) from the 2024 Chemical Data Reporting (CDR) data ([U.S. EPA, 2026a](#)). EPA describes production volumes as a range to protect confidential business information (CBI). TBBPA is imported and reasonably foreseen to be domestically manufactured in the United States and used as an additive and reactive chemical, which serves as a flame retardant. As an additive flame retardant, TBBPA is incorporated into polymers via physical mixing and used in acrylonitrile-butadiene-styrene (ABS) resins for electronic enclosures and electronic consumer products with an outer plastic casing. As a reactive flame retardant, TBBPA is incorporated into polymers via chemical reactions at an early stage of manufacturing and is primarily used in epoxy resin-printed circuit boards by covalently binding to epoxy and polycarbonate resins. Workers may be exposed while handling and directly contacting TBBPA, whereas ONUs work in the general vicinity of TBBPA manufacturing and processing (Section 4.1.1). Consumers may be exposed to TBBPA while using certain products or articles containing TBBPA (Section 4.1.3). When TBBPA is released to air, land, or water it may contribute to general population (Section 4.1.6) or ecological exposures (Section 5.1).

In this draft risk evaluation, EPA evaluated whether manufacturing, processing, distribution in commerce, use, or disposal of TBBPA present unreasonable risk to human health or the environment under its COUs. Human or environmental exposure to TBBPA through uses that are not subject to TSCA (e.g., use in cosmetics, medical devices, food additives) were not specifically evaluated by the Agency in reaching its preliminary determination. This is because these uses are excluded from TSCA's definition of a chemical substance under section 3(2)(B). Thus, conclusions in this draft risk evaluation cannot be extrapolated to form conclusions about uses of TBBPA that are not subject to TSCA and that EPA did not evaluate.

¹ ONUs do not directly handle TBBPA but may be indirectly exposed to it in the workplace as part of their employment.

Determining Unreasonable Risk to Human Health

In TSCA section 6 existing chemical risk evaluations, EPA must determine whether a chemical substance does or does not present unreasonable risk of injury to human health or the environment under the COUs. The unreasonable risk determination must be consistent with the best available science. In determining whether TBBPA *presents unreasonable risk to human health*, EPA considered risk-related factors (see TSCA section 6(b)(4)(F); 89 FR 37028, 37037 [May 3, 2024]) Risk-related factors include but are not limited to the type of health effect under consideration; the reversibility of the health effect being evaluated; exposure-related considerations (*e.g.*, duration, magnitude, frequency of exposure); population exposed (including any potentially exposed or susceptible populations [PESS]). EPA must also consider confidence in the information used to inform the hazard and exposure values. If an estimate of risk for a specific scenario exceeds the standard risk benchmarks, then the determination of whether those risks significantly contribute to the unreasonable risk of TBBPA under TSCA is both case-by-case and context-driven. EPA considers the aforementioned risk-related factors when determining whether a COU significantly contributes to unreasonable risk of injury to human health or the environment.

EPA evaluated the risks to people from being exposed to TBBPA at work, indoors, and outdoors. Human health risk to workers and ONUs were assessed via inhalation and dermal routes; risk to consumers via inhalation, dermal, and oral routes; and risk to bystanders via the inhalation route. As described further in Section 4.1.6, EPA assessed risks to the general population, which considered risk from exposure to TBBPA via oral ingestion of surface water, drinking water, fish, and soil from air to soil deposition. For environmental populations, the Agency evaluated risk to aquatic species via water and sediment as well as risk to terrestrial species via soil and qualitatively through trophic transfer.

To preliminarily determine whether TBBPA presents an unreasonable risk to human health, EPA considered the following PESS in its assessment—women of reproductive age, pregnant women, infants, children and adolescents; people who frequently use consumer products or articles containing high-concentrations of TBBPA; people exposed to TBBPA in the workplace; tribes whose diets include large amounts of fish; individuals with pre-existing conditions such as chronic kidney disease or lifestyle factors such as smoking cigarettes or secondhand smoke; and people in proximity to releasing facilities, including and fenceline communities. These subpopulations are PESS because some have greater exposure to TBBPA per body weight (*e.g.*, infants, children, adolescents) whereas others may experience exposure from multiple sources, higher exposures than others, or exhibit greater biological susceptibility than the general population. Although there is likely to be variability in susceptibility across the human population, EPA did not identify specific human groups that are expected to be more susceptible to cancer or non-cancer effects following TBBPA exposure.

For human health hazards, TBBPA was determined to not be acutely toxic and sensitive organ-level effects are unlikely to result from a single exposure at concentrations relevant to human exposures (see Section 3.8.2.1 of the *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)*) ([U.S. EPA, 2026t](#)). EPA identified the effect of polycystic kidney lesions in neonatal male rats and atypical endometrial hyperplasia uterine lesions in female rats as the most robustly supported hazards associated with oral exposure to TBBPA in experimental animal models for intermediate and chronic exposure duration scenarios, respectively (Sections 4.2.1 and 4.2.2). Regarding TBBPA cancer assessment, the Agency determined there were significant treatment-related cancer effects of uterine tumor formation associated with chronic oral TBBPA exposure in female Wistar Han rats, which was associated with a non-genotoxic threshold of biological effects (Section 4.2.2). Under EPA's *Guidelines for Carcinogen Risk Assessment* ([U.S. EPA,](#)

2005), the Agency determined TBBPA is *Not Likely Carcinogenic to Humans* at doses below levels associated with the non-cancer chronic point of departure (POD).

EPA conducted non-cancer hazard assessments and calculated preliminary risk estimates for male and female adolescents and adults following intermediate and chronic exposures. Because EPA determined TBBPA is *Not Likely Carcinogenic to Humans* at doses below levels associated with the chronic POD due to an associated non-genotoxic cancer mode of action, and because the chronic POD is based upon tumor precursor lesion data (atypical endometrial hyperplasia), the Agency considers the non-cancer chronic POD to adequately accounts for all chronic toxicity—including non-cancer and cancer effects.

Risks are characterized for occupational and ONU exposures to TBBPA. Based on the preliminary assessment of occupational and ONU exposures, the Agency preliminarily identified a total of three COUs where occupational inhalation exposure for workers, without PPE, significantly contributes to unreasonable risk of injury to human health. For workers, EPA has moderate confidence in the risk estimates calculated for inhalation exposure scenarios. All risk estimates from dermal exposure to TBBPA were above the benchmark; therefore, the Agency did not identify risk from the dermal route for any COU.

Determining Unreasonable Risk to the Environment

In preliminarily determining whether TBBPA presents an unreasonable risk to the environment, EPA considered the following groups of organisms in its assessment: aquatic and terrestrial vertebrates, invertebrates, plants, and algae. The Agency weighed the scientific evidence to determine confidence levels in underlying datasets and risk estimates for the environment (Section 5.3). Of the 24 total COUs associated with TBBPA,

- 16 COUs had reported facility-specific releases, 12 of which reported no releases to water;
- 1 COU was assessed via generic scenario modeling (Industrial and commercial use – Other – Laboratory chemical);
- 3 COUs were not assessed quantitatively because EPA does not expect releases to water during activities under these COUs (Recycling; Distribution in commerce; and Industrial and commercial use – Packaging, paper, plastic, and hobby products – Plastic and rubber products); and
- 4 COUs were only relevant to consumer uses for which Toxics Release Inventory (TRI) release data would not be applicable.

EPA has overall robust confidence in the preliminary risk characterization to aquatic organisms exposed to TBBPA using TRI-derived modeled surface water exposures from three COUs and modeled generic scenarios from one COU. For the screening-level trophic transfer assessments for terrestrial invertebrates, mammals, avian species, and aquatic-dependent mammals, EPA has moderate confidence that TBBPA exposures from the highest release exposure scenarios are well below the hazard thresholds that would present risk.

EPA has preliminarily determined that TBBPA presents unreasonable risk to the environment based on one of the four COUs assessed (described below) due to chronic exposure to aquatic invertebrates, sediment-dwelling (benthic) invertebrates, and amphibians from TBBPA releases to surface water and subsequent deposition to sediment. For the other three COUs assessed quantitatively, the Agency preliminarily determined that they do not contribute to unreasonable risk to the environment because the risk quotient (RQ) were below 1 or, for chronic risk, the exposure did not exceed the concentration of concern (COC) for the number of days to result in the chronic hazard. According to reported data for all other COUs, TBBPA is not released to water for sites mapped to those COUs.

Summary, Considerations, and Next Steps

The full list of 24 COUs evaluated for TBBPA under TSCA is presented in Table ES-1 and Table ES-2. EPA has preliminarily determined that the following three COUs significantly contribute to unreasonable risk of injury to human health from TBBPA—all through inhalation risk to workers:

- Manufacturing – Domestic manufacturing;
- Manufacturing – Import; and
- Processing – Repackaging.

EPA has preliminarily determined that the following COU significantly contributes to unreasonable risk of TBBPA to the environment from chronic exposure to aquatic invertebrates, aquatic sediment-dwelling invertebrates, and amphibians through exposure in surface water or sediment:

- Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing

No COUs significantly contributed to unreasonable risk for consumers or the general population, including fenceline populations.

Next Steps and Public Input

This draft risk evaluation—including EPA’s preliminary determination that 3 of 24 assessed COUs for TBBPA contribute to unreasonable risk of injury to human health (Table ES-1) and 1 other COU contributes to unreasonable risk of injury to the environment (Table ES-2) as well as the accompanying technical support documents (TSDs) and supplemental files (see Appendix C)—have been released for public comment. EPA seeks public comment on all aspects of this draft risk evaluation. In particular, the Agency seeks comments on the following:

1. information that may inform exposure assumptions for occupational exposure scenarios (OESs) (e.g., whether and how exposure controls and PPE are used for each of the COUs, the frequency of occupational task[s] per shift);
2. information regarding the use of respirators with an assigned protection factor (APF) higher than 10 (APF10) during higher exposure tasks (e.g., loading during repackaging, including repackaging at toll sites);
3. information that may inform the assumptions used for modeling each of the COU that do not have TRI data; for example, Industrial and commercial use – Other – Laboratory chemical;
4. information on the domestic manufacturing use as a reasonably foreseen use and any information regarding the use being reestablished in the United States;
5. information on the percent of TBBPA in the multiple waste disposal streams that would further refine the release assessment;
6. information that may inform the accuracy of the values used to assess water releases and environmental impacts; and
7. other information on any relevant studies or other data sources that were not identified by EPA.

The draft risk evaluation package for TBBPA will undergo independent, expert peer review by the Science Advisory Committee on Chemicals (SACC) during its August 2026 meeting. Recommendations from the SACC, as well as public comments on the draft risk evaluation package, will inform the final risk evaluation of TBBPA—including the Agency’s determination of whether TBBPA presents unreasonable risk of injury to human health or the environment, under the COUs. EPA will initiate regulatory action under TSCA section 6(a) to the extent necessary so that TBBPA no longer presents such risk.

514 **Table ES-1. Human Health: TBBPA COUs Contributing to a Preliminary Determination of Unreasonable Risk of Injury (Non-Cancer**
515 **Health Effects)**

Condition of Use	Workers			ONUs	Consumers/ Bystanders ^a			General Population			
	Inh.	Derm.	Aggr.	Inh.	Inh.	Derm.	Ingest.	Ingestion			Inhalation (Ambient Air)
								DW	Fish	Human Milk	
Manufacture – Domestic manufacture	×										
Manufacture – Import	×										
Processing – As a reactant – Flame retardant in plastic material and resin manufacturing											
Processing – As a reactant – Intermediate in all other chemical product and preparation manufacturing											
Processing – Incorporation into a formulation, mixture, or reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing											
Processing – Incorporation into a formulation, mixture, or reaction product – Adhesive manufacturing											
Processing – Incorporation into article – Reactive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., printed circuit boards and semiconductor packages)											
Processing – Incorporation into article – Reactive flame retardant in transportation equipment manufacturing (e.g., interior material for automotive and aviation articles)											
Processing – Incorporation into article – Additive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, Appliance, and component manufacturing; plastic product manufacturing (e.g., plastic electronic enclosures)											
Processing – Repackaging	×										
Processing – Recycling											
Distribution in commerce											
Industrial use – Construction, paint, electrical and metal products – Powder coatings											
Industrial and commercial use – Construction, paint, electrical, and metal products – Reactive flame retardant in electrical and electronic articles											
Industrial and commercial use – Construction, paint, electrical and metal products – Reactive flame retardant in automotive and aviation articles (i.e., laminate and prepreg material)											
Industrial and commercial use – Construction, paint, electrical and metal products – Additive flame retardant in electrical and electronic articles (i.e., plastic enclosures)											
Industrial and commercial use – Construction, paint, electrical and metal products – Building/Construction materials											

Condition of Use	Workers			ONUs	Consumers/ Bystanders ^a			General Population			
	Inh.	Derm.	Aggr.	Inh.	Inh.	Derm.	Ingest.	Ingestion			Inhalation (Ambient Air)
								DW	Fish	Human Milk	
Industrial and commercial use – Packaging, paper, plastic, hobby products – Plastic and rubber products											
Industrial and commercial use – Other – Laboratory chemical											
Consumer use – Construction, paint, electrical, and metal products – Reactive flame retardant in electrical and electronic articles											
Consumer use – Construction, paint, electrical, and metal products – Additive flame retardant in electrical and electronic articles (<i>i.e.</i> , plastic enclosures)											
Consumer use – Construction, paint, electrical, and metal products – Reactive flame retardant in automotive and aviation articles (<i>i.e.</i> , laminate and prepreg material)											
Consumer use – Packaging, paper, plastic, hobby products – Plastic and rubber products											
Disposal											
Aggr. = aggregate; COU = condition of use; Derm. = dermal; DW = drinking water; Ingest. = ingestion; Inh. = inhalation; ONU = occupational non-user Shaded cells with ✖ are COUs that contribute to a preliminary determination of unreasonable risk of injury (non-cancer health effects) to human health. ^a Only inhalation exposure was assessed for bystanders.											

Table ES-2. Environment: Assessed TBBPA COUs Contributing to a Preliminary Determination of Unreasonable Risk of Injury

Condition of Use	Aquatic						Amphibians		Terrestrial			
	Vertebrates		Invertebrates		Benthic ^a Invert.	Algae			Invert.	Plant	Mammal	Aq.-Dep Mammal
	Acute	Chronic	Acute	Chronic	Chronic		Acute	Chronic				
Processing – As a reactant – Flame retardant in plastic material and resin manufacturing												
Processing – Incorporation into a formulation, mixture, or reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing		✖	✖	✖	✖		✖	✖				
Industrial and commercial use – Other – Laboratory chemical												
Disposal												
Aq.-Dep. = aquatic-dependent; Invert. = invertebrates Shaded cells with ✖ are COUs that contribute to a preliminary determination of unreasonable risk of injury to the environment. ^a Sediment-dwelling												

1 INTRODUCTION

EPA has evaluated 4,4'-(1-methylethylidene)bis[2,6-dibromophenol], also known as tetrabromobisphenol A (TBBPA), under section 6(b) of the Toxic Substances Control Act (TSCA). Section 1.1 describes the scope of this draft TBBPA risk evaluation, including information on TBBPA production volume and a life cycle diagram (LCD). Section 1.2 provides the conditions of use (COUs) under TSCA, conceptual models used for TBBPA, and populations (including subpopulations) and durations of exposure assessed. Section 1.3 includes an overview of the systematic review process. This draft risk evaluation also includes the following major sections and a total of six appendices:

- Section 2 summarizes basic physical and chemical characteristics as well as the fate and transport of TBBPA.
- Section 3 includes an overview of releases and concentrations of TBBPA in the environment.
- Section 4 presents the human health risk assessment, including exposure, hazard, and risk characterization based on TBBPA.
- Section 5 provides a discussion and analysis of the environmental risk assessment, including the environmental exposure, hazard, and risk characterization based on the COUs.
- Section 6 presents EPA's preliminary determination of whether TBBPA presents an unreasonable risk to human health or the environment under the assessed COUs.

Figure 1-1 provides an overview of the major inputs, phases/components, and outputs of the [TSCA risk evaluation process](#) (accessed May 22, 2026)—from chemical prioritization to scoping to releasing the final risk evaluation.

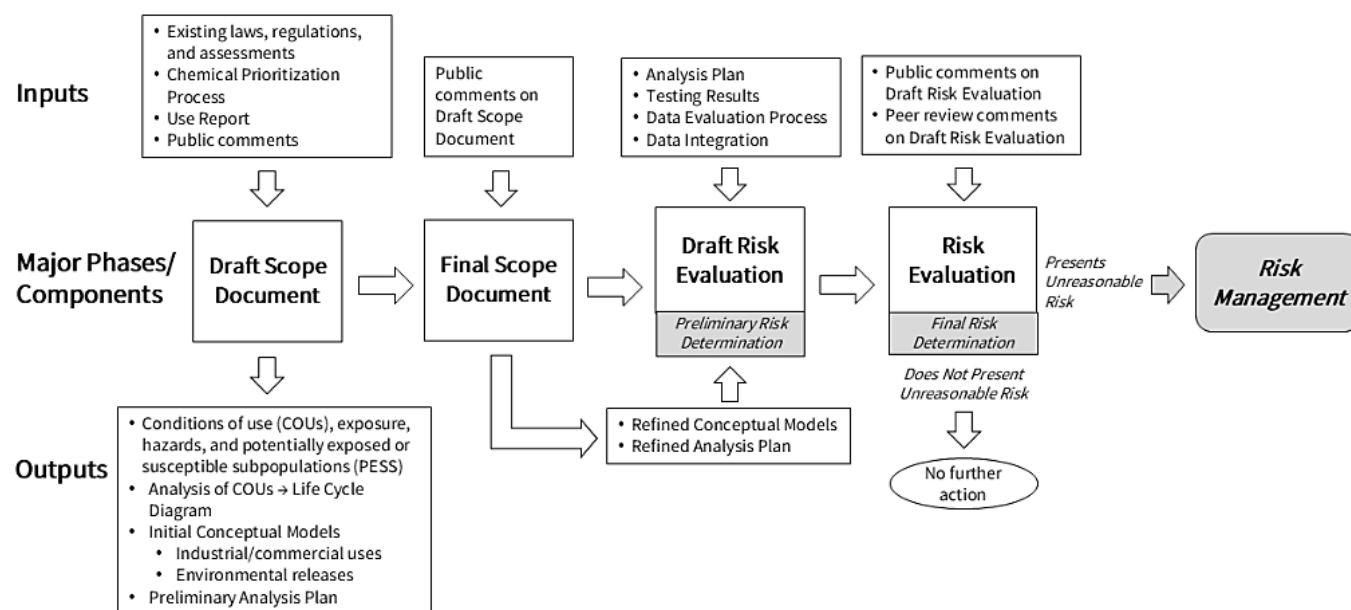


Figure 1-1. Overview of TSCA Risk Evaluation Process

1.1 Scope of the Risk Evaluation

EPA evaluated risk to human health and environmental populations for TBBPA. Specifically for human populations, the Agency evaluated risk to workers including occupational non-users (ONUs) via inhalation routes; risk to workers including ONUs via dermal routes; risk to consumers via inhalation, dermal, and oral routes; and risk to bystanders via the inhalation route. Additionally, EPA incorporated

the following potentially exposed and susceptible populations (PESS) into its assessment—females of reproductive age, pregnant women, infants, children and adolescents; people who frequently use consumer products and/or articles containing high-concentrations of TBBPA; people exposed to TBBPA in the workplace; tribes whose diets include large amounts of fish; and people in proximity to releasing facilities, including fenceline communities. As described further in Section 4.1.6, EPA assessed risks to the general population, which considered risk from exposure to TBBPA via oral ingestion of surface water, drinking water, fish, and soil from air to soil deposition. For environmental populations, the Agency evaluated risk to aquatic species via water and sediment as well as risk to terrestrial species via soil and qualitatively through trophic transfer.

The draft risk evaluation for TBBPA comprises a package of technical support documents (TSDs) and supplemental files. Each TSD contains an assessment with sub assessments that inform adjacent, “downstream” TSDs (and supplemental files). A basic diagram showing the layout and relationship of these TSDs/assessments is provided below in Figure 1-2. High-level summaries of each relevant TSD are presented throughout this draft risk evaluation. Detailed information for each TSD can be found in the corresponding documents. Appendix C includes a list and citations for TSDs and supplemental files included in the draft risk evaluation for TBPA.

The TSDs leveraged the data and information sources identified in the *Final Scope of the Risk Evaluation for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)*; CASRN 79-94-7 (also called the “final scope document” or “final scope”) ([U.S. EPA, 2020b](#)). EPA’s OPPT conducted a comprehensive search for “reasonably available information” to identify relevant TBBPA data for use in the draft risk evaluation. The approach used to identify specific relevant risk assessment information was discipline-specific and is detailed in the *Draft Systematic Review Protocol for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026ab](#)) (also called the “Draft Systematic Review Protocol for TBBPA”), or as otherwise noted in the relevant TSDs.

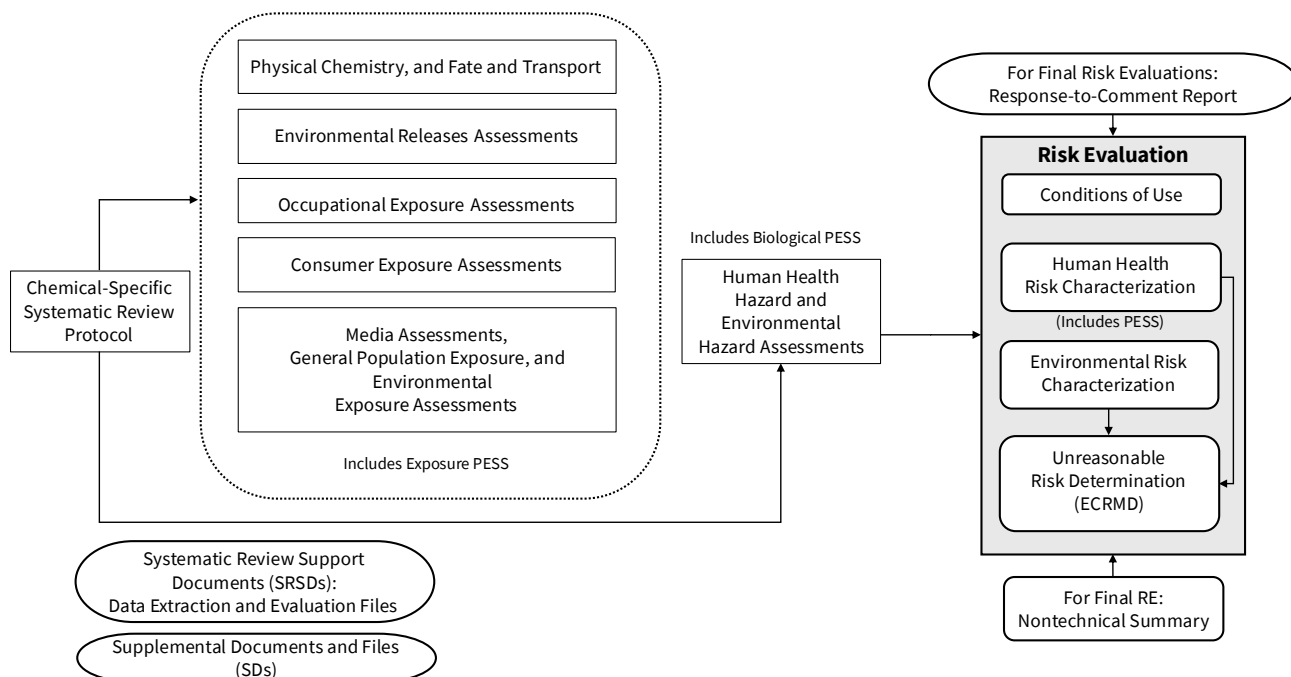


Figure 1-2. Draft Risk Evaluation Document Summary Map
PESS = potentially exposed or susceptible subpopulations

1.1.1 Life Cycle and Production Volume

The LCD shown in Figure 1-3 depicts the COUs that are within the scope of the risk evaluation, during various life stages, including manufacturing, processing, distribution, use (industrial, commercial, and consumer), and disposal. The information in the LCD is grouped according to the Chemical Data Reporting (CDR) processing codes and use categories (including functional use codes for industrial uses and product categories for industrial, commercial, and consumer uses). The CDR Rule under TSCA section 8(a) (40 CFR part 711) requires U.S. manufacturers (including importers) to provide EPA with information on the chemicals they manufacture or import into the United States. EPA collects CDR data approximately every 4 years with the latest collections occurring in 2006, 2012, 2016, 2020, and 2024, with typical reporting thresholds of 25,000 lb. Because TBBPA is the subject of a TSCA section 5(a)(2) Proposed Significant New Use Rule (SNUR), the reporting threshold for 2024 CDR was reduced to 2,500 lb.

One of the TSDs, the *Draft Occupational Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026v](#)) contains additional descriptions (e.g., process descriptions, worker activities, process flow diagrams) for each manufacturing, processing, use, and disposal category.

TBBPA has historically been the flame retardant with the largest production volume worldwide ([U.S. EPA, 2020c](#)). The national aggregate production volume of TBBPA was between 100 to 500 million lb per year from 1994 to 2011, based on submissions required by the CDR Rule (previously known as the Inventory Update Rule). Since 2011, the U.S. production volume has decreased. The production volume reported in the final scope document was between 50 and 100 million lb, based on total production volume of TBBPA in 2015 from the 2016 CDR reporting period. The range decreased in the 2020 CDR data (the reported total production volume in 2019 was between 20–100 million lb) ([U.S. EPA, 2022a](#)). The latest 2024 CDR indicates further decrease in the U.S. production volume of TBBPA, with the reported total production volume in 2023 to be between 10 and 50 million lb ([U.S. EPA, 2026a](#)). EPA presents production volume as a range to protect data claimed as confidential business information (CBI).

1.2 Conditions of Use Included in the Risk Evaluation

The final scope document ([U.S. EPA, 2020b](#)) identified and described the life cycle stages, categories, and subcategories that comprise COUs that EPA planned to consider in the risk evaluation. The COUs included in this draft risk evaluation are reflected in the LCD (Figure 1-3) and conceptual models (Section 1.2.1). Table 1-1 below presents all COUs for TBBPA.

In this draft risk evaluation, EPA made updates to the COUs listed in the final scope document ([U.S. EPA, 2020b](#)) (see Appendix D). These updates reflect EPA's improved understanding of the COUs based on new CDR data and other reasonably available information, which have been added to the reference(s) column of Table 1-1. Updates included (1) additions and clarification of COUs based on new reporting in CDR for 2020 or information received from stakeholders; (2) consolidation of redundant COUs from the processing life stage based on inconsistencies found in CDR reporting for TBBPA processing and uses as well as communications with stakeholders about the use of TBBPA in industry; (3) removal of COUs that EPA determined are no longer intended, known, or reasonably foreseen to be manufactured, processed, distributed in commerce, used, or disposed of; and (4) correction of typos or edits for consistency. A complete list of updates and explanations of the updates made to COUs for TBBPA from the final scope document to this draft risk evaluation is provided in Appendix D.1.

625 Table 1-1 presents the revised COUs that were included and evaluated in the risk evaluation for TBBPA.
626 In addition, Appendix D.2 contains descriptions of each COU. These COUs were evaluated for acute,
627 intermediate, chronic, and lifetime exposures, as applicable, based on reasonably available exposure and
628 hazard data as well as the relevant study populations for each.

MFG / IMPORT

PROCESSING

INDUSTRIAL, COMMERCIAL, CONSUMER USES

RELEASES AND
WASTE DISPOSAL

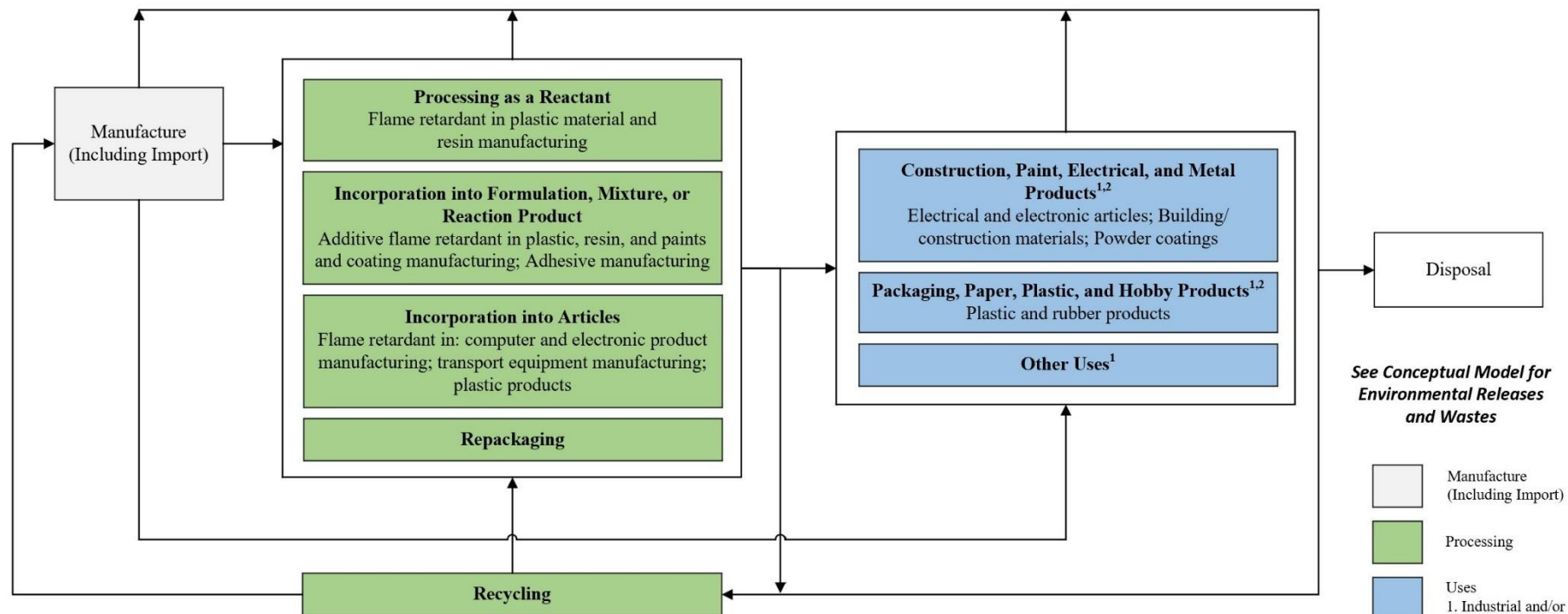


Figure 1-3. TBBPA Life Cycle Diagram

632 Table 1-1. Categories and Subcategories of Use and Corresponding Exposure Scenario in the Draft Risk Evaluation for TBBPA

Life Cycle Stage ^a	Category ^b	Subcategory ^c	Reference(s)
Manufacture	Domestic manufacture	N/A ^d	U.S. EPA (2019a) ; U.S. EPA (2020a) ; U.S. EPA (2026a)
	Import	N/A ^d	EPA-HQ-OPPT-2018-0462-0041 ; U.S. EPA (2019a) ; U.S. EPA (2020a) ; U.S. EPA (2026a)
Processing	As a reactant	Flame retardant in plastic material and resin manufacturing	U.S. EPA (2019a) ; U.S. EPA (2020a) ; EPA-HQ-OPPT-2023-0012-0005 ; EPA-HQ-OPPT-2023-0012-0014 ; Integral Consulting (2025a) ; U.S. EPA (2026a)
		Intermediate in all other chemical product and preparation manufacturing	U.S. EPA (2019a) ; U.S. EPA (2020a) ; EPA-HQ-OPPT-2023-0012-0005 ; EPA-HQ-OPPT-2023-0012-0014
	Incorporation into formulation, mixture, or reaction product	Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing	EPA-HQ-OPPT-2018-0462-0006 ; EPA-HQ-OPPT-2018-0462-0016 ; EPA-HQ-OPPT-2018-0462-0017 ; U.S. EPA (2019a) ; U.S. EPA (2020a) ; Integral Consulting (2025a) ; U.S. EPA (2026a)
		Adhesive manufacturing	NIEHS (2002) ; CPSC (2015) ; EPA-HQ-OPPT-2018-0462-0003 ; EPA-HQ-OPPT-2018-0462-0004 ; EPA-HQ-OPPT-2018-0462-0016 ; U.S. EPA (2020a) ; Integral Consulting (2025a) ; U.S. EPA (2026a)
	Incorporation into article	Reactive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., printed circuit boards and semiconductor packages)	EPA-HQ-OPPT-2018-0462-0006 ; EPA-HQ-OPPT-2018-0462-0016 ; EPA-HQ-OPPT-2018-0462-0030 ; EPA-HQ-OPPT-2018-0462-0038 ; EPA-HQ-OPPT-2018-0462-0036 ; EPA-HQ-OPPT-2018-0462-0041 ; U.S. EPA (2019a) ; U.S. EPA (2020a) ; Integral Consulting (2025a)

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Life Cycle Stage ^a	Category ^b	Subcategory ^c	Reference(s)
Processing	Incorporation into article	Reactive flame retardant in transportation equipment manufacturing (<i>e.g.</i> , interior material for automotive and aviation articles)	U.S. EPA (2019a) ; EPA-HQ-OPPT-2018-0462-0004 ; EPA-HQ-OPPT-2018-0462-0006 ; EPA-HQ-OPPT-2018-0462-0016 ; EPA-HQ-OPPT-2018-0462-0041 ; EPA-HQ-OPPT-2018-0462-0045 ; Integral Consulting (2025a)
		Additive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (<i>e.g.</i> , plastic electronic enclosures)	EPA-HQ-OPPT-2018-0462-0006 ; EPA-HQ-OPPT-2018-0462-0016 ; EPA-HQ-OPPT-2018-0462-0030 ; EPA-HQ-OPPT-2018-0462-0038 ; U.S. EPA (2019a) ; U.S. EPA (2020a) ; Integral Consulting (2025a)
	Repackaging	N/A ^d	
	Recycling	N/A ^d	EPA-HQ-OPPT-2018-0462-0016 ; U.S. EPA (2019a) ; U.S. EPA (2019d) ; EPA-HQ-OPPT-2023-0012-0013
Distribution in commerce	N/A ^d	N/A ^d	
Industrial use	Construction, paint, electrical, and metal products	Powder coatings	SolEpoxy (2010) ; EPA-HQ-OPPT-2018-0462-0016
Industrial and commercial use	Construction, paint, electrical, and metal products	Reactive flame retardant in electrical and electronic articles	EPA-HQ-OPPT-2018-0462-0006 ; EPA-HQ-OPPT-2018-0462-0016 ; EPA-HQ-OPPT-2018-0462-0030 ; EPA-HQ-OPPT-2018-0462-0036 ; EPA-HQ-OPPT-2018-0462-0038 ; EPA-HQ-OPPT-2018-0462-0041 ; U.S. EPA (2019a) ; U.S. EPA (2020a) ; EPA-HQ-OPPT-2023-0012-0013 ; Integral Consulting (2025a) ; U.S. EPA (2026a)
		Reactive flame retardant in automotive and aviation articles (<i>i.e.</i> , laminate and prepreg material)	EPA-HQ-OPPT-2018-0462-0041 ; EPA-HQ-OPPT-2018-0462-0004 ; EPA-HQ-OPPT-2018-0462-0016 ; EPA-HQ-OPPT-2018-0462-0033 ;

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Life Cycle Stage ^a	Category ^b	Subcategory ^c	Reference(s)
Industrial and commercial use	Construction, paint, electrical, and metal products		Integral Consulting (2025a)
		Additive flame retardant in electrical and electronic articles (<i>i.e.</i> , plastic enclosures)	EPA-HQ-OPPT-2018-0462-0006 ; EPA-HQ-OPPT-2018-0462-0016 ; EPA-HQ-OPPT-2018-0462-0030 ; EPA-HQ-OPPT-2018-0462-0038 ; U.S. EPA (2019a) ; U.S. EPA (2020a) ; EPA-HQ-OPPT-2023-0012-0013 ; U.S. EPA (2026a)
		Building/construction materials	U.S. EPA (2019a) ; NIEHS (2002) ; U.S. EPA (2026a)
	Packaging, paper, plastic, and hobby products	Plastic and rubber products	3DXTECH (2017) ; U.S. EPA (2020a) ; U.S. EPA (2026a)
	Other	Laboratory chemical	Inc. (2019) ; EPA-HQ-OPPT-2018-0462-0039
Consumer use	Construction, paint, electrical, and metal products	Reactive flame retardant in electrical and electronic articles	EPA-HQ-OPPT-2018-0462-0006 ; EPA-HQ-OPPT-2018-0462-0016 ; EPA-HQ-OPPT-2018-0462-0017 ; EPA-HQ-OPPT-2018-0462-0030 ; EPA-HQ-OPPT-2018-0462-0036 ; EPA-HQ-OPPT-2018-0462-0038 ; U.S. EPA (2019a) ; U.S. EPA (2020a) ; U.S. EPA (2026a)
		Additive flame retardant in electrical and electronic articles (<i>i.e.</i> , plastic enclosures)	EPA-HQ-OPPT-2018-0462-0006 ; EPA-HQ-OPPT-2018-0462-0016 ; EPA-HQ-OPPT-2018-0462-0030 ; EPA-HQ-OPPT-2018-0462-0038 ; U.S. EPA (2019a) ; U.S. EPA (2020a) ; U.S. EPA (2026a)
		Reactive flame retardant in automotive and aviation articles (<i>i.e.</i> , laminate and prepreg material)	EPA-HQ-OPPT-2018-0462-0041 ; RJLG (2023b) ; RJLG (2023a) ; NORDAM (2023) ; MAT-CS (2023)
	Packaging, paper, plastic, and hobby products	Plastic and rubber products	3DXTECH (2017) ; U.S. EPA (2026a)

Life Cycle Stage ^a	Category ^b	Subcategory ^c	Reference(s)
Disposal	Disposal	Disposal	
^a Life cycle stage use definitions (40 CFR 711.3) – “Industrial use” means use at a site at which 1 or more chemicals or mixtures are manufactured (including imported) or processed. – “Commercial use” means the use of a chemical or a mixture containing a chemical (including as part of an article) in a commercial enterprise providing saleable goods or services. – “Consumer use” means the use of a chemical or a mixture containing a chemical (including as part of an article, such as furniture or clothing) when sold to or made available to consumers for their use. – Although EPA has identified both industrial and commercial uses here for purposes of distinguishing scenarios in this document, the Agency interprets the authority over “any manner or method of commercial use” under TSCA section 6(a)(5) to reach both. ^b These categories of condition of use (COU) appear in the LCD, reflect CDR codes, and broadly represent COUs of TBBPA in industrial and/or commercial settings and for consumer uses. ^c These subcategories reflect more specific COUs of TBBPA. ^d “N/A” means not applicable where the category name, subcategory name, or both are duplicative and therefore unnecessary for identifying the COU.			

633

1.2.1 Conceptual Models

The conceptual model in Figure 1-4 presents the exposure pathways, exposure routes, and hazards to human populations from industrial and commercial activities and uses of TBBPA. There is potential for exposures to workers and ONUs via inhalation and dermal routes. Dermal exposure to TBBPA in liquids, semi-solids and solids is expected. Figure 1-5 presents the conceptual model for consumer activities and uses, Figure 1-6 presents general population exposure pathways and hazards for environmental releases and wastes, and Figure 1-7 presents the conceptual model for ecological exposures and hazards from environmental releases and wastes.

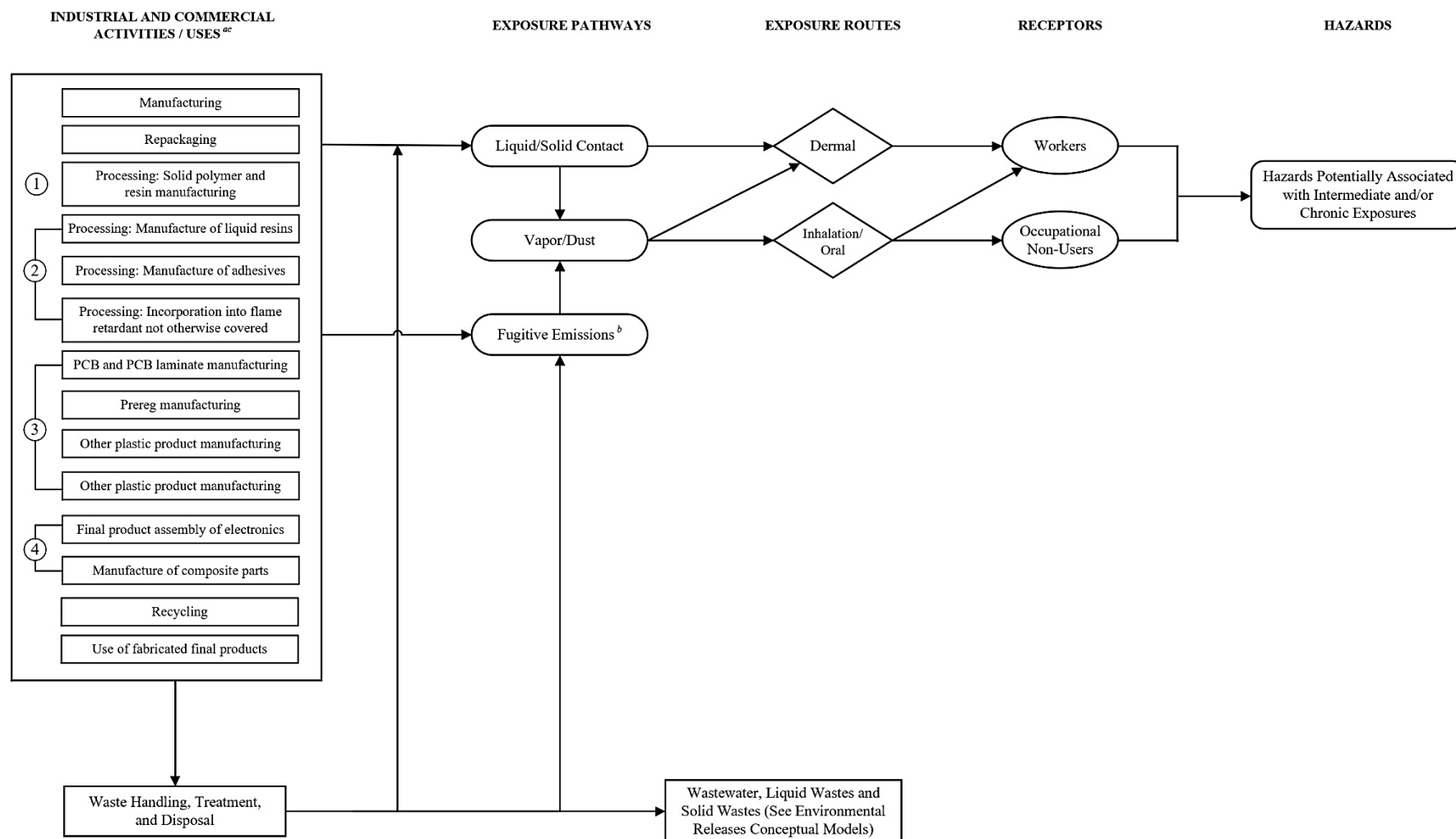


Figure 1-4. TBBPA Conceptual Model for Industrial and Commercial Activities and Uses: Potential Exposure and Hazards

^a Some products are used in both commercial and consumer applications. See Table 1-1 for categories and subcategories of COUs.

^b Fugitive air emissions are emissions that are not routed through a stack and may occur during sampling, equipment cleaning, and container loading/unloading.

^c Use groupings are based on test report data submitted to EPA by the American Chemistry Council (ACC)'s TBBPA Consortium.

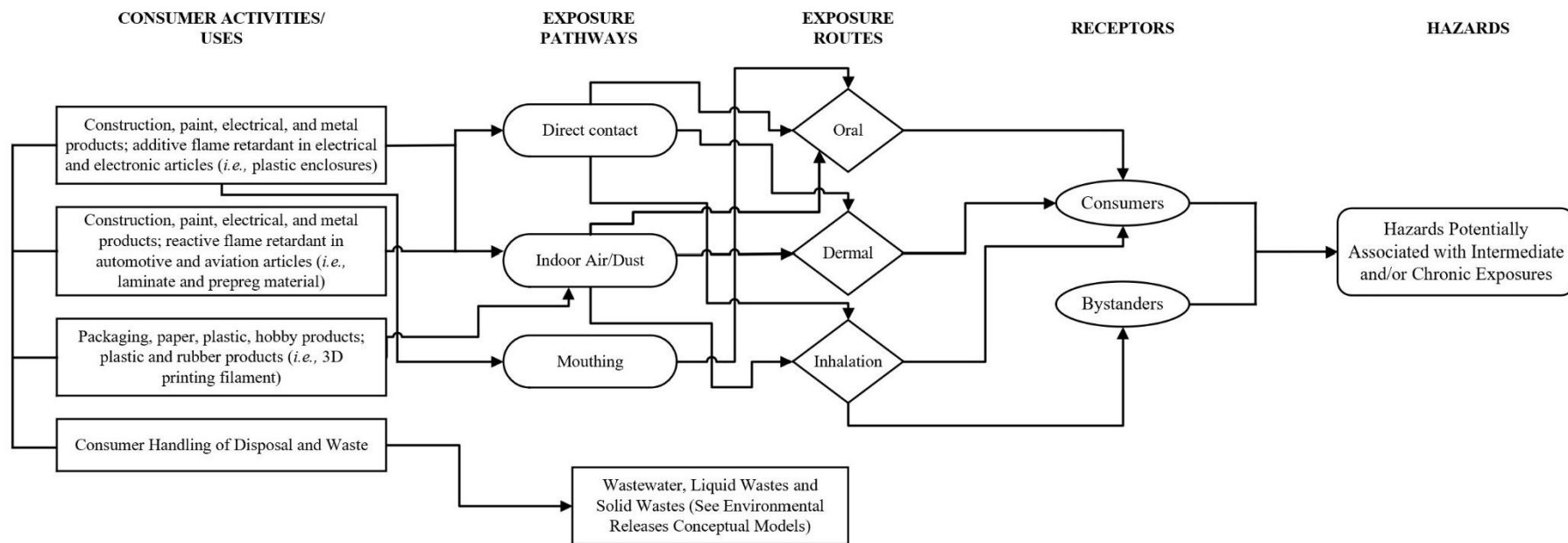


Figure 1-5. TBBPA Conceptual Model for Consumer Activities and Uses: Potential Exposures and Hazards

The conceptual model presents the exposure pathways, exposure routes, and hazards to human populations from consumer activities and uses of TBBPA. The conceptual model illustrates only the consumer COUs that were quantitatively evaluated.

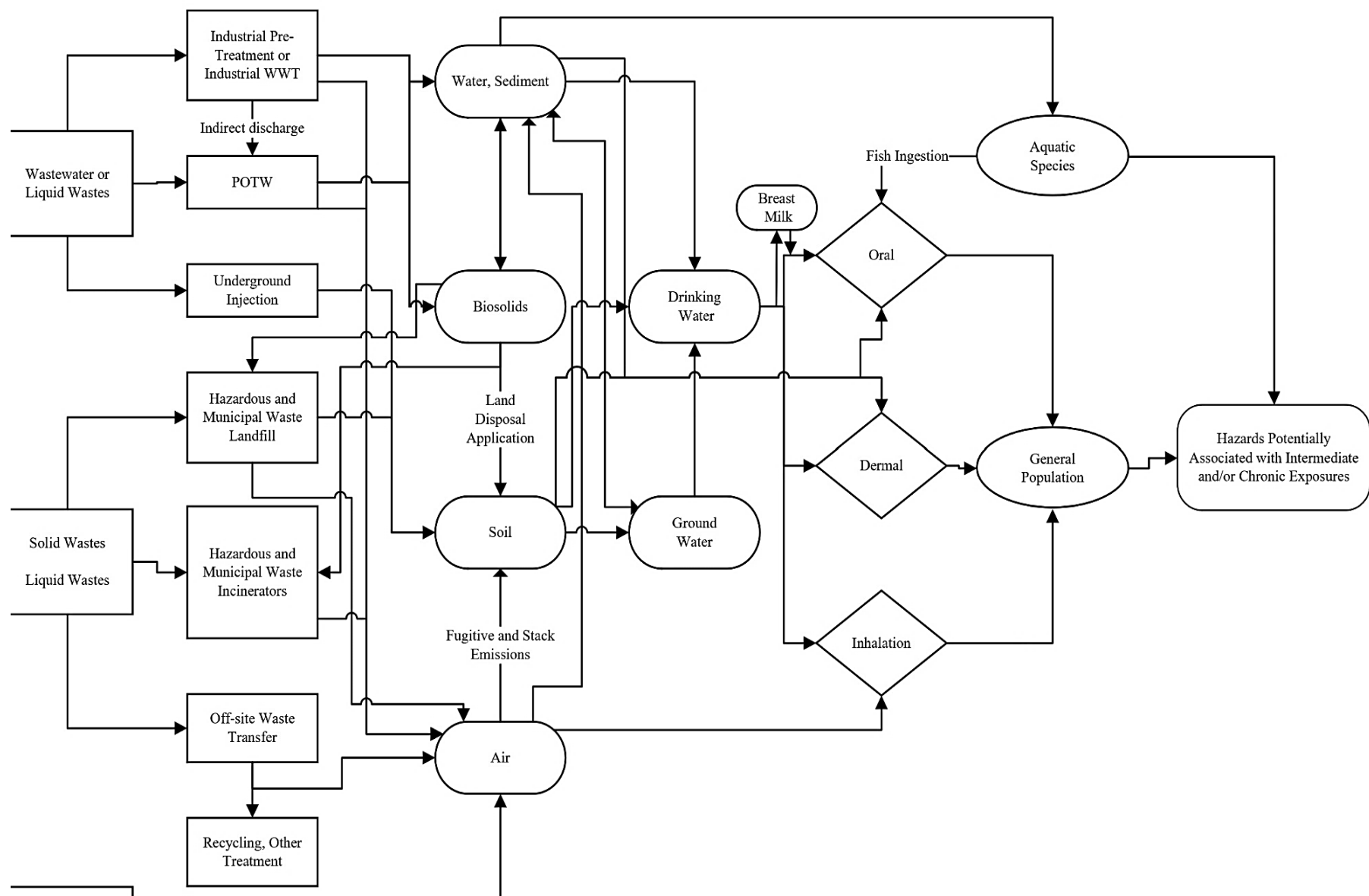


Figure 1-6. TBBPA Conceptual Model for Environmental Releases and Wastes: General Population Hazards

The conceptual model presents the exposure pathways, exposure routes, and hazards to human populations from releases and wastes from industrial, commercial, and/or consumer uses of TBBPA.

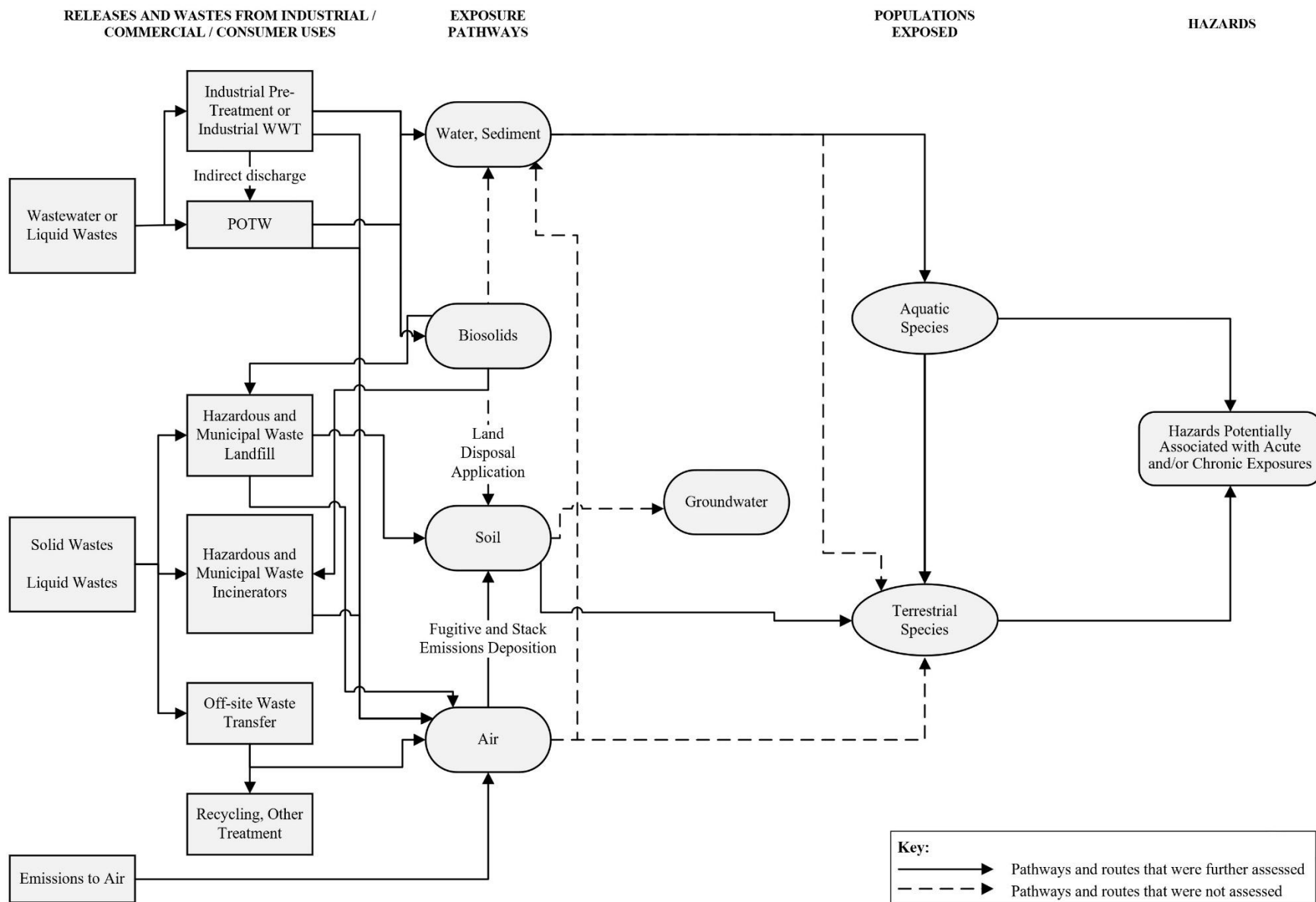


Figure 1-7. TBBPA Conceptual Model for Environmental Releases and Wastes: Ecological Exposure and Hazards

The conceptual model presents the exposure pathways, exposure routes, and hazards to human populations from releases and wastes from industrial, commercial, and/or consumer uses of TBBPA.

1.2.2 Populations and Durations of Exposures Assessed

Based on the conceptual models presented in Section 1.2.1, EPA evaluated risk to environmental and human populations. Environmental risks were evaluated for acute and chronic exposure scenarios for aquatic and terrestrial species, as appropriate. Human health risks were evaluated for intermediate and chronic exposure scenarios, as applicable based on reasonably available exposure and hazard data for TBBPA as well as the relevant populations for each. TBBPA is not expected to be acutely toxic (Section 4.2.1), thus acute exposure scenarios were not developed. Human populations assessed include the following:

- workers, including adults and women of reproductive age;
- ONUs, including adults of both sexes aged 16 or more years (including pregnant workers);
- consumers, including infants (<1 year), toddlers (1–2 years), children (3–5 years and 6–10 years), young teens (11–15 years), teenagers (16–20 years), and adults (21+ years);
- bystanders, including infants (<1 year), toddlers (1–2 years), and children (3–5 years and 6–10 years); and
- general population, including infants, children, youth, and adults.

Note that the age groups for consumers, bystanders, and general population are different because each life stage used unique exposure factors (e.g., mouthing, drinking water ingestion, fish consumption rates). These exposure factors are provided in EPA's *Exposure Factors Handbook* ([U.S. EPA, 2011b](#)).

1.2.2.1 Potentially Exposed or Susceptible Subpopulations

TSCA section 6(b)(4)(A) requires that risk evaluations “determine whether a chemical substance presents an unreasonable risk of injury to health or the environment, without consideration of costs or other non-risk factors, including an unreasonable risk to a potentially exposed or susceptible subpopulation identified as relevant to the risk evaluation by the Administrator, under the conditions of use.” TSCA section 3(12) states that “the term ‘potentially exposed or susceptible subpopulation’ (PESS) means a group of individuals within the general population identified by the Administrator who, due to either greater susceptibility or greater exposure, may be at greater risk than the general population of adverse health effects from exposure to a chemical substance or mixture, such as infants, children, pregnant women, workers, or the elderly.”

This draft risk evaluation considers PESS throughout the human health risk assessment (Section 4)—including throughout the exposure assessment, hazard identification, dose-response analysis supporting this assessment—and as summarized in the hazard characterization (Section 4.3.5). Evaluation of the qualitative and quantitative evidence for PESS begins as part of the systematic review process (Section 1.3). Any available relevant published studies and other data are identified from a broad literature search strategy across several databases and focused only on the chemical name (including synonyms and trade names) with no additional search limits. This broad search process is described in the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances: A Generic TSCA Systematic Review Protocol with Chemical-Specific Methodologies* (also referred to as “2021 Draft Systematic Review Protocol”) ([U.S. EPA, 2021a](#)).

PESS factors can influence the selection of relevant exposure pathways, the sensitivity of derived hazard values, the identification of human subpopulations, and the discussion of uncertainties throughout the assessment. In this draft risk evaluation, EPA integrated and assessed available information on hazards and exposures for COUs of TBBPA, including information relevant to specific risks of injury to PESS. Incorporated PESS include people exposed to TBBPA in the workplace, people who frequently use

consumer products and/or articles containing high concentrations of TBBPA, and people exposed to TBBPA following its releases to the environment (*i.e.*, the general population).

1.3 Systematic Review

EPA applies systematic review principles in the development of risk evaluations under the amended TSCA. Section 26(h) of TSCA requires EPA to use scientific information, technical procedures, measures, methods, methodologies, and models consistent with the best available science and bases decisions under TSCA section 6 on the weight of scientific evidence.

To meet the TSCA section 26(h) science standards, EPA used the TSCA systematic review process described in the 2021 Draft Systematic Review Protocol ([U.S. EPA, 2021a](#)) and the *Draft Systematic Review Protocol for 4,4'-(1-methylethylidene)bis[2,6-dibromophenol] (TBBPA)* (also called the “Draft Systematic Review Protocol for TBBPA”) ([U.S. EPA, 2026ab](#)). Systematic review supports the risk evaluation in that data searching, screening, evaluation, extraction, and evidence integration are used to develop the exposure and hazard assessments based on reasonably available information. EPA defines “reasonably available information” to mean information that the Agency possesses or can reasonably obtain and synthesize for use in risk evaluations, considering the deadlines for completing the evaluation (40 CFR 702.33).

The systematic review process is illustrated in Figure 1-8. Details regarding these steps are provided in the 2021 Draft Systematic Review Protocol ([U.S. EPA, 2021a](#)) and the Draft Systematic Review Protocol for TBBPA ([U.S. EPA, 2026ab](#)). The latter is a chemical-specific systematic review protocol used to transparently document any updates or clarifications made to the systematic review process used for considering information identified for TBBPA as compared to the steps described and published in the 2021 Draft Systematic Review Protocol ([U.S. EPA, 2021a](#)).



Figure 1-8. Diagram of the Systematic Review Process

Additional details on data evaluation and extraction as well as evidence integration are described in Sections 5 and 6 of the Draft Systematic Review Protocol for TBBPA ([U.S. EPA, 2026ab](#)). EPA also identified key assessments conducted by other Agency programs and other U.S. and international organizations. These are provided in Appendix B.

2 CHEMISTRY AND FATE AND TRANSPORT OF TBBPA

Physical and chemical properties determine the behavior and characteristics of a chemical that inform its condition of use, environmental fate and transport, potential toxicity, exposure pathways, routes, and hazards. Environmental fate and transport include environmental partitioning, accumulation, degradation, and transformation processes. Environmental transport is the movement of the chemical within and between environmental media, such as air, water, soil, and sediment. Thus, understanding the environmental fate of TBBPA informs the specific exposure pathways as well as the potential human and environmentally exposed populations that EPA considered in this draft risk evaluation.

Sections 2.1 and 2.2 summarize the physical and chemical properties and environmental fate and transport of TBBPA, respectively. For detailed information, see the *Draft Physical Chemistry and Fate, Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026w](#)).

2.1 Summary of Physical and Chemical Properties

EPA identified and evaluated physical and chemical property data and information according to the process described in the Draft Systematic Review Protocol for TBBPA ([U.S. EPA, 2026ab](#)). The Agency considered both measured and estimated physical and chemical property data/information as described in the *Draft Physical Chemistry and Fate, Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026w](#)). The selected values are summarized in Table 2-1, as applicable. Information on the full, extracted dataset is available in the *Draft Data Quality Evaluation and Data Extraction Information for Physical and Chemical Properties for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026l](#)).

TBBPA exists as a white (colorless) crystalline powder and melts around 181 °C. The boiling point of TBBPA is reported to be 316 °C. However, TBBPA is expected to decompose over the temperature range of 200 to 300 °C ([Barontini et al., 2004](#)). Hence the boiling point likely represents the decomposition temperature of TBBPA rather than its true boiling point. TBBPA is reported to have low volatility with a vapor pressure of 4.68×10^{-8} mm Hg at 25 °C ([BRE, 2009](#)) and Henry's Law constant of 1.45×10^{-10} atm·m³/mol at 25 °C. TBBPA has a water solubility of 4.15 mg/L at pH 7.56 and 25 °C, and a log octanol/water partition coefficient (K_{OW}) of 4.75 ± 0.07 at pH 7.53 and 25 °C, which makes it a hydrophobic organic compound. Its water solubility and log K_{OW} is highly dependent on the pH level as increasing pH leads to the ionization of TBBPA, which will increase its water solubility and decrease its log K_{OW} value (see Table 2-1). TBBPA has two dissociation constants (pK_a) of 7.5 (pK_{a1}) and 8.5 (pK_{a2}). This means that the ionized forms of TBBPA (*i.e.*, monobasic and dibasic) will become dominant under neutral environment conditions (pH 7–8). At lower pHs, TBBPA will be present in a nonionic (neutral) form ([NICNAS, 2020](#); [Abou-Elwafa Abdallah, 2016](#); [ECB, 2008, 2006a](#)). TBBPA is categorized as a semi-volatile organic compound (SVOC) because of its high molecular weight, low vapor pressure, low water solubility, and slightly high log K_{OW} value ([CPSC, 2015](#)).

775 **Table 2-1. Physical and Chemical Properties of TBBPA**

Property	Selected Value(s) ^a	Source(s)	Data Quality Rating ^b
Molecular formula	C ₁₅ H ₁₂ Br ₄ O ₂	HSDB (2018)	High
Molecular weight	543.88 g/mol	Haynes (2014)	High
Physical form	White (colorless) crystalline powder	Van Esch (1995) ; NICNAS (2001b) ; NIEHS (2002) ; ECB (2008) ; EC (2013) ; CPSC (2015) ; IARC (2018) ; HSDB (2018) ; U.S. EPA (2019c)	High
Melting point	181 °C	Average of Kuramochi et al. (2008) and Fu and Suuberg (2012)	High
Boiling point	316 °C	ECB (2006a) ; O'Neil (2013) ; U.S. EPA (2015b) ; IARC (2018) ; HSDB (2018)	High
Density	2.158 g/m ³ at 19.85 °C	Elsevier (2019)	High
Vapor pressure	4.68E-08 mm Hg at 25 °C	BRE (2009) ; CPSC (2015) ; IARC (2018) ; HSDB (2018)	High
Vapor density	No data identified		
Water solubility	0.171 mg/L at pH 3.05 and 25 °C (nonionic form) 4.15 mg/L at pH 7.56 and 25 °C 1,510 mg/L at pH 8.91 and 25 °C 27,900 mg/L at pH 9.5 and 25 °C	Kuramochi et al. (2008)	High
Octanol/water partition coefficient (log K _{OW})	6.53 ± 0.12 at pH 3.05 and 25 °C (non-ionic form) 4.75 ± 0.07 at pH 7.53 and 25 °C 1.25 ± 0.01 at pH 9.18 and 25 °C -1.22 ± 0.00 at pH 11.83 and 25 °C	Kuramochi et al. (2008)	High
Henry's law constant	1.45E-10 atm·m ³ /mol at 25 °C	Kuramochi et al. (2008)	High
Flash point	No data identified		
Auto flammability	Does not undergo autoignition, but decomposes at 200–300 °C	HSDB (2018) ; NCBI (2020)	Medium
Viscosity	No data identified		
Refractive index	No data identified		
Dielectric constant	No data identified		
Dissociation constants (pKa)	pK _{a1} = 7.5 pK _{a2} = 8.5	IPCS (1995) as cited in ECB (2006a) , ECB (2008) , O'Neil (2013) , HSDB (2018) , and U.S. EPA (2019c)	High
UV-vis absorption	λ _{max} (water): 310 nm (ε 9170 M ⁻¹ cm ⁻¹)	O'Neil (2013)	High

^a Measured unless otherwise noted. Additional details on the basis for each of these values are provided in the *Draft Physical Chemistry and Fate Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026w](#)).

^b “Data Quality Rating” applies to all references listed in this table.

2.2 Summary of Environmental Fate and Transport

Reasonably available environmental fate data, including biotic and abiotic biodegradation rates, removal during wastewater treatment, volatilization from water sources, and organic carbon/water partition coefficient (log K_{OC}), are used in the current draft risk evaluation. In assessing the environmental fate and transport of TBBPA, EPA considered the full range of results from data sources that were rated high confidence during systematic review. Information on the full extracted dataset is available in the *Draft Data Quality Evaluation and Data Extraction Information for Environmental Fate and Transport for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* (U.S. EPA, 2026j). Other fate estimates were based on modeling results from EPI Suite™ (U.S. EPA, 2017), a predictive tool for physical and chemical properties and environmental fate estimation. Information regarding the model inputs is available in the *Draft Physical Chemistry and Fate Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* (U.S. EPA, 2026w). EPA evaluated the reasonably available information to characterize the environmental fate and transport of TBBPA, the key points of the fate assessment for TBBPA are summarized below and listed in Table 2-2.

Given the consistent results from numerous high-quality studies, there is a robust confidence that TBBPA:

- is not expected to undergo significant direct photolysis and will degrade slowly by reaction with photochemically produced ·OH in the atmosphere.
- is not readily biodegradable in water under aerobic conditions.
- will undergo primary biodegradation in sediment under aerobic and anaerobic conditions yielding several intermediate byproducts and ultimately bisphenol A (BPA) and will have a strong affinity for organic carbon.
- is not expected to undergo hydrolysis since it lacks the functional groups required to hydrolyze under environmental conditions.
- is not expected to volatilize from surface water and moist soil.
- is expected to transform into BPA, which is not expected to be persistent in the environment.
- will be effectively degraded (>99.9%) and its emission through incineration ash landfill will be negligible.
- will be removed significantly after undergoing wastewater treatment primarily by sorption to sludge, with a small fraction of TBBPA in the wastewater effluent being discharged to receiving water.
- will not bioconcentrate and bioaccumulate in fish.
- will not bioaccumulate in sediment-dwelling organisms.
- does not exhibit trophic magnification.

As a result of mixed conclusions, there is moderate confidence that TBBPA:

- has potential to undergo atmospheric long-range transport due to its persistence in the air.

Findings with a robust weight of evidence had two or more high-quality studies that were largely in agreement with each other. Findings that have a moderate weight of evidence were based on high-quality studies that were mostly in agreement but varied in sample size and consistency of results.

817 **Table 2-2. Summary of Environmental Fate Information for TBBPA**

Parameter	Value	Reference(s)	Data Quality Rating
Indirect photodegradation in air	$t_{1/2}$ = 280.8 hours (based on $\cdot\text{OH}$ rate constant of $1.02\text{E}-12 \text{ cm}^3/\text{mole}\cdot\text{sec}$ at 25°C and $9.7\text{E}05 \cdot\text{OH}/\text{cm}^3$; calculated)	He et al. (2016)	High
	$t_{1/2}$ = 3.615 days (based on $\cdot\text{OH}$ rate constant of $2.96\text{E}-12 \text{ cm}^3/\text{mole}\cdot\text{sec}$ at 25°C and 12-hour day with $1.5\text{E}06 \cdot\text{OH}/\text{cm}^3$; estimated) ^b	U.S. EPA (2017)	
Direct photodegradation in water	$t_{1/2}$ = 16, 30, and 350 minutes at pH values of 10, 7.1, and 5.5, respectively, based on UV absorption maximum at 310 nm	Eriksson et al. (2004)	High
	2,6-dibromo-p-benzosemiquinone anions and tribromohydroxybisphenol A were identified as the main photodecomposition byproducts	Han et al. (2009) ; Han et al. (2016)	
	$t_{1/2}$ = 23–99 minutes at test substance concentration of 0.1–10 mg/L and pH 7.6–7.7 based on UV absorption maximum at 800 nm	Bao and Niu (2015)	
	Phototransformation rate = 0.0093 per minute after irradiation with simulated solar light, irradiance of $20 \text{ mW}/\text{cm}^2$, in ultrapure water at initial pH of 8	Wang et al. (2015)	
Direct photodegradation in soil	67.88% and 83.29% after 256 hours of exposure to natural sunlight and artificial UV light, respectively	Liu et al. (2016)	High
Hydrolysis half-life	Not expected to be susceptible to hydrolysis because TBBPA lacks functional groups that hydrolyze under environmental conditions	ECB (2008) ; EC (2013) ; NCBI (2020) ; NICNAS (2020)	High
Aerobic biodegradation in water	$t_{1/2}$ = 21 days at pH 7 and 30°C	Yang et al. (2017)	High
Anaerobic biodegradation in water	$t_{1/2}$ = 0.53–0.59 days at pH 7.6 and 37°C	Gerecke et al. (2006)	High
	17.5%/20 days with unacclimated sludge	Peng et al. (2017)	
Aerobic biodegradation in sediment	$t_{1/2}$ = 48, 69, and 84 days at test substance concentration of 10, 100, and 1,000 $\mu\text{g}/\text{L}$	Springborn Laboratories (1989b)	High
	$t_{1/2}$ = 13.1, 9.0 and 11.0 days for sediment samples from sites A, B and C, respectively	Chang et al. (2012b)	
	$t_{1/2}$ = 11.2 days	Chang et al. (2014)	
	15%/15 days, 33%/45 days, and 44%/90 days at test concentration of 1 mg/kg	Wang et al. (2019a)	
	$t_{1/2}$ = 73.3 (spring) and 90.9 (autumn) days in Guandu sediment; 34.7 (spring) and 51.6 (autumn) days in Bali sediment	Yang et al. (2019)	

Parameter	Value	Reference(s)	Data Quality Rating
Anaerobic biodegradation in sediment	80%/10 days; major byproduct is bisphenol A	Ronen and Abeliovich (2000)	High
	Primary degradation is nearly completed within 55 days of incubation; primary byproduct is bisphenol A	Voordeckers et al. (2002)	
	Intermediate products were identified as mono-, di-, and tribromobisphenol A, with the final product being bisphenol A	Arbeli and Ronen (2003)	
	Intermediate products were identified as tri- and dibromobisphenol A, with the final product being bisphenol A	Ravit (2005); Ravit et al. (2005)	
	89%/7 days; major byproduct is bisphenol A	Arbeli et al. (2006)	
	$t_{1/2}$ = 27.5 days in Turkey Creek sediment and 23.7 days in Choptank River sediment	Wildlife International Ltd (2006a)	
	1.1 and 0.9% mineralization in abiotic and abiotic systems, respectively, with nominal test concentration of 50 µg/L (OECD 308)	Wildlife International Ltd (2006b)	
	$t_{1/2}$ = 16.6 days	Chang et al. (2012a)	
	$t_{1/2}$ = 41.1 (spring) and 65.4 (autumn) days in Guandu sediment; 31.4 (spring) and 42.9 (autumn) days in Bali sediment	Yang et al. (2019)	
Aerobic biodegradation in soil	$t_{1/2}$ = 65 days in soil amended with activated sludge and 93 days in soil amended with digested sludge	Nyholm et al. (2010)	High
	$t_{1/2}$ = 40.8 days in sandy soil	Li et al. (2014)	
	$t_{1/2}$ = 14.7 days in loamy sand soil; full degradation after 143 days; primary byproducts are mono- and dimethyl ethers	Li et al. (2015)	
	58.4%/28 days in sludge-amended soil	Yang et al. (2016)	
	$t_{1/2}$ = 14.6 days (9.2% mineralization and 80.1% formed in bound residues after 93 days in silty clay soil); primary byproducts are mono- and dimethyl ethers	Wang et al. (2017)	
	3.9% mineralization after 214 days in silty clay soil	Wang et al. (2019b)	
	<0.4% mineralization after 14 days in clay loam soil	Chen et al. (2019)	High
Anaerobic biodegradation in soil	$t_{1/2}$ = 430 days with activated sludge (OECD 307)	Nyholm et al. (2010)	High
	22.8%/10 days and 94%/130 days in ferric acrisol soil (a strongly weathered, acidic soil, characterized by a subsurface layer rich in iron oxides and a sandy-to-silt loam texture)	Wei et al. (2018)	

Parameter	Value	Reference(s)	Data Quality Rating
Aerobic and anaerobic biodegradation in soil	$t_{1/2} = 20.8$ in silty clay loam soil (11.5% mineralization and 60.8% associated with bound residues after 66 days)	Sun et al. (2014)	High
Bioconcentration factor (BCF) (L/kg wet weight, unless noted)	160 in tissue of fathead minnow (<i>Pimephales promelas</i>) at test substance concentration of 5 µg/L	Fackler (1989)	High
	148 in tissue of eastern oyster (<i>Crassostrea virginica</i>)	Springborn Laboratories (1989a)	
	0.08, 0.06, and 0.04 in gills and 0.29, 0.19, and 0.11 in digestive gland of scallop (<i>Chlamys farreri</i>) at test substance concentration of 0.2, 0.4, and 0.8 mg/L, respectively	Hu et al. (2015a)	
	632 ^b	U.S. EPA (2017)	
	480 for oyster (<i>Crassostrea gigas</i>) and 920 for mussel (<i>Mytilus coruscus</i>)	Gu et al. (2017)	
Bioaccumulation factor (BAF) (L/kg wet weight, unless noted)	514–1,386 for scallop (<i>Chlamys farreri</i>)	Hu et al. (2015b)	High
	5,184 for Chinese mystery snail (<i>Cipangopaludina chinensis</i>), 4,132 for prawn (<i>Macrobrachium nipponense</i>), 1,921 for mud carp (<i>Cirrhinus molitorella</i>), 1,553 for crucian carp (<i>Carassius auratus</i>), and 921 for northern snakehead (<i>Ophicephalus argus</i>)	Tao et al. (2016)	
	153 ^b (Arnot-Gobas upper trophic fish)	U.S. EPA (2017)	
Organic carbon/water partition coefficient (log K _{OC}) in soil	3.34–4.27 at pH 7–8 and 25 °C	Sun et al. (2008)	High
	4.49 at pH 7.02 and 20 °C	Han et al. (2013)	
	3.56 at pH 7.45 and 25 °C	Tong et al. (2015)	
Organic carbon/water partition coefficient (log K _{OC}) in sediments	4.84 at pH 7 and 22 °C	ECB (2008) citing Springborn Laboratories (1989c)	High
	6.02 at pH 7.1 and 21.5 °C	MS (2015)	
	3.80 at pH 7 and 25 °C	Yang et al. (2015)	
Removal in wastewater treatment	Mean: 96.7%	Potvin et al. (2012)	High
	Mean: 86.7%	Mcphedran et al. (2013)	
	Mean: 83%	Islam et al. (2014) ; MS (2015)	
Biota-sediment accumulation factor (BSAF)	1.07 ± 3.92 for oyster (<i>Crassostrea gigas</i>) and 6.96 ± 19.3 for mussel (<i>Mytilus coruscus</i>)	Gu et al. (2017)	High
	0.312	Choo et al. (2019)	

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Parameter	Value	Reference(s)	Data Quality Rating
Trophic magnification factor (TMF)	0.25	Tao et al. (2016)	High
	Marine food web: 0.545	Choo et al. (2019)	
^a Additional information on value selection can be found in the <i>Draft Physical Chemistry and Fate Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)</i> (U.S. EPA, 2026w).			
^b Information was estimated using EPI Suite™ (U.S. EPA, 2017).			

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3 RELEASES AND CONCENTRATIONS OF TBBPA IN THE ENVIRONMENT

EPA estimated environmental releases and concentrations of TBBPA. Section 3.1 describes the approach and methodology for estimating releases. Section 3.1.2 presents estimates of environmental releases, and Section 3.3 presents the approach and methodology for estimating environmental concentrations as well as a summary of TBBPA concentrations in the environment.

3.1 Approach and Methodology

This section provides an overview of the approach and methodology for assessing releases of TBBPA to the environment from manufacture, processing, and industrial, commercial, and consumer uses.

3.1.1 Manufacture, Processing, Industrial, and Commercial Use

This subsection provides an overview of the approaches for assessing releases of TBBPA to the environment from industrial and commercial facilities. Specifically, Section 3.1.1.1 provides a brief description of TBBPA use, processes and occupational exposure scenario (OES) information per COU, Section 3.1.1.2 provides an overview of the approaches for assessing releases of TBBPA to the environment from industrial and commercial facilities and Section 3.1.1.3 provides a brief description of the estimation of daily release rates and the number of days of release.

3.1.1.1 Description of TBBPA Use for Each OES

A brief description of the process and/or use of TBBPA for each occupational exposure scenario (OES) is presented in Table 3-1.

838 Table 3-1. Description of the Process and/or Use of TBBPA for Each COU

COU Number	Life Cycle Stage	Category	Subcategory	TBBPA Use, Process, and OES Information
1	Manufacture	Domestic manufacture	N/A	TBBPA is manufactured as a powder and is produced via bromination of BPA. The bromination reaction may be conducted in the presence of a hydrocarbon solvent or with water, 50% hydrobromic acid (HBr) or aqueous alkyl monoethers (ILS, 2002).
2		Import	N/A	See 'Repackaging' below
3	Processing	As a reactant	Flame retardant in plastic material and resin manufacturing	TBBPA is used as a reactive flame retardant to produce epoxy and polycarbonate resins (Corporation, 2017 ; U.S. EPA, 2015b ; ECB, 2008); all of the TBBPA is mostly converted if TBBPA is the limiting reactant (U.S. EPA, 2015b ; ECB, 2008). TBBPA is also used as a reactive flame retardant to produce vinyl esters (NICNAS, 2020 ; Corporation, 2017) and epoxy oligomers (Corporation, 2017 ; ECB, 2008).
4			Intermediate in all other chemical product and preparation manufacturing	
5		Incorporation into formulation, mixture, or reaction product	Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing	TBBPA is used in the production of flame-retarded ABS resin (Integral Consulting, 2025a). This use is the largest additive use of TBBPA (EC, 2013 ; ECB, 2008). TBBPA is also used as an additive flame retardant in phenolic resins (EC, 2013). This COU may also include the reactive use of TBBPA as a flame retardant with incomplete reaction of TBBPA.
6			Adhesive manufacturing	
7		Incorporation into article	Reactive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and Component manufacturing; Plastic product manufacturing (e.g., printed circuit boards and semiconductor packages)	TBBPA is used in two aspects of electronic product manufacturing: incorporation into PCBs, and in the plastics converting that takes place to create housing and casings for electronic products. Flame resistant, otherwise known as FR-4, laminates may contain residual TBBPA in the epoxy resin used to make the FR-4 laminate. TBBPA is reacted into this resin via chain extension, where it is chemically bound in the resin afterwards. FR-4 laminates are flame-retardant systems of woven glass reinforced with epoxy-like resin. To make the FR-4 laminate, the TBBPA-containing epoxy resin is applied to a woven fiberglass mat, then hardened (cured) to form a sheet (U.S. EPA, 2015b).
8			Reactive flame retardant in transportation equipment manufacturing (e.g., interior material for automotive and aviation articles)	

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COU Number	Life Cycle Stage	Category	Subcategory	TBBPA Use, Process, and OES Information
9	Processing	Incorporation into article	Additive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., plastic electronic enclosures)	TBBPA-containing compounded plastic resins are converted into solid plastic articles through many processes, including closed processes such as extrusion, injection molding, compression molding, extrusion blow molding, partially open processes such as film extrusion, and open processes including calendaring, thermoforming, and fiber reinforced plastic fabrication (OECD, 2009).
10		Repackaging	N/A	This OES encompasses sites that strictly receive TBBPA in bulk, and transfer it into different containers, without any dilution, mixing, or other modification. No changes to chemical composition occur during repackaging (U.S. EPA, 2022b). TBBPA is repackaged as a dry powder, liquid, solid, or pellet (U.S. EPA, 2022a).
11		Recycling	N/A	TBBPA is recycled as electronic waste in a variety of electronics products, including PCBs, laminates, plastic housings for computer jacks, terminal boards, and as a component in the resin used in refrigerators and other appliances, business machines and telephones (Panduit, 2017 ; U.S. EPA, 2015a ; EC, 2013).
12	Distribution in commerce	N/A	N/A	
13	Industrial use	Construction, paint, electrical, and metal products	Powder coatings	Powder coatings containing TBBPA as a flame retardant are used in electronic products.
14	Industrial and commercial use	Construction, paint, electrical, and metal products	Reactive flame retardant in electrical and electronic articles	TBBPA is a common flame-retardant additive used in various laminates, resins, and plastics that then go on to make up various types of electronic products (U.S. EPA, 2015b). The amount of TBBPA in finished articles like PCBs will vary depending on the amount of epoxy resin used and the concentration of TBBPA in the resin.
15			Additive flame retardant in electrical and electronic articles (i.e., plastic enclosures)	
16			Reactive flame retardant in automotive and aviation articles (i.e., laminate and prepreg material)	TBBPA may be used as an additive flame retardant in ABS and HIPS, which are used in automotive parts found in dashboards, engine components, interiors, grill work, motor housings, and heating/ventilation systems (NICNAS, 2020 ; EC, 2013).
17			Building/construction materials	TBBPA is used additively or reactively in products that are used in construction. TBBPA is used additively to manufacture flame retarded phenolic resins (NICNAS, 2020) as stated above. The concentration of TBBPA in phenolic resins is 0.1–0.4% (NICNAS, 2020). Phenolic resins are used to manufacture decorative laminates

COU Number	Life Cycle Stage	Category	Subcategory	TBBPA Use, Process, and OES Information
17	Industrial and commercial use	Construction, paint, electrical, and metal products	Building/construction materials	which are used in interiors of public buildings, such as elevator linings, hospital furniture, doors, partitions, public corridors, and hallways according to NICNAS (2020) . TBBPA is used additively to manufacture flame retarded ABS resin (Integral Consulting, 2025a ; EC, 2013 ; ECB, 2008) as stated above. The concentration of TBBPA in ABS is 17.6–22% (EC, 2013). ABS is used in pipes and fittings (ECB, 2008). Flame retardant resins containing TBBPA, including epoxy resins, are used for the manufacture of glass-reinforced construction panels (U.S. EPA, 2020c). TBBPA is used reactively to manufacture vinyl ester resins (NICNAS, 2020) as stated above. The vinyl ester resins are then used to manufacture fiberglass composite products such as pipelines and storage tanks for the building industries (NICNAS, 2020). TBBPA is used reactively to manufacture resins that are blended with reinforcing components such as fiberglass and then reacted to produce thermoset composite articles. These articles are used in the United States to construct architectural fascia, building panels, bridges, and pilings (ACC, 2025a).
18		Packaging, paper, plastic, and hobby products	Plastic and rubber products	Flame-retarded polycarbonate resins containing TBBPA are used in a range of applications, including communications and electronic equipment, household appliances, transportation components, sporting and recreational goods, lighting fixtures, and signage, and ABS resins containing TBBPA are used in automotive parts, pipes and fittings, refrigerators, business machines, and telephones (GPPC, 2023).
19		Other	Laboratory chemical	TBBPA was identified as a reference material and/or laboratory reagent in flame retardant products.
20	Disposal	Disposal	Disposal	Each of the OES may generate waste streams of TBBPA that are collected and transported to third-party sites for disposal or treatment. These cases are assessed under this OES.
ABS = acrylonitrile-butadiene-styrene; BPA = bisphenol A; FR = flame retardant; HIPS = high-impact polystyrene; OES = occupational exposure scenario; PCB = printed circuit board				

3.1.1.2 Overview of Assessment Approach

EPA's approach for estimating releases of chemical substances in general is illustrated in Figure 3-1. No TBBPA data were reported in the Discharge Monitoring Report (DMR) or National Emissions Inventory (NEI) but Toxics Release Inventory (TRI) data for TBBPA are available for most but not all COUs.

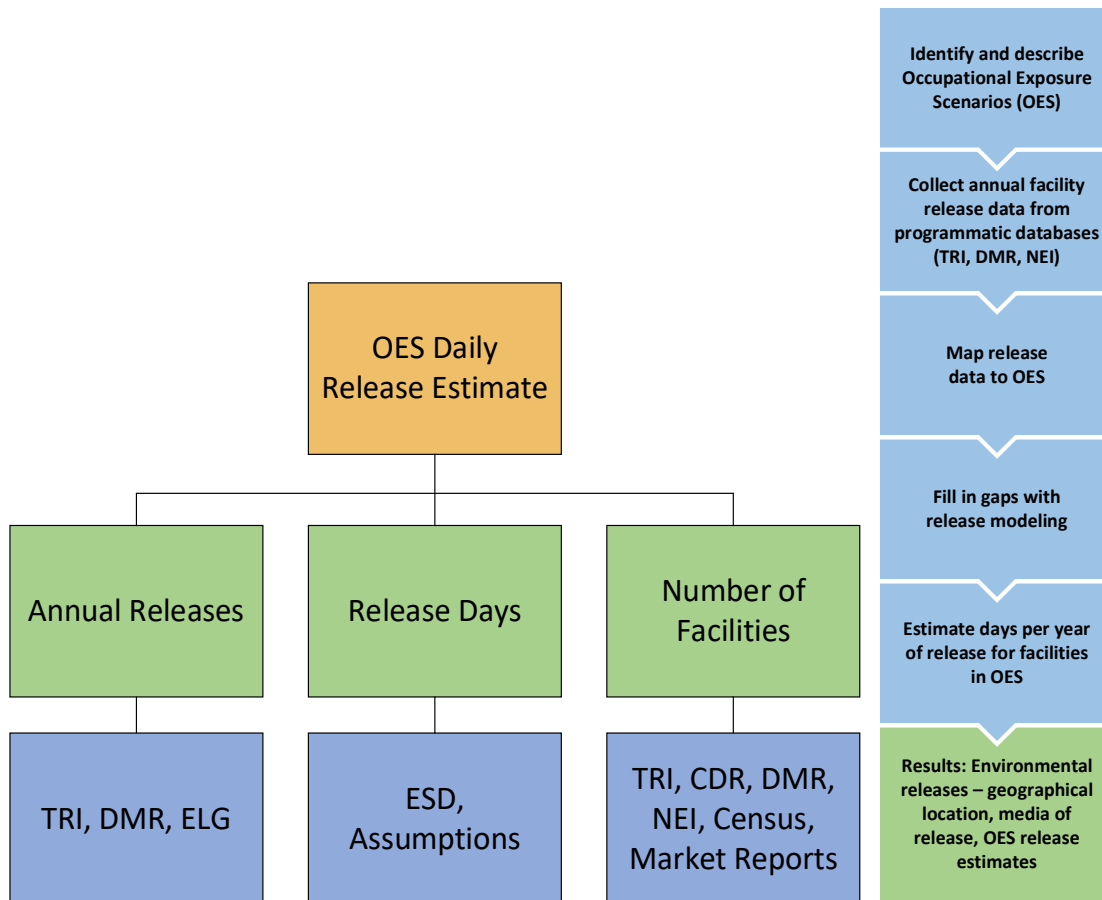


Figure 3-1. Overview of EPA's Approach to Estimate Releases for Each OES

CDR = Chemical Data Reporting (rule); DMR = Discharge Monitoring Report; ELG = Effluent Limitation Guidelines; ESD = emission scenario document; GS = generic scenario; OES = occupational exposure scenario; NEI = National Emissions Inventory; TRI = Toxics Release Inventory

EPA assessed TBBPA releases based on TRI data for 15 COUs only, because TRI data for the other three COUs are not available. The Agency assessed releases quantitatively and qualitatively in the case of two (Processing – Recycling; and Industrial and commercial use – Other – Laboratory chemical) and one (Industrial and commercial use – Packaging, paper, plastic, and hobby products – Plastic and rubber products) of these other three COUs, respectively. The assessment approach by COU and medium of release is provided in Table 3-1. The Agency assessed releases to water from TRI data for the reporting years 2019 to 2023 and assessed releases to air and land from TRI data for the reporting years 2014 to 2023; the total number of TRI sites is 86.

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Table 3-2. TBBPA Environmental Release Assessment Approaches by COU and Release Media

Life Cycle Stage	Category	Subcategory	Releases to Water ^{a b}	Releases to Air ^b	Releases to Land ^{a b}
Manufacture	Domestic manufacture	N/A	TRI (release reported as zero in TRI)	TRI	
	Import	N/A	See “Repackaging” COU below		
Processing	Repackaging	N/A	TRI (release reported as zero in TRI)	TRI (release reported as zero in TRI)	TRI
	As a reactant	Flame retardant in plastic material and resin manufacturing	TRI		
		Intermediate in all other chemical product and preparation manufacturing			
	Incorporation into formulation, mixture of reaction product	Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing	TRI		
		Adhesive manufacturing			
	Incorporation into article	Reactive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., printed circuit boards and semiconductor packages)	TRI (release reported as zero in TRI)	TRI	
		Reactive flame retardant in transportation equipment manufacturing (e.g., interior material for automotive and aviation articles)	TRI (release reported as zero in TRI)	TRI	
		Additive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., plastic electronic enclosures)	TRI (release reported as zero in TRI)	TRI	
	Repackaging	N/A	TRI (release reported as zero in TRI)		TRI

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Life Cycle Stage	Category	Subcategory	Releases to Water ^{a b}	Releases to Air ^b	Releases to Land ^{a b}
	Recycling	N/A	This COU is not part of TRI ^c ; releases are not expected.	This COU is not part of TRI ^c ; releases assessed quantitatively.	
Industrial use	Construction, paint, electrical, and metal products	Powder coatings	EPA assessed releases that result from this COU as part of the releases that result from the “Processing; Incorporation into article; Reactive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance and component manufacturing; Plastic product manufacturing (<i>e.g.</i> , printed circuit boards and semiconductor packages) ” and “Industrial and commercial use; Construction, paint, electrical, and metal products; Reactive flame retardant in electrical and electronic articles and Additive flame retardant in electrical and electronic articles (<i>i.e.</i> , plastic enclosures” COUs.		
Industrial and commercial use	Construction, paint, electrical, and metal products	Reactive flame retardant in electrical and electronic articles	TRI (release reported as zero in TRI)	TRI	
		Additive flame retardant in electrical and electronic articles (<i>i.e.</i> , plastic enclosures)			
		Reactive flame retardant in automotive and aviation articles (<i>i.e.</i> , laminate and prepreg material)	TRI (release reported as zero in TRI)	TRI	
		Building/construction material	TRI (release reported as zero in TRI)		TRI
Industrial and commercial use	Packaging, paper, plastic, hobby products	Use in plastic and rubber products	This COUs is a part of TRI, but TRI TBBPA data are lacking; releases assessed qualitatively.		
	Other	Laboratory chemical	This COU is not part of TRI ^d and is assessed quantitatively.		
Disposal	N/A	N/A	TRI (release reported as zero in TRI)	TRI	
COU = condition of use; NAICS = North American Industry Classification System; POTW = publicly owned treatment work; TRI = Toxics Release Inventory					
^a The assessments of releases to water and land based on TRI data include assessments of transfers of waste containing TBBPA from the sites of the COUs to disposal sites where applicable. For example, the assessments of releases to water from the sites of the COUs include assessments of transfers to POTW where applicable.					
^b If all or only some of the sites that EPA associated with a COU reported non-zero releases to a release medium, then EPA noted the assessment method as “TRI” in the case of that release medium. On the other hand, if all of the sites that EPA associated with a COU reported zero releases to a release medium, then EPA noted the assessment method as “TRI (release reported as zero in TRI)” in the case of that release medium.					
^c The NAICS code for electronics recycling sites (562920) is not included in the NAICS list for TRI reporting.					
^d The NAICS codes for laboratories (541380 and 541714) are not included in the NAICS list for TRI reporting.					

3.1.1.3 Estimation of Daily Release Rates

This section contains descriptions of the methodologies for estimating daily TBBPA release rates.

3.1.1.3.1 Estimation of Daily Release Rates Based on TRI Data

This section contains information about the COUs that EPA assessed based on TBBPA TRI data. EPA assessed releases to water from each site reported in TRI (*i.e.*, a site-specific assessment) and conducted screening-level assessments of releases to air and land. Each of these screening-level assessments involves the calculation of the maximal possible rate of release from any site. EPA calculated daily TBBPA release rates from the annual environmental release quantities reported to TRI and also using estimates of the number of release days. For sites reporting release quantities to the TRI, EPA typically assumes that the number of release days equals the number of operating days. The Agency's method for estimating the number of operating days varied by site depending on the available data. The various methods included estimation in accordance with EPA's standard method (cited below), estimation based on site-specific data, and estimation based on data associated with occupational exposure OESs. An explanation of these methods follows.

EPA associated the sites that reported non-zero water releases to TRI with either COU #3 (Processing – As a reactant – Flame retardant in plastic material and resin manufacturing;) or COU #5 (Processing – Incorporation into formulation, mixture or reaction product – Flame retardant in plastic materials and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resin; Paints and coating manufacturing;). The Agency associated the following two TRI sites, which reported non-zero releases to water, with COU #5: Benvic Trinity LLC and Avient Colorants USA LLC – Albion. Site-specific data or data associated with OESs are not available for these two sites. Therefore, the Agency estimated the number of operating days for these two sites to be 246 in accordance with the Agency's standard method for determining the number of release days, which is described in the *Draft Release Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026x](#)).

According to the TRI, Ravago Manufacturing Americas and SolEpoxy, Inc., which EPA also associated with COU #5, reported nonzero releases to water from their sites located in Manchester, TN and Olean, NY, respectively. At the Ravago site, one batch of TBBPA-containing product is produced each month ([Integral Consulting, 2025a](#)). Therefore, EPA assumed 12 days of operation per year for this site. SolEpoxy, Inc. reported the number of operating days for TBBPA-containing products to be equal to 15 days ([Integral Consulting, 2026](#)). Therefore, EPA assumed 15 days of operation for this site.

Some data on the operating days of certain TBBPA processes at various sites are reported in the ACC TBBPA Consortium's Amended Final Study Report ([Integral Consulting, 2025a](#)), which contains TBBPA worker monitoring data collected pursuant to EPA's test order. The Consortium consists of 21 companies that process or industrially use TBBPA at 25 sites in the United States. The processes at these sites are grouped into four groups and each of these groups corresponds to an OES. These groups (OESs) are described in Table 4-3. There may be several processes per group. Each group is associated with multiple COUs because the processes within a group vary by COU. For each group, two ranges of annual operating days are reported—one for the batch processes of the group and one for the continuous processes of the group — except for Group 1, for which a single range applying to all processes is reported; these ranges are given in Table 3-3. As indicated in that table, the processes are associated with the following eight COUs:

1. COU #3: Processing – As a reactant – Flame retardant in plastic material and resin manufacturing;
2. COU #5: Processing – Incorporation into formulation, mixture or reaction product – Flame

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- retardant in plastic materials and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resin; Paints and coating manufacturing;
3. COU #6: Processing – Incorporation into formulation, mixture or reaction product – Adhesive manufacturing;
 4. COU #7: Processing – Incorporation into article – Reactive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., printed circuit boards and semiconductor packages)
 5. COU #8: Processing – Incorporation into article – Reactive flame retardant in transportation equipment manufacturing (e.g., interior material for automotive and aviation articles);
 6. COU #9: Processing – Incorporation into article – Additive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., plastic electronic enclosures);
 7. COU #14: Industrial and commercial use – Construction, paint, electrical, and metal products – Reactive flame retardant in electrical and electronic articles; and
 8. COU #16: Industrial and commercial use – Construction, paint, electrical, and metal products – Reactive flame retardant in automotive and aviation articles (i.e., laminate and prepreg material).

Table 3-3. Number of Operating Days for Each of the ACC TBBPA Consortium Group

ACC TBBPA Consortium Group (OES)	COU Number ^a	Range of Operating Days per Year (Integral Consulting, 2025a)
1st	5	6–13
2nd	3, 5, 6	Batch processes: 2–305 Continuous processes: 260–312
3rd	5, 7, 8, 9	Batch processes: 4–156 Continuous Processes: 104–260
4th	14, 16	Batch processes: 12–365 Continuous processes: 260–275
ACC = American Chemistry Council; COU = condition of use; OES = occupational exposure scenario ^a Table 1-1 contains the names of all COUs and their corresponding ordinal numbers. Also, Section 3.1.1.3 contains the names of the COUs that are referenced in this column.		

EPA associated Sabic Innovative Plastics Mt. Vernon LLC, which reported non-zero TRI releases to water, with COU #3. Based on the above data, EPA estimated the number of operating days for this site as a range values equal to 2 to 350 days. The lower-end of this range is equal to the lower-end of the range of values reported by the ACC TBBPA Consortium and the high-end of this range equal to the value determined in accordance with EPA's standard method for estimating the number of operating days, which is described in the *Draft Release Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026x](#)).

EPA conducted a screening-level assessment of releases to air. Specifically, the Agency assessed the maximum possible rate of daily release to air from any of the sites that reported air release quantities to TRI. The Agency accomplished this by determining from TRI data the annual TBBPA air releases from Albemarle Corporation's site and the sum of annual air releases from all other sites. The Agency did this in the case of stack releases and the case of fugitive air releases that occurred during the years 2014 to 2023. The highest releases occurred in 2020—stack releases at Albemarle's site and total fugitive releases from non-Albemarle sites. These highest releases were converted to maximum daily rates by

assuming a minimum of 2 days of release based on the data of Table 3-3. EPA also calculated the daily release rate, assuming 365 release days.

For releases to land, EPA assessed the maximum possible rates of daily release from any of the sites that reported land release quantities to TRI. The Agency accomplished this by determining from TRI data the sum of the annual TBBPA land releases from all sites for each of the various types of land releases that occurred during the years 2014 to 2023. These sums were converted to daily rates by assuming a minimum of 2 days of release based on the data of Table 3-3. The Agency also calculated the daily release rate assuming 365 release days. The daily land releases were then considered in a qualitative assessment of general population and environmental exposure to TBBPA via the land pathway.

3.1.1.3.2 Estimation of Daily Release Rates via Mathematical Modeling

EPA assessed releases that result from the COU of (1) Processing – Recycling and (2) Industrial and commercial use – Other – Laboratory chemical via mathematical modeling. The following are brief descriptions of the assessment method for each of these two assessments.

Processing – Recycling COU

EPA estimated rates of daily releases of TBBPA to the environment that result from the recycling of waste electrical and electronic equipment (WEEE) from the following data:

1. Amounts of WEEE recycled in the United States annually and number of recycling sites in the United States that are reported in the gray literature (EPA did not find U.S. site-specific WEEE recycling throughput data.)
2. Annual capacity of a state-of-the-art WEEE recycling facility in Switzerland.
3. Empirically obtained data about TBBPA concentration in WEEE and three TBBPA emission factors for a WEEE recycling site in Switzerland that are reported in scientific literature (EPA's systematic review did not result in such data that is applicable to the U.S.)

The Agency estimated the rates of daily releases of TBBPA via the following three steps:

1. Calculated central tendency annual WEEE throughput per WEEE recycling facility by dividing the amount of WEEE recycled annually by the number of recycling facilities.
2. Assumed the high-end annual WEEE throughput per facility is equal to the annual capacity of the state-of-the-art facility located in Switzerland.
3. Calculated daily WEEE throughputs by dividing the annual WEEE throughput by 365 days.
4. Calculated TBBPA daily throughput per WEEE recycling facility by multiplying the WEEE daily throughput by the concentration of TBBPA in WEEE.
5. Calculated TBBPA releases to the environment by multiplying the TBBPA daily throughput by the sum of the three emission factors described below.

The three TBBPA emission factors equal the ratios of the mass of TBBPA in: (1) bag filters that contain airborne dust that is collected, (2) the air emitted from bag filters and (3) the plastic fines² process stream, respectively, to the mass of TBBPA in the WEEE feed to the recycling facility. EPA calculated central tendency and high-end rates of daily release of TBBPA to air or to landfill or to incineration or to some combination of these methods of release, disposal, or treatment methods. EPA does not expect this COU to result in releases to water. To calculate these release rates, EPA assumed a lack of collection of dust and plastic fines. While this assumption is reasonable in the case of a facility with a capacity equal to the central tendency value, it is a conservative assumption in the case of a facility with a high-end WEEE recycling capacity because this capacity is that of an actual state-of-the-art facility, which

² The plastic fines are particles that are less than 2 mm in size ([Morf et al., 2005](#))

includes these pollution controls. Therefore, the high-end estimate of releases is a screening-level estimate that does not include pollution controls.

Industrial and Commercial Use – Other – Laboratory Chemical COU

EPA estimated rates of daily releases of TBBPA to the environment that result from the use of TBBPA as a laboratory chemical via the following three steps:

1. Estimated the quantity of TBBPA that is used daily in a laboratory based on commercially available package sizes of TBBPA.
2. Estimated the rate of daily releases to air, land or treatment (e.g., incineration) to be equal to the quantity of TBBPA that is used daily in a laboratory (i.e., release of the entire quantity used).
3. Estimated the rate of daily releases to water in accordance with the Use of Laboratory Chemicals Generic Scenario ([U.S. EPA, 2023b](#)).

EPA estimated the quantity of TBBPA that is used daily in a laboratory based on the sizes of commercially available packages of TBBPA. Package sizes for TBBPA products marketed for laboratory use are 100 mg, 250 mg, 1 g, 25 g, 100 g, 500 g, and 1 mL of a 50 µg/mL solution of TBBPA in methanol ([Avantor, 2026](#); [Sigma-Aldrich, 2026](#); [TCI America, 2026](#)). EPA assumed that the sizes of commercially available packages are related to the use rates of TBBPA as a laboratory chemical. For example, a package size of 100 mg is commercially available because approximately 100 mg of TBBPA are used to do certain laboratory tasks. Furthermore, EPA assumed that the largest available packages likely serve as a supply of TBBPA for doing multiple laboratory tasks and these tasks are done during periods exceeding a single day. Also, TBBPA is a specialty industrial chemical and therefore EPA expects it to be used in laboratories for relatively few purposes. Based on the above, EPA assumed that the quantity of TBBPA that is used daily in a laboratory does not exceed 1 g.

EPA assumed that the entire quantity of TBBPA that is used daily in a laboratory is released to air, landfill, or incineration. Accordingly, EPA assessed TBBPA releases to air, landfill or incineration to be equal to the TBBPA use rate or 0.001 kg per site per day. This is a health-protective screening-level assessment because the assessed release rate is maximal. With regard to releases to water, TBBPA releases result from fugitive emissions caused by the transfer of TBBPA powder from transport containers, and cleaning of transport containers and labware equipment ([U.S. EPA, 2023b](#)); EPA assessed releases from these three sources in accordance with the Use of Laboratory Chemicals GS ([U.S. EPA, 2023b](#)) based on the use rate of 0.001 kg per site per day. Disposal of spent laboratory chemical results in a release to water if the laboratory chemical is water soluble ([U.S. EPA, 2023b](#)). Because TBBPA has a low water solubility (4.15 mg/L at pH 7.56 and 25 °C ([U.S. EPA, 2026w](#))), EPA did not assess water releases from the disposal of spent laboratory chemical.

3.1.2 Consumer Disposal (Down-the-Drain) and Landfills

Down-the-drain releases from consumer uses were not considered because no liquid products containing TBBPA were identified. For articles, environmental releases of TBBPA may occur via their end-of-life disposal or landfills. It is difficult for EPA to quantify these exposures from end-of-life consumer articles due to limited information on source attribution of the consumer COUs. However, high-quality physical and chemical property data suggest that TBBPA is expected to be immobile in landfills because of its strong affinity for organic carbon (log K_{OC} = 5.57 at pH 7 and 23 °C), low water solubility (4.15 mg/L at pH 7.56 and 25 °C), and low volatility (vapor pressure = 4.68×10⁻⁸ mm Hg) (Table 2-1).

No U.S. studies measuring the concentration of TBBPA in landfill leachates were found through systematic review. Three non-U.S. studies reported low values of TBBPA in the dissolved phase from raw landfill leachates ([Suzuki and Hasegawa, 2006](#); [Osako et al., 2004](#); [de Boer et al., 2002](#)). The

concentrations ranged from non-detect (<10 ng/L) to 620 ng/L. Although there are uncertainties regarding the applicability of foreign studies to U.S. conditions, results support the prediction of limited leaching. High-quality physical and chemical property data indicate that TBBPA is likely to strongly adsorb to particulates (*i.e.*, organic carbon, minerals) rather than migrate to the landfill leachate. TBBPA can also degrade under anaerobic conditions, further reducing its potential for leaching into groundwater ([U.S. EPA, 2026w](#)).

3.2 Summary of Environmental Releases

3.2.1 Manufacture, Processing, Industrial, and Commercial Uses

EPA assessed air and land releases on an overall basis, as presented in Table 3-4 through Table 3-9. For water releases, EPA combined its estimates for annual releases, release days, and number of facilities, to estimate a range of daily water releases for each COU. Table 3-10 presents a summary of these ranges across facilities. EPA did not quantitatively assess releases for the COU of Industrial use in powder coatings because any releases to the environment that result from this COU are also associated with any of three other COUs that EPA assessed quantitatively. These three other COUs are as follows: (1) Processing; Incorporation into article; Reactive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance and component manufacturing; Plastic product manufacturing (*e.g.*, printed circuit boards and semiconductor packages), (2) Industrial and commercial use; Construction, paint, electrical, and metal products; Reactive flame retardant in electrical and electronic articles, and (3) Industrial and commercial use; Construction, paint, electrical, and metal products; Additive flame retardant in electrical and electronic articles (*i.e.*, plastic enclosures). Releases that result from these three COUs may also be releases that result from the COU of Industrial use in powder coatings because powder coatings containing TBBPA are used in the manufacture of electronic products.

EPA also did not quantitatively assess releases from the COU of Industrial and commercial use; Packaging, paper, plastic, and hobby products; Plastic and rubber products and assessed releases from this COU qualitatively. The reason for this approach is that this COU is subject to TRI reporting. However, EPA did not find water release data for this COU in TRI or during systematic review. Furthermore, as this COU is in-scope with regard to TRI reporting, the lack of identified TRI data are an indication of lack of releases. EPA expects TBBPA to remain in the articles associated with the COU and any releases to be small and disperse in comparison with releases from other COUs. See the *Draft Release Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol]* (TBBPA) ([U.S. EPA, 2026x](#)) for additional detail.

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Table 3-4. Annual Air Releases of TBBPA (kg)

Year	Stack Air (5.2)			Fugitive Air (5.1)		
	Total Releases from All Sites ^a	Release from Albemarle Corporation South Plant, Magnolia, AR	Total Releases from all Sites Except Albemarle	Total Releases from All Sites ^a	Release from Albemarle Corporation South Plant, Magnolia, AR	Total of Releases from All Sites Except Albemarle
2014	1,012	721	291	163	5	158
2015	1,210	794	416	312	5	307
2016	1,798	794	1,004	340	6	334
2017	1,897	794	1,103	280	6	274
2018	3,197	2,237	960	327	5	322
2019	2,857	2,237	620	325	5	321
2020	3,351	2,370	981	440	29	410
2021	3,327	2,328	998	155	5	151
2022	3,443	2,316	1,127	195	5	190
2023	1,120	637	483	407	5	402

^a The sum of the total stack and the total fugitive air releases (*i.e.*, releases from all sites) is a maximum during 2020 and is equal to 3,791 kg. The 2024 CDR aggregate production volume is between 10–50 million lb ([U.S. EPA, 2026a](#)) or approximately between 6–23 million kg.

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Table 3-5. Daily Air Releases of TBBPA (kg/day) Assuming 2 Days of Release per Year^a

Year	Stack Air (5.2)			Fugitive Air (5.1)		
	Total Releases from All Sites	Release from Albemarle Corporation South Plant, Magnolia, AR	Total Releases from All Sites Except Albemarle	Total Releases from All Sites	Release from Albemarle Corporation South Plant, Magnolia, AR	Total Releases from All Sites Except Albemarle
2014	506	361	145	81	2	79
2015	605	397	208	156	3	153
2016	899	397	502	170	3	167
2017	949	397	552	140	3	137
2018	1,599	1,119	480	163	2	161
2019	1,429	1,118	310	163	2	160
2020	1,676	1,185	491	220	15	205
2021	1,663	1,164	499	78	2	75

Year	Stack Air (5.2)			Fugitive Air (5.1)		
	Total Releases from All Sites	Release from Albemarle Corporation South Plant, Magnolia, AR	Total Releases from All Sites Except Albemarle	Total Releases from All Sites	Release from Albemarle Corporation South Plant, Magnolia, AR	Total Releases from All Sites Except Albemarle
2022	1,721	1,158	564	97	2	95
2023	560	318	241	203	2	201

^a EPA's assessment of TBBPA releases to air is a screening-level assessment. EPA estimated maximum release rates by assuming two days of release for every site as the minimum number of release days as discussed in Section 3.1.1.3.1.

Table 3-6. Daily Air Releases of TBBPA (kg/day) Assuming 365 Days of Releases per Year^a

Year	Stack Air (5.2)			Fugitive Air (5.1)		
	Total Releases from All Sites	Release from Albemarle Corporation South Plant, Magnolia, AR	Total Releases from All Sites Except Albemarle	Total Releases from All Sites	Release from Albemarle Corporation South Plant, Magnolia, AR	Total Releases from All Sites Except Albemarle
2014	2.77	1.98	7.97E-01	4.46E-01	1.24E-02	4.34E-01
2015	3.31	2.17	1.14	8.55E-01	1.49E-02	8.40E-01
2016	4.93	2.17	2.75	9.32E-01	1.62E-02	9.16E-01
2017	5.20	2.17	3.02	7.67E-01	1.62E-02	7.51E-01
2018	8.76	6.13	2.63	8.95E-01	1.24E-02	8.82E-01
2019	7.83	6.13	1.70	8.91E-01	1.24E-02	8.78E-01
2020	9.18	6.49	2.69	1.20	8.08E-02	1.12
2021	9.11	6.38	2.74	4.26E-01	1.24E-02	4.13E-01
2022	9.43	6.34	3.09	5.33E-01	1.24E-02	5.21E-01
2023	3.07	1.74	1.32	1.11	1.24E-02	1.10

^a EPA's assessment of TBBPA releases to air is a screening-level assessment. EPA estimated minimum release rates by assuming 365 days of release for every site as the maximum number of release days as discussed in Section 3.1.1.3.1.

1076 **Table 3-7. Total TBBPA Land Releases Reported to TRI**

Year	Underground Injection (kg/yr)	RCRA Subtitle C Surface Impoundments (kg/yr)	Land Treatment (kg/yr)	Other Land Disposal (kg/yr)	RCRA Subtitle C Landfills (kg/yr)	Other Landfills (kg/yr)	Other Surface Impoundments (kg/yr)	Off-Site Transfers (kg/yr)	Total of all Releases to Land and Off-Site Transfers (kg/yr)
2014	34	0	0	0	417	4	0	3,641	4,096
2015	23	0	0	45	32,601	1	0	4,170	36,840
2016	23	0	0	45	33,386	0	0	11,603	45,057
2017	23	0	0	45	48,844	0	0	28,810	77,722
2018	23	0	0	0	33,699	21,202	0	18,825	73,749
2019	0	0	0	2.3	18,097	82,321	0	11,482	111,902
2020	0	0	0	0	19,085	64,263	0	22,745	106,093
2021	0	0	0	0	17,737	41,145	0	10,011	68,893
2022	0	0	0	1.1	23,271	0	0	56,065	79,337
2023	0	0	0	1.2	12,862	0	0	1,332	14,195

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Table 3-8. Daily Land Releases of TBBPA (kg/day) Assuming 2 Days of Release per Year

Year	Underground Injection (kg/yr)	RCRA Subtitle C Surface Impoundments (kg/yr)	Land Treatment (kg/yr)	Other Land Disposal (kg/yr)	RCRA Subtitle C Landfills (kg/yr)	Other Landfills (kg/yr)	Other Surface Impoundments (kg/yr)	Off-Site Transfers (kg/yr)
2014	17	0	0	0	209	2	0	1,525
2015	11	0	0	23	16,301	0.68	0	1,782
2016	11	0	0	23	16,693	0	0	5,235
2017	11	0	0	23	24,422	0	0	12,916
2018	11	0	0	0	16,849	10,601	0	9,126
2019	0	0	0	1.2	9,048	41,161	0	5,741
2020	0	0	0	0	9,543	32,132	0	11,373
2021	0	0	0	0	8,869	20,573	0	5,006
2022	0	0	0	0.55	11,635	0	0	28,033
2023	0	0	0	0.59	6,431	0	0	666

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Table 3-9. Daily Land Releases of TBBPA (kg/day) Assuming 365 Days of Release per Year

Year	Underground Injection (kg/yr)	RCRA Subtitle C Surface Impoundments (kg/yr)	Land Treatment (kg/yr)	Other Land Disposal (kg/yr)	RCRA Subtitle C Landfills (kg/yr)	Other Landfills (kg/yr)	Other Surface Impoundments (kg/yr)	Off-Site Transfers (kg/yr)
2014	9.3E-02	0	0	0	1.1	1.1E-02	0	8.4
2015	6.2E-02	0	0	0.12	89	3.7E-03	0	9.8
2016	6.2E-02	0	0	0.12	91	0	0	29
2017	6.2E-02	0	0	0.12	134	0	0	71
2018	6.2E-02	0	0	0	92	58	0	50
2019	0	0	0	6.4E-03	50	226	0	31
2020	0	0	0	0	52	176	0	62
2021	0	0	0	0	49	113	0	27
2022	0	0	0	3.0E-03	64	0	0	154
2023	0	0	0	3.2E-03	35	0	0	3.6

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Life Cycle Stage	Category	Subcategory	Type of Discharge ^a	Median Annual Discharge (kg/site-year)	Median Daily Discharge (kg/site-day)	Maximum Annual Discharge (kg/site-year)	Maximum Daily Discharge (kg/site-day)	Number of Facilities	Reference(s)
Manufacture	Domestic manufacture	N/A	All discharge types	0	0	0	0	1	U.S. EPA (2023c)
Processing	Import	N/A	See “Repackaging” below						
	As a reactant	Flame retardant in plastic material and resin manufacturing;	Surface water ^b	4.5	1.3E-02	15	4.2E-02	10	U.S. EPA (2023c)
		Intermediate in all other chemical product and preparation manufacturing	POTW and non-POTW WWT	0	0	0	0		
	Incorporation into formulation, mixture of reaction product	Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing	Surface water ^{b c}	0	0	0.45	1.5E-03	16	U.S. EPA (2023c)
			POTW ^{d e}	2.5	8.3E-03	11	3.7E-02		
			Non-POTW WWT	0	0	0	0		
		Adhesive manufacturing	All discharge types	0	0	0	0	8	U.S. EPA (2023c)
	Incorporation into article	Reactive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (<i>e.g.</i> , printed circuit boards and semiconductor packages)	All discharge types	0	0	0	0	4	U.S. EPA (2023c)
		Reactive flame retardant in transportation equipment manufacturing (<i>e.g.</i> , interior material for automotive and aviation articles)	All discharge types	0	0	0	0	13	U.S. EPA (2023c)

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Life Cycle Stage	Category	Subcategory	Type of Discharge ^a	Median Annual Discharge (kg/site-year)	Median Daily Discharge (kg/site-day)	Maximum Annual Discharge (kg/site-year)	Maximum Daily Discharge (kg/site-day)	Number of Facilities	Reference(s)
Processing	Incorporation into article	Additive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (<i>e.g.</i> , plastic electronic enclosures)	All discharge types	0	0	0	0	8	U.S. EPA (2023c)
	Repackaging	N/A	All discharge types	0	0	0	0	2	U.S. EPA (2023c)
	Recycling	N/A	All discharge types	Water releases not expected				860	e-Stewards (2026) ; Sustainable Electronics (2026)
Industrial use	Construction, paint, electrical, and metal products	Powder coatings	All discharge types	Qualitatively assessed				Unknown	Per identified SDSs (3M, 2023 , 2019)
Industrial and commercial use	Construction, paint, electrical, and metal products	Reactive flame retardant in electrical and electronic articles;	All discharge types	0	0	0	0	3	U.S. EPA (2023c)
		Additive flame retardant in electrical and electronic articles (<i>i.e.</i> , plastic enclosures)	All discharge types	0	0	0	0	9	U.S. EPA (2023c)
		Reactive flame retardant in automotive and aviation articles (<i>i.e.</i> , laminate and prepreg material)	All discharge types	0	0	0	0	1	U.S. EPA (2023c)
	Other	Building/construction materials	All discharge types	0	0	0	0	1	U.S. EPA (2023c)
		Laboratory Chemical	All discharge types	4.35E-03 ^f	2.5E-05	6.5E-03 ^f	2.5E-05	<40,639 ^g	U.S. EPA (2023c)

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Life Cycle Stage	Category	Subcategory	Type of Discharge ^a	Median Annual Discharge (kg/site-year)	Median Daily Discharge (kg/site-day)	Maximum Annual Discharge (kg/site-year)	Maximum Daily Discharge (kg/site-day)	Number of Facilities	Reference(s)
Disposal	Disposal	Disposal	All discharge types	0	0	0	0	1	U.S. EPA (2023c)
COU = condition of use; POTW = publicly owned treatment works; WWT = wastewater treatment ^a Direct discharge to surface water; indirect discharge to non-POTW WWT; indirect discharge to POTW. ^b All discharge values calculated from 2019–2023 TRI reporting from 1 site. ^c The site only reported TBBPA discharges to surface water for 1 year, so EPA was unable to calculate a median value. ^d All discharge values calculated from 2019–2023 TRI reporting from 4 sites. ^e For 3–5 facilities, EPA estimated the medians and maximums using the 50th percentile of all median values, and 95th percentile of maximum values, respectively. ^f EPA calculated the median and maximum annual release rates by multiplying the estimated daily release rate of 2.5E–05 kg/site-day with 174 days and 260 days, respectively. ^g There are an estimated 40,639 laboratories in the U.S. (U.S. EPA, 2023b), but EPA lacks data on how many of these sites utilize TBBPA.									

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3.2.1.1 Weight of Scientific Evidence Conclusions for Environmental Releases from Industrial and Commercial Sources

EPA determined the weight of scientific evidence in accordance with the 2021 Draft Systematic Review Protocol ([U.S. EPA, 2021a](#)). Judgment on the weight of scientific evidence is based on the strengths, limitations, and uncertainties associated with the exposure estimates. The Agency considers factors that increase or decrease the strength of the evidence supporting the exposure estimate. Factors that increase or decrease the strength of evidence are given in Table 7-6 of the 2021 Draft Systematic Review Protocol ([U.S. EPA, 2021a](#)) and Table 7-7 of this reference provides examples of judgments. The best professional judgment about the weight of scientific evidence is summarized using the descriptors of robust, moderate, slight, or indeterminate ([U.S. EPA, 2021a](#)).

EPA estimated environmental releases of TBBPA that result from 15 COUs based on TBBPA TRI data; the following discussion is pertinent in the case of these estimates.

Strengths

The data quality rating of the TRI data are high according to EPA's systematic review. The reason for this data quality rating is that the annual release rates of chemical substances in general that are reported to TRI are chemical-specific and site-specific data. Apart from this, the TRI reporting threshold for TBBPA in terms of amounts manufactured, processed or otherwise used is 100 lb or approximately 45 kg. The reason for this low reporting threshold in the case of TBBPA in particular is that TBBPA is designated as persistent, bioaccumulative, and toxic (PBT) in TRI ([U.S. EPA, 2023c](#)). Also, all of the TRI data of this release assessment are TRI Form R data. Finally, approximately 62% of the TBBPA annual releases were determined by mass balance, continuous or periodic monitoring, or published or on-site emission factors ([U.S. EPA, 2023c](#)). EPA estimated TBBPA daily release rates from TRI TBBPA annual release rates.

Limitations

TRI data about chemical substances in general may not include data about all pertinent facilities because of the various TRI reporting criteria, which are criteria related to North American Industry Classification System (NAICS) codes, chemical substance throughput or number of employees. The TRI TBBPA reporting threshold of 100 lb may preclude non-reporting by sites as a result of the TRI reporting criteria related to chemical substance throughput and number of employees. EPA compared the numbers of TBBPA manufacturing, processing or use sites that are reported in TRI and CDR as shown in Table 3-11 to consider whether EPA lacks information about all sites that manufacture, process or use TBBPA (any uncertainty about the number of such sites does not affect the assessment of TBBPA daily release rates which are based on TBBPA annual release rates reported in TRI.) These numbers are mostly comparable given uncertainty in the number of sites reported in CDR. The exception is the case of the Processing – Incorporation into formulation, mixture of reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing COU. In this case, the range of CDR sites is 83 to 297 while the number of sites that EPA associated with this COU is 16. The reason may be that the number of CDR sites includes downstream sites and not just the sites associated with the particular COU given that in principle the reported number of CDR sites includes pertinent sites of the entire supply chain and not just the sites to which the CDR reporter provides products to. This is supported by the fact that the total number of TRI sites for all COUs, which is 86, is comparable to the lower-end of the range of the totals of CDR sites for all COUs, which is 106 to 372. Alternatively, the reason for this discrepancy may be that small quantities of TBBPA that are less than the threshold related to throughput are occasionally processed at some facilities (e.g., custom compounders of purchased resin.)

Assumptions

EPA estimated the rate of daily release of TBBPA to water from a site as the ratio of the rate of annual release of TBBPA to water and the number of release days. EPA assumed that the number of facility operating days is equal to the number of release days. The Agency has developed generic estimates of operating days for each COU, as described in Section 3.1.1.3.1 and equated the number of TBBPA water release days to these values.

Uncertainties

The following factors result in uncertainty in the assessment results: (a) uncertainty about the number of days of release to water, (b) the method of determining amounts of TBBPA releases reported to TRI and (c) uncertain association (mapping) of TRI sites with COUs. With regard to factor (a), EPA calculated the rates of daily release of TBBPA to water from Benvic Trinity LLC and Avient Colorants USA LLC – Albion from a number of release days that may be greater than the actual number of days of release as discussed in Section 3.1.1.3.1. Therefore, the assessed release rates may be less than actual release rates. With regard to factor (b), approximately 54% of amounts of TBBPA reported to TRI as releases to water were determined by a method other than monitoring, mass balance and emission factors. Therefore, there is uncertainty about the quality of 54% of the reported annual releases to water. Releases to water were mostly reported to TRI as zero release as shown in Table 3-11. TBBPA releases to water from processing are reported in the literature ([VECAP, 2012](#), [2010](#); [ECB, 2008](#)). Also, a TRI report of zero release to a given environmental medium may mean that release to the medium is possible but has been prevented by, for example, the release of the waste stream to another medium. For example, an aqueous waste containing TBBPA was disposed in a Class V injection well ([Albemarle, 2015](#)). In conclusion, there is uncertainty about the accuracy of releases to water reported to TRI as zero release. With regard to factor (c), EPA's mapping of sites reporting to TRI to a specific COU may be uncertain in some cases. Table 3-12 summarizes EPA's overall confidence in the release estimates for each COU.

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Table 3-11. Numbers of Assessed Sites and TRI Sites by COU and Number of TRI Sites That Reported Zero Release to Each Release Medium

Life Cycle Stage	Category	Subcategory	Number of Sites According to CDR	TRI Sites EPA Associated with the COU	TRI Sites Reporting Zero Release to Water	TRI Sites Reporting Zero Release to Air	TRI Sites Reporting Zero Release to Land
Manufacture	Domestic manufacture	N/A	1–3	1	1	0	0
Processing	Repackaging	N/A	N/A ^a	2	2	2	0
	As a reactant	Flame retardant in plastic material and resin manufacturing	3–27	10	9	1	7
		Intermediate in all other chemical product and preparation manufacturing					
	Incorporation into formulation, mixture of reaction product	Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing	83–297	16	13	4	5
		Adhesive manufacturing	10–24	8	8	4	6
	Incorporation into article	Reactive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., printed circuit boards and semiconductor packages)	10–24	4	4	2	2
		Reactive flame retardant in transportation equipment manufacturing (e.g., interior material for automotive and aviation articles)	N/A ^a	13	13	11	10
		Additive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., plastic electronic enclosures)	N/A ^a	8	8	6	5

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Life Cycle Stage	Category	Subcategory	Number of Sites According to CDR	TRI Sites EPA Associated with the COU	TRI Sites Reporting Zero Release to Water	TRI Sites Reporting Zero Release to Air	TRI Sites Reporting Zero Release to Land
Industrial and commercial use	Construction, paint, electrical, and metal products	Reactive flame retardant in electrical and electronic articles	N/A ^a	3	3	2	1
		Additive flame retardant in electrical and electronic articles (<i>i.e.</i> , plastic enclosures)					
		Reactive flame retardant in automotive and aviation articles (<i>i.e.</i> , laminate and prepreg material)	N/A ^a	9	9	7	5
		Use in building and construction materials	N/A ^a	1	1	1	0
Disposal	N/A	N/A	N/A ^a	11	11	3	6
CDR = Chemical Data Reporting; COU = condition of use; N/A = not available; TRI = Toxics Release Inventory ^a CDR data were lacking for these COUs.							

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Table 3-12. Summary of Overall Confidence in Environmental Release Estimates by COU

Life Cycle Stage	Category	Subcategory	Weight of Scientific Evidence Conclusion in Water Release Estimates
All COUs that are assessed were based on TRI data (except Recycling, Use in plastic and rubber products, and Laboratory chemical use)			EPA has concluded that the weight of scientific evidence for this assessment is moderate based on the strengths, limitations, assumptions and uncertainties associated with the TBBPA TRI data that are the basis of the assessments of these COUs as presented in Section 3.2.1.1.
Recycling	N/A	N/A	EPA assessed releases based on measured TBBPA emission factors pertaining to a site in Switzerland and estimates of WEEE throughput. The literature received a high data quality rating in systematic review. EPA believes a strength of the assessment approach is the estimation of releases based on TBBPA concentrations in electronic waste (e-waste) recycling output streams and release rates from a WEEE recycling facility. There is uncertainty in the assessed TBBPA release rates because the TBBPA concentration data and the maximum annual e-waste recycling rate per site are based on information from Switzerland and Canada, which may not be representative of e-waste recycling facilities in the United States. The data that EPA has presented is reasonably available public information, meeting the TSCA standard under section 26(k). Based on this information, EPA has concluded that the weight of scientific evidence for the assessed central tendency values is moderate and EPA has robust confidence that the assessed high-end values are overestimates because a screening-level assessment was done to obtain these results.
Industrial and commercial use	Packaging, paper, plastic, hobby products	Use in plastic and rubber products	For this COU, EPA had no release information from standard sources, so the Agency assessed water releases qualitatively. Based on this information, EPA has concluded that the weight of scientific evidence for this assessment is moderate.
	Other	Laboratory chemical use	EPA assessed releases based on estimate throughput that is based on package size and based on the laboratory use generic scenario. Based on this information, EPA has concluded that the weight of scientific evidence for the assessment of releases to water is moderate and EPA has high confidence that the assessed releases to the other environmental media are overestimates because a screening-level assessment was done to obtain these results.
COUs = conditions of use; TRI = Toxics Release Inventory			

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3.3 Summary of Concentrations of TBBPA in the Environment

Based on the environmental release assessment summarized in Section 3.1.2 and presented in the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)), TBBPA is expected to be released to the environment via air, water, biosolids, and disposal to landfills.

EPA relied on reported environmental releases in TRI, environmental monitoring data, and its fate assessment to determine which environmental pathways to consider. Details on the environmental partitioning and media assessment can be found in the *Draft Physical Chemistry and Fate Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026w](#)). Table 3-13 summarizes the modeled environmental media concentrations by COU and whether they were used for the environmental exposure assessment or the general population exposure assessment.

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Table 3-13. Summary of TBBPA Concentrations in Environmental Media from Environmental Releases

COU	Release Media	Environmental Media	TBBPA Concentration ^a	Environmental and/or General Population
Processing – As a reactant – Flame retardant in plastic material and resin manufacturing	Water	Surface water (7Q10, 30Q5, and HM if applicable)	350 release days 7Q10: 4.47E-04 µg/L 30Q5: 3.59E-04 µg/L HM: 1.56E-04 µg/L	Environmental General population General population
Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing ^b			4 release days 7Q10: 3.91E-02 µg/L 30Q5: 3.14E-02 µg/L	Environmental General population
Disposal ^b			7Q10: 12.8 µg/L 30Q5: 9.39 µg/L	Environmental General population
• Manufacture – Domestic manufacture • Processing – As a reactant – Flame retardant in plastic material and resin manufacturing • Processing – As a reactant – Intermediate in all other chemical product and preparation manufacturing • Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing • Processing – Incorporation into formulation, mixture, or reaction product – Adhesive manufacturing • Processing – Incorporation into article – Reactive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., printed circuit boards and semiconductor packages) • Processing – Incorporation into article – Reactive flame retardant in: Transportation equipment manufacturing (e.g., interior material for automotive and aviation articles) • Processing – Incorporation into article – Additive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., plastic electronic enclosures)	Ambient air	Fugitive and stack, 100 m	Daily-averaged total: 300 µg/m ³ Annual-averaged total: 4.68 µg/m ³	Both

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COU	Release Media	Environmental Media	TBBPA Concentration ^a	Environmental and/or General Population
- Industrial and commercial use – Construction, paint, electrical, and metal products – Reactive flame retardant in automotive and aviation articles (<i>i.e.</i>, laminate and prepreg material) - Disposal	Ambient air	Fugitive and stack, 100 m		
Electrical and electronics recycling			Daily-averaged total: 27.63 µg/m ³ Annual-averaged total: 26.50 µg/m ³	Both
30Q5 = 30 consecutive days of lowest flow over a 5-year period; 7Q10 = lowest 7-day flow (on average) in a 10-year period; HM = harmonic mean				
^a The definitions of these flow metrics and how they were applied are described in Section 4.1.6.				
^b HM was not calculated for this COU because water releases are expected to occur 12 days per year. The low number of release days does not align with a HM that represents long-term average flow conditions.				

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3.3.1 Surface Water

For the water pathway, EPA conducted modeling using the Variable Volume Water Model (VVWM) in the Point Source Calculator (PSC) tool ([EPA, 2019](#)) to estimate surface water concentrations of TBBPA resulting from COU releases. PSC inputs include physical and chemical properties of TBBPA and reported TBBPA releases to water ([U.S. EPA, 2026ae](#)), which are used to predict receiving water column concentrations. The standard EPA water body characteristics were used to parameterize the water column and sediment parameters, which is applied consistently as a conservative screening scenario. Standardized water body geometry was also applied consistently across runs, with a width of 5 m, length of 40 m, and depth of 1 m. Only the release parameters (daily release amount and days of release) and the hydrologic flow rate were changed between model runs to reflect facility-specific release conditions.

A required input for the PSC model is the hydrologic flow rate of the receiving water body. For facilities reporting releases to TRI, relevant flow data from the associated receiving water body were collected. EPA queried several databases to estimate a flow rate, such as EPA's Enforcement and Compliance History Online (ECHO), National Hydrography Dataset Plus (NHDPlus), and NHDPlus V2.1 Flowline Network Enhanced Runoff Method (EROM) Flow. For facilities that do not report to TRI, a generic distribution of hydrologic flows was developed by collecting flow data for facilities across a NAICS code associated with each COU for a TBBPA-releasing facility. Flow information was extracted from the same databases. The 50th, 75th percentile, and 90th percentile (P50, P75, P90, respectively) flows from the distribution were applied to represent variation in the potential receiving water bodies. The complete methods for retrieving and processing flow data are detailed in Appendix B in the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)).

A number of hydrologic flow rates were estimated to represent higher and lower flows and therefore capture a range of corresponding surface water concentrations. The 30Q5 flows (lowest 30-day average flow that occurs in a 5-year period) are used to estimate intermediate exposure from drinking water. The annual average flow represents long-term flow rates, but a harmonic mean (HM) provides a more conservative estimate and is preferred for assessing potential chronic human exposure via drinking water. The harmonic mean is also typically used for estimating human exposure through fish ingestion because it takes time for chemical concentrations to accumulate in fish. However, it is not appropriate for some COUs with few release days (*i.e.*, <1 month). In those instances, EPA used the 30Q5 as a conservative screening-level analysis even though the 30Q5 is expected to occur less frequently and unlikely to be sustained long-term. Lastly, for aquatic or ecological exposure, a 7Q10 flow (lowest 7-day average flow that occurs [on average] in a 10-year period) is used to estimate exceedances of concentrations of concerns (COCs) for aquatic life.

Receiving water body TBBPA concentrations were estimated at the point of release (*i.e.*, in the immediate area of the water body receiving the effluent). For the screening analysis, concentrations were modeled for the two COUs that reported direct releases to water in TRI (*i.e.*, after any on-site treatment and without any transfers to off-site publicly owned treatment works [POTWs]), as well as for one POTW that indirectly receives industrial waste containing TBBPA according to TRI. For the POTW indirectly receiving industrial waste, TRI reports only the amount of TBBPA being transferred from the industrial facility to the receiving POTW. Because treatment is expected at the receiving POTW prior to

discharge to surface water, EPA applied a mean removal efficiency of 88.8%³ in its modeling. See the *Draft Physical Chemistry and Fate Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026w](#)) for more details on the derivation of the removal efficiency based on systematic review. Three other POTWs reported indirectly receiving industrial waste containing TBBPA. The resultant media concentrations from those wastewater treatment plants (WWTPs) are presented in Section 5.3.2.1. However, for screening purposes, the resultant media concentrations from these WWTPs were not modeled because their lower daily releases combined with higher flow rates of the receiving water body yielded media concentrations that were several orders of magnitude lower than the POTW considered.

3.3.2 Ambient Air

For air releases, EPA queried both TRI and estimated releases for two COUs that do not have TRI data ([U.S. EPA, 2026x](#)). Refer to section 3.1.1.2 for a summary of the results of the TRI query. For TRI facilities that represent 15 COUs, EPA obtained annual releases of TBBPA across all COUs that manufacture, process, use, or dispose of TBBPA between 2019 and 2023. The ambient air releases were separated into releases by Albemarle Corporation only (single facility) and by all other facilities (n = 29) combined as part of a screening assessment. The highest stack release from Albemarle Corporation in 2020 (2,370 kg/site-year) was lower than the stack release from all other facilities combined. On the other hand, the highest fugitive release was from all other facilities in 2020 (410 kg/site-year) and were used in the screening assessment.

For the Electrical and electronic waste recycling COU, environmental releases were estimated using mathematical modeling (Section 3.1.1.3.2). The media types that this COU releases to are air, landfill, incineration, or some combination of the above. EPA is uncertain as to the extent of releases to each media type. Therefore, for the ambient air screening analysis, EPA assumed all releases are to air. EPA also assumed that an electrical and electronic waste recycling facility is operated continuously with two weeks of annual downtime for maintenance, for a total of 350 days per year.

EPA used the Integrated Indoor/Outdoor Air Calculator (IIOAC) Model to estimate daily- and annual-average ambient air concentrations of TBBPA, as well as annual average wet, dry, and total air deposition rates of TBBPA from the ambient air. EPA assumed the fugitive and stack releases occur simultaneously throughout the day and year. Therefore, the total concentration and deposition rate used is the sum of the separately modeled fugitive and stack concentrations and deposition rates at 100 m from a releasing facility.

The IIOAC outputs are the following:

- *Upper bound* of all modeled hourly concentrations across the entire distribution of modeled concentrations at 100 m.
- *Upper bound* annual-average concentration across the entire distribution of modeled concentrations at 100 m.
- *Upper bound* annual-average deposition rate across the entire distribution of modeled deposition rates at 100 m.

³ This removal efficiency was derived by averaging the mean removal rates reported in Potvin ([2012](#)), McPhredran ([2013](#)), Islam ([2014](#)), and Islam ([2015](#)). More information can also be found in *Draft Physical Chemistry and Fate, Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026w](#)).

3.3.3 Weight of Scientific Evidence Conclusions for Environmental Concentrations

EPA used the release estimates presented in Table 3-8 to model environmental media concentrations. EPA also considers additional variables when evaluating the weight of scientific evidence for its estimation of environmental media concentrations. These include the use of multiple models for appropriate media (e.g., PSC, IIOAC, etc.) using the release as an input, the applicability of the release data to the environmental media, likelihood of an occurrence of a release to the specific environmental compartment, and available monitoring data. The weight of scientific evidence conclusion is summarized below for the modeled concentrations for surface water and ambient air. A detailed discussion of the strengths, limitations, and sources of uncertainty leading to a weight of scientific evidence conclusion can be found in the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)).

3.3.3.1 Surface Water

EPA conducted modeling with PSC to estimate concentrations of TBBPA within surface water, pore-water, and sediment. PSC considers model inputs of physical and chemical properties of TBBPA (i.e., K_{ow}, K_{oc}, water column half-life, photolysis half-life, hydrolysis half-life, and benthic half-life) and allows EPA to estimate surface water, sediment, and pore-water concentrations. The use of high-quality data on the physical and chemical properties of TBBPA increases confidence in the application of the PSC. A standard EPA water body was used to represent a consistent receiving water body scenario.

Flow data collected via the EPA ECHO API (Application Programming Interface) and the NHDPlus V2.1 EROM flow database include self-reported hydrologic reach codes on National Pollutant Discharge Elimination System (NPDES) permits and the best available flow estimations from the EROM flow data. Confidence in the flow values is considered robust because they are based on receiving water bodies reported in TRI and standard regression equations from EPA's Exposure and Fate Assessment Screening Tool (E-FAST) ([U.S. EPA, 2007](#)).

Direct releases to surface water reported via TRI were applied as the actual loading to surface water. Resulting surface water concentration from indirect discharges to off-site POTWs from TRI were also modeled. However, a removal efficiency was applied prior to modeling because discharges to POTWs are not directly released into the environment but to treatment facilities. The modeled data represent estimated surface water concentrations at the point of discharge for facilities that are actively releasing TBBPA to surface water. Modeled surface water concentrations were based on TRI reporting of releases to water, flow rates of known receiving water bodies or effluent discharge rates (whichever is higher), as well as high-quality physical and chemical property data derived from reasonably literature collected and evaluated through EPA's systematic review process. Overall, the Agency has robust confidence that the high-end estimated surface water concentrations modeled are appropriate to use in its general population and environmental exposure assessment.

3.3.3.2 Ambient Air and Air-to-Soil Deposition

EPA used the IIOAC Model and previously peer-reviewed methodology for fence-line communities ([U.S. EPA, 2022c](#)) to evaluate exposures and deposition rates via the ambient air pathway. IIOAC was developed based on a series of pre-run scenarios within EPA's American Meteorological Society/EPA Regulatory Model (AERMOD). IIOAC provides reliable and reproducible results that can be used to characterize upper-bound exposures and derive screening-level risk estimates. Because IIOAC is based on the pre-run AERMOD scenarios, there are limitations regarding which inputs can be modified and which cannot. Default input parameters (e.g., stack characteristics and 2011–2015 meteorological data) are already predefined and cannot be changed, but these defaults are based on national averages

identified during the model's development. Other parameters not accounted for include building dimensions, release elevation, and land use. Furthermore, IIOAC does not consider the presence or location of residential areas relative to the 100 m distance from releasing facilities, the size of the facility, and the release point within a facility. For larger facilities, 100 m from a release point may still fall within the facility property where individuals within the general population do not live or frequent. In contrast, for smaller facilities, there may be fenceline communities (*i.e.*, individuals within the general population that live or frequent locations 100 m away from the release point) and therefore could be exposed continuously. EPA thus assumed that individuals stay within their residences 24 hours per day, 7 days per week throughout the year—which introduces a level of uncertainty and biases towards overestimating exposure.

The use of annual release data and number of operating days to calculate daily average releases assumed operations are continuous and releases are the same for each day of operation. This can underestimate short-term or daily exposure and deposition rates because results may miss actual peak releases (and associated exposures and risks) if higher and lower releases occur on different days.

Any limitations and uncertainties of these releases, as described in the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)), are carried over to this ambient air exposure assessment. Overall, EPA has moderate confidence in the modeled ambient air concentrations. The air release assessment handles all facilities except Albemarle Corporation as one site because the combined stack releases from all the facilities are still an order of magnitude less than Albemarle's stack releases alone. This approach results in modeled air concentrations that are neither spatially nor temporally aligned. Furthermore, EPA used conservative inputs in its IIOAC modeling and considered a series of exposure scenarios under varying operating scenarios and multiple particle sizes. The IIOAC modeling is also based on previously peer-reviewed methodology and incorporates recommendations received during previous peer review and public comment. Taken together, the modeling approach incorporates health-protective assumptions for each individual release type (fugitive or stack) and ensures possible upper-bound exposures are not missed.

4 HUMAN HEALTH RISK ASSESSMENT

TBBPA – Draft Human Health Risk Assessment (Section 4): Key Points

EPA evaluated all reasonably available information to support human health risk characterization of TBBPA for workers, ONUs, consumers, bystanders, and the general population, including PESS. Exposures to these population groups are described in Section 4.1; human health hazards are described in Section 4.2; and human health characterization is described in Section 4.3. The following bullets summarize the key points.

Exposure Key Points

- EPA relied on monitoring data and modeled scenarios to estimate the inhalation for workers and ONUs and dermal exposure to workers for each COU.
- EPA used a screening-level analysis that modeled inhalation exposure for consumers and bystanders, as well as dermal and oral exposures to consumers for each COU.
- EPA used a screening-level analysis that modeled general population exposure to TBBPA via inhalation of ambient air, oral exposure through drinking water, and ingestion through fish consumption.
 - For a screening-level analysis of the human milk pathway, EPA used the maximum measured concentrations of TBBPA across 18 biomonitoring studies to characterize a nursing infant's exposure. EPA expects the human health hazard values based on early-life (neonatal) and maternal exposure scenarios to be protective of nursing infants because TBBPA does not likely cause adverse development outcomes.

Hazard Key Points

- EPA identified the effect of polycystic kidney lesions in neonatal male rats and atypical endometrial hyperplasia uterine lesions in female rats as the most robustly supported hazards associated with oral exposure to TBBPA in experimental animal models for intermediate and chronic exposure duration scenarios, respectively (Sections 4.2.1 and 4.2.2).
- In evaluating acute exposure effects, EPA considered limited available acute exposure studies and one- and two-generation offspring studies reporting reproductive and developmental outcomes. Assessment of these data indicated acute (single dose) studies did not display toxicity outcomes and gestational exposure studies indicated TBBPA did not impact offspring survival, body weight, or weight gain, or other malformations/maturation markers (*i.e.*, anogenital distance and preputial separation). There were no hazard data to indicate specific gestational effects, fertility marker changes, or adverse developmental outcomes associated with TBBPA exposure. Thus, EPA determined TBBPA is not acutely toxic and did not propose an acute exposure point of departure (POD) human hazard value.

TBBPA – Draft Human Health Risk Assessment (Section 4): Key Points (continued)

Hazard Key Points, continued

- A non-cancer HED of 6.8 mg/kg-day (derived from a POD of BMDL₁₀ = 28.8 mg/kg-day) was selected to characterize risk for intermediate durations of exposure. A total uncertainty factor (UF) of 30 was selected for use as the benchmark margin of exposure (MOE). A non-cancer HED of 4.4 mg/kg-day (derived from a POD of BMDL₁₀ = 18.5 mg/kg-day) was selected to characterize risk for chronic durations of exposure. A total UF of 30 was selected for use as the benchmark MOE. Because no data were identified to inform route-specific dermal or inhalation POD derivation, route-to-route extrapolation of the oral HEDs to dermal HEDs and to inhalation HEDs were calculated in accordance with EPA guidelines. The Agency considers the proposed oral PODs for use in characterizing risk from exposure to TBBPA to be protective of PESS and lifestages, including infants (Section 4.2). Under the *Guidelines for Carcinogen Risk Assessment* ([U.S. EPA, 2005](#)), EPA reviewed the weight of the evidence for the carcinogenicity and determined TBBPA is *Not Likely Carcinogenic to Humans* at doses below levels associated with the chronic POD.
 - The chronic POD based on atypical endometrial hyperplasia adequately accounts for all chronic toxicity associated with TBBPA, including non-cancer and cancer effects.
 - EPA determined uterine tumor formation follows a threshold of biological effects through a non-genotoxic sulfotransferase family 1E member 1 (SULT1E1) enzyme inhibition mode of action (MOA). Upon review of genotoxicity and cancer data as well as mechanistic MOA analysis, and consistent with guidelines ([U.S. EPA, 2005](#)), the Agency opted to approach dose-response assessment of uterine tumors through a non-genotoxic, non-linear cancer threshold of effects for consideration in POD selection for chronic TBBPA exposure duration scenarios (Section 4.2.2).

Risk Characterization Key Points

- All risk estimates for workers from central tendency and high-end inhalation exposures are above the benchmark MOE for all COUs and OESs with the following exceptions:
 - Manufacture (high-end only) Repackaging/Scenario 2 (central tendency and high-end); Industrial and commercial use – Construction, paint, electrical, and metal products – Building/construction materials (high-end only) and Disposal (high-end only) COUs
- All risk estimates for ONUs from inhalation exposures and workers and ONUs for dermal exposures are above the benchmark MOE for all COUs and OESs.
- Screening-level risk estimates for consumers from inhalation, oral, and dermal exposure are above the benchmark MOE for all COUs and scenarios.
- Screening-level risk estimates for the general population from exposures through drinking water consumption, ambient air inhalation, and fish ingestion are all above the benchmark MOE for all COUs and scenarios.
- Risk estimates using the maximum measured concentrations in human milk from available biomonitoring data exceed the benchmark. Available hazard data demonstrate that TBBPA is unlikely to cause adverse developmental outcomes. EPA expects human health hazard values based on early-life (neonatal) and adult (maternal) exposure scenarios to be protective of nursing infants.

4.1 Summary of Human Exposures

EPA evaluated all reasonably available information for occupational, consumer, and general population exposures, including consideration of increased exposure or susceptibility across PESS considerations.

4.1.1 Occupational Exposures

This section contains descriptions of EPA's occupational exposure assessment approaches, methods, results, including estimates of the number of potentially exposed workers and ONUs, and a discussion of the weight of scientific evidence and confidence in assessment results.

4.1.1.1 Inhalation Exposure Assessment Approach for Each COU

To assess the TBBPA potential occupational inhalation and dermal exposures that result from the COUs, EPA determined OESs for each TBBPA COU. The names of these OESs for each COU are given in Table 4-1. In some cases, multiple COUs are assessed via a single OES as shown in Table 4-2. OESs in general involve two major occupational exposure groups, which are workers and ONUs. In the case of each of the OESs that are derived from the TBBPA occupational inhalation exposure test order data, EPA assessed the occupational exposure of multiple similar exposure groups (SEGs) of workers and also ONUs as an SEG. Workers are in close proximity to TBBPA and may handle TBBPA while ONUs do not directly handle TBBPA but may be indirectly exposed to it as part of their employment. EPA assessed inhalation, dermal, and aggregate exposures of worker and ONUs. For inhalation exposure, the Agency assessed exposures of workers and ONUs to TBBPA in dust and for some OESs, the Agency assessed inhalation exposure based on worker and ONU monitoring data that were collected using the Occupational Safety and Health Administration (OSHA) OVS sampler, which collects TBBPA as both particulate matter and vapor. For dermal exposure, the Agency assessed exposures of workers to liquid, semi-solids and solids, and exposure of ONUs to settled dust on surfaces.

EPA assessed central tendency and high-end inhalation and dermal exposures. For inhalation exposure, the Agency assessed exposures based on worker inhalation exposure monitoring data or mathematical modeling if monitoring data were lacking. The inhalation exposure assessment approaches by OES are stated in Table 4-2. For dermal exposure, EPA assessed exposure based on the results of the *in vitro* dermal absorption study following the Organisation of Economic Co-operation and Development (OECD) test guideline (TG) 428 that was conducted in response to the TBBPA occupational exposure test order ([Charles River Laboratories, 2024](#)).

1374 **Table 4-1. OESs that EPA Assessed in the Case of Each COU**

COU Number	Life Cycle Stage	Category	Subcategory	OES
1	Manufacture	Domestic manufacture	N/A	Manufacturing
2		Import	N/A	N/A ^a
3	Processing	As a reactant	Flame retardant in plastic material and resin manufacturing	ACC TBBPA Consortium’s Group 2: Production of Intermediate Products (Liquid, Semi-Solid, and Powder) from TBBPA Powder
4	Processing		Intermediate in all other chemical product and preparation manufacturing	
5		Incorporation into formulation, mixture, or reaction product	Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing	ACC TBBPA Consortium’s Group 1: Production of Formulations (Particulate Solids) from TBBPA Powder
				ACC TBBPA Consortium’s Group 2: Production of Intermediate Products (Liquid, Semi-Solid, and Powder) from TBBPA Powder
				ACC TBBPA Consortium’s Group 3: Production of Intermediate Solid Products (Sheet, Film, and Pellet) from the Products of Group 2
6			Adhesive manufacturing	ACC TBBPA Consortium’s Group 2: Production of Intermediate Products (Liquid, Semi-Solid, And Powder) from TBBPA Powder
7		Incorporation into article	Reactive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., printed circuit boards and semiconductor packages)	ACC TBBPA Consortium’s Group 3: Production of Intermediate Solid Products (Sheet, Film, and Pellet) from the Products of Group 2
8			Reactive flame retardant in transportation equipment manufacturing (e.g., interior material for automotive and aviation articles)	ACC TBBPA Consortium’s Group 3: Production of Intermediate Solid Products (Sheet, Film, and Pellet) from the Products of Group 2
9	Additive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., plastic electronic enclosures)		ACC TBBPA Consortium’s Group 3: Production of Intermediate Solid Products (Sheet, Film, and Pellet) from the Products of Group 2	

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COU Number	Life Cycle Stage	Category	Subcategory	OES
10	Processing	Repackaging	N/A	Repackaging of TBBPA Powder
11		Recycling	N/A	Recycling Waste Electrical and Electronic Equipment
12	Distribution in commerce	N/A	N/A	N/A ^b
13	Industrial use	Construction, paint, electrical, and metal products	Powder coatings	Use of Powder Coatings in Electronics
14	Industrial and commercial use	Construction, paint, electrical, and metal products	Reactive flame retardant in electrical and electronic articles	ACC TBBPA Consortium's Group 4: Production of Composite Parts from Prepreg and Adhesive Film
15			Additive flame retardant in electrical and electronic articles (<i>i.e.</i> , plastic enclosures)	Industrial and Commercial Use in Electrical and Electronic Articles
16			Reactive flame retardant in automotive and aviation articles (<i>i.e.</i> , laminate and prepreg material)	ACC TBBPA Consortium's Group 4: Production of Composite Parts from Prepreg and Adhesive Film
17			Building/construction materials	Industrial and Commercial Use in Building and Construction Materials
18		Packaging, paper, plastic, hobby products	Plastic and rubber products	Industrial Use in Plastic and Rubber Products
				Commercial Use in Plastic and Rubber Products
19		Other	Laboratory chemical	Industrial and Commercial Laboratory Chemical Use
20	Disposal	N/A	N/A	Disposal

ACC = American Chemistry Council; COU = condition of use; OES = occupational exposure scenario

^a Importation results in potential exposure once the contents of imported containers are transferred for repackaging or processing. Repackaging of imported containers is part of the repackaging OES and unloading of imported containers for processing is part of the OESs involving TBBPA processing.

^b For the purpose of this risk evaluation, distribution in commerce is the transportation of TBBPA and TBBPA-containing products between sites at which TBBPA manufacturing, processing, and use occurs or the transportation of TBBPA-containing wastes for recycling or disposal. EPA expects all of the above-mentioned materials to be transported in closed system or otherwise to be transported in a form (*e.g.*, articles containing TBBPA) such that there is negligible potential for occupational exposure except during an incident.

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Table 4-2. OES to COU Crosswalk and Inhalation Exposure Assessment Approach per OES

OES	COU Number ^a	Assessment Approach			
		Worker Monitoring Data		Mathematical Modeling	Qualitative Assessment
		TBBPA Data Applicable to OES	Surrogate Monitoring Data		
Manufacturing	1		✓		
ACC TBBPA Consortium's Group 1: Production of Formulations (Particulate Solids) from TBBPA Powder	5	✓			
ACC TBBPA Consortium's Group 2: Production of Intermediate Products (Liquid, Semi-Solid, And Powder) from TBBPA Powder	3, 4, 5, 6	✓			
ACC TBBPA Consortium's Group 3: Production of Intermediate Solid Products (Sheet, Film, and Pellet) from the Products of Group 2	5, 7, 8, 9	✓			
ACC TBBPA Consortium's Group 4: Production of Composite Parts from Prepreg and Adhesive Film	14, 16	✓			
Repackaging of TBBPA Powder	10		✓		
Recycling Waste Electrical and Electronic Equipment	11	✓			
Use of Powder Coatings in Electronics	13			✓	
Industrial and Commercial Use in Electrical and Electronic Articles	15			✓	
Industrial and Commercial Use in Building and Construction Materials	17			✓	
Industrial Use in Plastic and Rubber Products	18		✓		
Commercial Use in Plastic and Rubber Products	18				✓
Industrial and Commercial Laboratory Chemical Use	19		✓		
Disposal	20			✓	
ACC = American Chemistry Council; COU = condition of use; OES = occupational exposure scenario					
^a Table 3-1 contains the names of all COUs and their corresponding ordinal numbers.					

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4.1.1.2 Inhalation Exposure Assessment Method for Each OES

This section contains a brief description of the assessment method for each OES. The assessment methods for the OESs associated with the TBBPA occupational exposure test order are described first followed by the assessment methods of the other OESs.

4.1.1.2.1 OESs of the TBBPA Occupational Inhalation Exposure Test Order Data

EPA issued a test order to certain companies to conduct TBBPA occupational inhalation exposure monitoring of the workers they employ ([Integral Consulting, 2025a](#)). The ACC TBBPA Consortium, which includes most recipients of this order, collected the required data and reported results ([Integral Consulting, 2025a](#)); a summary of information in their report is given below followed by a summary of EPA's method for assessing inhalation exposures from the data of this report.

Summary of the ACC TBBPA Consortium Methodology

1. *Sampling and Analysis Method:* A sampling and analysis method was developed for the purpose of executing the TBBPA inhalation exposure test order. This method involves the OSHA Versatile Sampler with Tenax and quartz fiber filter.
2. *Determination of OESs:* The ACC TBBPA consortium comprises 28 companies. Five of these companies did not manufacture (including import), process or otherwise conduct operations involving TBBPA in the United States. Another two companies of the Consortium imported TBBPA and sent this product directly to customer sites. Therefore, the workers of seven companies were not potentially exposed to TBBPA.

The other 21 companies of the Consortium processed or industrially used TBBPA at a total of 25 sites in the United States. The chemical process facilities at these sites (henceforth referred to as "processes") are associated with a total of eight EPA TBBPA COUs. Some sites contained two different processes. The Consortium divided the processes into four groups to facilitate TBBPA worker inhalation exposure monitoring. Each of these groups may include a variety of processes, but TBBPA inhalation exposure determinants are comparable in the case of each group. The Consortium considered exposure determinants that include the following: the physical state of material used and the concentration of TBBPA in this material, TBBPA throughput, production frequency, worker activities, engineering controls, and process description. The four Consortium groups are the OESs of this draft risk evaluation. Table 4-3 contains information about the four groups (OESs).

3. *Selection of Sites for Conducting Worker Monitoring:* The Consortium conducted worker inhalation exposure monitoring at one or more sites of each of the four groups of processes; this monitoring was done at the sites that contained the processes that were expected to result in the worst-case TBBPA potential inhalation exposure based on the exposure determinants. Worker monitoring was done at a total of seven sites to determine the potential inhalation exposure that results from the operation of eight TBBPA processes. Limited worker monitoring was done at an additional site to ensure that the worst-case exposure occurred at the sites selected for monitoring.
4. *Selection of Workers for Monitoring, Sampling Type, and Number of Samples:* The workers associated with each of the four Consortium groups (OESs) who may be potentially exposed to TBBPA were divided into SEGs. In general, each of the following groups of workers were associated with a SEG: process operators, maintenance workers, logistics workers, laboratory technicians and ONUs. SEGs may comprise workers from multiple sites. The monitored workers

mostly did routine worker activities (*i.e.*, activities done daily) but a few of them also did non-routine activities (*i.e.*, activities done weekly, monthly or annually). Full-shift personal breathing zone (PBZ) and task-based sampling were conducted. A total of 106 full-shift samples and 62 task-based samples were collected. Shift durations varied between 8 and 12.25 hours. The number of SEGs of the monitored workers, the number of full-shift PBZ samples, and the number of sites at which sampling occurred are given in Table 4-4 for each OES.

Summary of EPA's Method of Assessing Exposures Based on the TBBPA Test Order Data

EPA assessed central tendency and high-end exposure per SEG in the case of each of the four Consortium groups (OESs). EPA assessed central tendency and high-end full-shift time-weighted average (TWA) concentrations to be equal to the 50th and 95th percentile full-shift TWA PBZ concentrations that are reported in the ACC TBBPA Consortium final study report ([Integral Consulting, 2025a](#)) per SEG in the case of each consortium group with the exception of Group 4. The consortium did not report summary statistics for this group because of the high number of non-detects but EPA calculated summary statistics by equating non-detects to one half the level of detection. The full-shift TWA concentrations referenced above are not adjusted for shift duration (*e.g.*, a 12-hour full-shift TWA concentration is not adjusted to report this concentration value as an equivalent 8-hour full-shift TWA concentration). Furthermore, production frequency per consortium group was reported, which in some cases is equivalent to worker exposure frequency of fewer than 250 days per year. Accordingly, to calculate average daily concentrations, EPA assumed that workers work 40 hours per week on average and a total of 2,000 hours per year, which is equivalent to working 8 hours per day for 250 days per year, irrespective of shift duration and actual exposure frequency.

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Table 4-3. Description of the OESs that are Associated with the TBBPA Occupational Inhalation Exposure Test Order Data^a

ACC TBBPA Consortium Group	EPA OES	COU Number ^b	OES Description					Range of Operating Days per Year
			Feed Material		Product			
			Physical Form and Type of Material	TBBPA Conc. (weight %)	Physical Form	TBBPA Conc. (weight %)	Function	
1st	ACC TBBPA Consortium’s Group 1: Production of Formulations (Particulate Solids) from TBBPA Powder	5	Particulates (powder)	>98%	Granules	<5%	Polymer material	6–13 days
		5			Pellets	15–19.5%	Resin	
2nd	ACC TBBPA Consortium’s Group 2: Production of Intermediate Products (Liquid, Semi-Solid, And Powder) from TBBPA Powder	3	Particulates (powder)	90 to >98%	Liquids	200–500 ppm	Resin	Batch processes: 2–305 Continuous processes: 260–312 days
		5			Liquids	5–26%	Resin	
		5			Powder	<1%	Flame retarded powder	
		6			Semi-solids	0.05–20%	Adhesive	
3rd	ACC TBBPA Consortium’s Group 3: Production of Intermediate Solid Products (Sheet, Film, and Pellet) from the Products of Group 2	7	1. Liquid resin 2. Semi-solid adhesive	<30%	Solids: • Sheet • Film • Pellet	1. up to 6% 2. <0.1% (trace)	1. Copper clad laminate 2. Electronic component	Batch processes: 4–156 days Continuous processes: 104–260 days
		8	Liquid resin			≥ 5–20%	• Prepreg composite • Adhesive film	
		8	Semi-solid adhesives			15–20%	Structural film adhesive	
		5	Pellets			<17%	Engineering resin pellets	
		9	Pellets			<1% (trace)	Molded electronic part	
4th	ACC TBBPA Consortium’s Group 4: Production of Composite Parts from Prepreg and Adhesive Film	14, 16	Prepreg composite and adhesive films	<30%	Solids	2–17%	Composite parts for aerospace industry, including aviation interiors and composite products for electrical utilities	Batch processes: 12–365 days Continuous processes: 260–275 days
ACC = American Chemistry Council; COU = condition of use; Conc. = concentration; OES = occupational exposure scenario								
^a Table 4-1 contains the names of all COUs and their corresponding ordinal numbers.								

ACC TBBPA Consortium Group	EPA OES	COU Number ^b	OES Description					
			Feed Material		Product			Range of Operating Days per Year
			Physical Form and Type of Material	TBBPA Conc. (weight %)	Physical Form	TBBPA Conc. (weight %)	Function	
^b The TBBPA occupational exposure test order resulted in worker and ONU TBBPA inhalation monitoring data as summarized in section 4.1.1.2.1.								

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1447 **Table 4-4. Number of Samples and SEGs for Each of the Test Order OESs**

OES	Number of Full-Shift PBZ Samples Collected and the Corresponding Number of SEGs		
	Total Number of Sites at Which Sampling Was Conducted	Total Number of Samples	Number of SEGs
ACC TBBPA Consortium's Group 1: Production of Formulations (Particulate Solids) from TBBPA Powder	1	6 workers and 2 ONUs	3, including SEG of ONUs
ACC TBBPA Consortium's Group 2: Production of Intermediate Products (Liquid, Semi-Solid, And Powder) from TBBPA Powder	3	22 workers and 6 ONUs	3, including SEG of ONUs
ACC TBBPA Consortium's Group 3: Production of Intermediate Solid Products (Sheet, Film, and Pellet) from the Products of Group 2	2	21 workers and 8 ONUs	6, including SEG of ONUs
ACC TBBPA Consortium's Group 4: Production of Composite Parts from Prepreg and Adhesive Film	2	22 workers and 9 ONUs	4, including SEG of ONUs
ACC = American Chemistry Council; OES = occupational exposure scenario; ONU = occupational non-user; PBZ = personal breathing zone; SEG = similar exposure group			

1448 **4.1.1.2.2 Other OESs**

1449 With regard to OESs other than the OESs associated with the TBBPA inhalation exposure test order,
 1450 EPA assessed occupational inhalation exposure based on worker inhalation exposure monitoring data or
 1451 surrogate worker inhalation exposure monitoring data, and exposure modeling using EPA's PNOR
 1452 model ([U.S. EPA, 2021b](#)).

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 1454 The following scenarios used scenario-specific, chemical-specific inhalation monitoring data:

- 1455 • Recycling Waste Electrical and Electronic Equipment
- 1456 • Commercial Use in Plastic and Rubber Products

1457 The following scenarios used surrogate or analogous inhalation monitoring data:

- 1458 • Manufacturing
- 1459 • Repackaging of TBBPA Powder
- 1460 • Industrial Use in Plastic and Rubber Products
- 1461 • Industrial and Commercial Laboratory Chemical Use

1462 The following scenarios used EPA's PNOR Model:

- 1463 • Industrial and Commercial Additive Use in Electrical and Electronic Articles
- 1464 • Industrial and Commercial Use in Building and Construction Materials
- 1465 • Use of Powder Coatings in Electronics
- 1466 • Waste Handling, Treatment, and Disposal

1467 All of the assessment methods are summarized in Table 4-5.

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Table 4-5. Approaches for Estimation of Inhalation Exposures for OESs Other than OESs Derived from Test Order Data

OES	Approach Used to Estimate Inhalation Exposure
Manufacturing	Surrogate full-shift TWA PBZ worker monitoring data that are total dust data: EPA assessed inhalation exposure concentrations based on surrogate data that are worker total dust PBZ monitoring data (<i>i.e.</i>, these are not TBBPA data per se). The data were collected by monitoring TBBPA manufacturing workers during the manufacture of TBBPA at Albemarle Corporation's Magnolia, Arkansas, site between July 2003 and November 2021. These data were collected by Albemarle Corporation as surrogate TBBPA inhalation exposure data because a TBBPA sampling and analysis method was lacking. The ACC TBBPA Consortium submitted these data as surrogate data for assessing the manufacturing OES. The data comprise 10 full-shift personal monitoring samples that were collected for four packagers, a maintenance worker, an electrical and instrumentation technician, a backend operator, a loader operator, and 2 general operators. Sample durations ranged from 330–490 minutes. Two other samples were excluded from this dataset because these samples were obtained by monitoring workers who work at the front-end of the process and raw material for TBBPA manufacture was present in that location but not TBBPA; each of these samples was below the limit of detection ($<0.01 \text{ mg/m}^3$ and $<0.32 \text{ mg/m}^3$), respectively (Integral Consulting, 2025b). EPA assessed central tendency and high-end full-shift TWA exposure concentrations to be equal to the 50th percentile and 95th percentile of the 10 PBZ samples, or 0.8 mg/m^3 and 2.8 mg/m^3, respectively. In contrast, the ACC TBBPA Consortium, Albemarle Corporation and Integral Consulting, LLC estimated central tendency and high-end exposures to be equal to 0.82 mg/m^3 and 3.75 mg/m^3 because they assumed the 10 PBZ samples are lognormally distributed (Integral Consulting, 2025b). ONUs: EPA used a default assumption of the central tendency from identified workers inhalation exposures to represent ONU inhalation exposures.
Repackaging of TBBPA Powder	Surrogate full-shift TWA PBZ and task-based worker monitoring data that are TBBPA data: Albemarle Corporation imported 98–100% TBBPA powder in 1-ton (approximately 2,200 lb) super sacks and transloaded this material into trucks that are located outdoors using a custom funnel cone that is placed on top of the truck. A worker untied the super sack after it was placed on top of the cone, and the contents of the sack flowed by gravity with some manual jostling of the sack. The cone prevented some dust emissions. The task occurred over a 4- to 5-hour period per truckload. During this period, the worker was in close proximity to TBBPA during opening of the super sack and manual jostling but exited the cone and monitored from a distance as it was unloading each super sack. The number of super sacks emptied in a truck and the number of trucks that are filled per day is CBI. This work was done by workers who worked 12-hour shifts (Integral Consulting, 2025b, c). This repackaging operation ceased at Albemarle's site and is conducted instead at the site of a toller (contract facility) (Albemarle, 2025a). EPA lacks information about the toll repackaging site at which Albemarle conducts repackaging. The ACC TBBPA Consortium submitted TBBPA full-shift TWA (sample durations: 510–675 minutes) and task-based (sample durations: 15–270 minutes) PBZ worker monitoring data as surrogate data for assessing the repackaging OES. EPA assessed the inhalation exposure concentrations of the repackaging OES based on this surrogate data. The surrogate data that is the basis of EPA's assessment of the repackaging OES are data that the ACC TBBPA Consortium collected at two TBBPA processing sites in response to an order that EPA had issued pursuant to TSCA section 4(a) (Integral Consulting, 2025c). At one of these sites, which is Site L, workers repackaged 100% TBBPA powder from super sacks into

OES	Approach Used to Estimate Inhalation Exposure
	smaller bags using a self-contained machine with dust collection. At the other site, which is Site K, workers transferred 100% TBBPA powder in 2,000 lb super sacks into a reactor using a mechanism that automatically empties the super sacks after the worker unties the sack. EPA assessed exposure in the case of two scenarios: Scenario 1, which involves robust engineering controls, and Scenario 2 which involves less robust engineering controls. The Agency assessed Scenarios 1 and 2 based on the data of Sites L and K, respectively. In the case of Site L, which corresponds to Scenario 1, three full-shift TWA PBZ samples (each from a different worker) and 2 task-based samples (each paired with one of those full-shift samples) were collected. The task-based samples were collected while the workers repackaged the super sacks; observers noted a very clean area with little visible dust. The ranges of these full-shift TWA and task-based PBZ data are 0.11–0.45 mg/m³ and 0.36–0.74 mg/m³, respectively. Sample durations are 510–675 minutes (full-shift samples) and 190–270 minutes (task-based samples) (Integral Consulting, 2025c). EPA assessed central tendency and high-end full-shift TWA concentrations of Scenario 1 as the 50th and 95th percentile of the three full-shift TWA PBZ samples of Site L. In the case of Site K, which corresponds to Scenario 2, 6 task-based samples (each from a different worker) were collected while the workers transferred the contents of the super sacks into the reactor. The range of these data are 4.2–48 mg/m³. The sample durations are mostly 15 or 17 minutes, and the exception is one sample with a duration of 25 minutes (Integral Consulting, 2025c). The sampling duration of each task-length sample is equal to the duration of transferring a super sack into the reactor (Integral Consulting, 2025c). To assess the exposure of Scenario 2, EPA assumed that 2 trucks are filled per day because of the following: first, as stated above, a truck was filled at Albemarle’s site by emptying multiple super sacks during a period of 4–5 hours. Second, EPA assumed a work shift of 12 hours because Albemarle’s works shift was 12 hours. Based on this, a worker is able to fill 2 trucks at most because the work shift will include work breaks (<i>i.e.</i>, there are two 4-to-5-hour work periods in a 12-hour work shift at most.) In conclusion, EPA assumed that a worker unloads the super sacks during 10 hours of the 12-hour shift. The Agency converted each of the 6 task-based samples to 12-hour full-shift TWA samples and then assessed central tendency and high-end full-shift TWA concentrations as the 50th and 95th percentile of the resulting six full-shift TWA concentrations. To convert each task-based concentration to a full-shift concentration, EPA divided the 10-hour work period by the sampling duration of the task-length sample to determine the number of super sacks that would be emptied if the duration of emptying a super sack equaled the sampling duration and did not vary during the day. Then, the Agency assumed that exposure concentration during the emptying of each super sack is equal to the concentration of task-length sample and did not vary by sack. The Agency then multiplied the task-length concentration by the number of sacks and divided by the shift duration of 12 hours. ONUs: EPA used a default assumption of the central tendency from identified workers inhalation exposures to represent ONU inhalation exposures.
Recycling Waste Electrical and Electronic Equipment	TBBPA PBZ monitoring data obtained from literature search: For recycling facilities, EPA identified two NIOSH Health Hazard Evaluations (HHEs) reports that conducted studies at two separate e-waste recycling locations (Grimes et al., 2019; Beaucham et al., 2018). These studies contained four statistical distributions created from 42 full-shift PBZ samples taken for

OES	Approach Used to Estimate Inhalation Exposure
	workers at the facilities. The Agency obtained samples for an additional four workers for full-shift PBZ taken from European e-waste recycling facilities (Rosenberg et al., 2011). These data were combined with the NIOSH HHE data to generate an overall distribution of full-shift worker exposure. ONUs: EPA did not identify data applicable to the estimation of ONU exposure at recycling facilities. The Agency used a default assumption of the central tendency from estimated workers inhalation exposures to represent ONU inhalation exposures.
Industrial and Commercial Additive Use in Electrical and Electronic Articles	Exposure modeling: The Agency estimated inhalation exposures using EPA’s PNOR Model (U.S. EPA, 2021b). A subset of OSHA CEHD inhalable dust data were taken for facilities with NAICS codes starting with 334 – Computer and Electronic Product Manufacturing to estimate final product particulate concentrations in the air. EPA identified 20% by mass as the highest expected TBBPA concentration based on an identified product SDS (Panduit, 2017). The estimated exposures assume that TBBPA is present in particulates in the air at this same concentration. ONUs: The Agency used a default assumption of the central tendency from modeled workers inhalation exposures to represent ONU inhalation exposures.
Industrial and Commercial Use in Building and Construction Materials	Exposure modeling: According to EPA’s PNOR Model (U.S. EPA, 2021b), workers associated with NAICS code 23 (construction of buildings; heavy and civil engineering construction; specialty trade contractors) are possibly exposed to PNOR via inhalation. Furthermore, the 50th and 95th percentiles of the PNOR total dust 8-hour TWA PBZ inhalation exposure concentrations of these workers are 2.4 and 15 mg/m³, respectively. EPA multiplied these concentrations with the mass fraction of TBBPA in pipes and fittings made from ABS resin which may be equal to a maximum value of 22% by mass (ECB, 2006a) to estimate the 50th and 95th percentiles of the 8-hour TWA TBBPA PBZ inhalation exposure concentrations of this OES. ONUs: The Agency used a default assumption of the central tendency from modeled workers inhalation exposures to represent ONU inhalation exposures.
Use of Powder Coatings in Electronics	Exposure modeling: The Agency estimated inhalation exposures using EPA’s PNOR Model (U.S. EPA, 2021b). A subset of OSHA CEHD inhalable dust data were taken for facilities with NAICS codes starting with 334 – Computer and Electronic Product Manufacturing, 335 – Electrical Equipment, Appliance, and Component Manufacturing, and 336 – Transportation Equipment Manufacturing to estimate final product particulate concentrations in the air. EPA identified 10% by weight as the highest expected TBBPA concentration based on a documented epoxy powder product for the electronics industry (EPA-HQ-OPPT-2018-0462-0016). The estimated exposures assume that TBBPA is present in particulates in the air at this same concentration. ONUs: The Agency used a default assumption of the central tendency from modeled workers inhalation exposures to represent ONU inhalation exposures
Industrial Use in Plastic and Rubber Products	TBBPA PBZ monitoring data from test order used as analogous data for this OES: Analogous occupational inhalation data for TBBPA were provided via a test order submission from the ACC TBBPA Consortium, which includes manufacturers and processors of TBBPA. Data provided for ACC TBBPA Consortium’s Group 4: Production of TBBPA-containing solids from

OES	Approach Used to Estimate Inhalation Exposure
	TBBPA-containing material EPA identified 21 worker personal sample data points and 8 ONU personal sample data points for activities involving the use and manipulation of solid materials containing TBBPA. The Agency assumes the tasks described for the ACC Group 4 OES would be similar to tasks performed by industrial users of TBBPA-containing plastic and rubber articles and uses the data as analogous data to assess inhalation exposure for workers under this OES.
Commercial Use in Plastic and Rubber Products	<i>TBBPA area monitoring data obtained from literature search:</i> EPA identified a risk assessment conducted for TBBPA by European Chemicals Bureau (ECB) during systematic review. The data included a total of 12 8-hour TWA area samples; 2 of these samples were for workers and the remaining 10 were for employees that worked in offices, which EPA would not consider to be workers or ONUs because they are not present where TBBPA-containing solid components are being used to produce final plastic and rubber articles (ECB, 2008). The 2 worker samples were taken in a computer repair facility and had 8-hour TWA values of 3.1E-08 mg/m ³ and 3.8E-08 mg/m ³ . Based on these data, EPA did not quantitatively assess worker exposures for commercial use of plastic and rubber products containing TBBPA as the low concentrations provided by these samples are not expected to generate considerable risk to workers.
Industrial and Commercial Laboratory Chemical Use	<i>TBBPA PBZ monitoring data from test order were used as analogous data for this OES:</i> Occupational inhalation data for TBBPA were provided via a test order submission from the ACC TBBPA Consortium, which includes manufacturers and processors of TBBPA. Within this dataset for manufacturers, processors, and users, EPA identified 9 worker full-shift PBZ samples for laboratory and quality control technicians. The Agency assumes the tasks described for these technicians in a manufacturing setting would be similar to tasks performed by laboratory technicians in a commercial laboratory setting and uses the data as analogous data to assess inhalation exposure for workers for the laboratory use OES. <i>ONUs:</i> The Agency used a default assumption of the central tendency from estimated workers inhalation exposures to represent ONU inhalation exposures.
Waste Handling, Treatment, and Disposal	<i>Exposure modeling:</i> According to EPA's PNOR Model (U.S. EPA, 2021b), workers associated with NAICS code 56 (administrative and Support and Waste Management and Remediation Services) are possibly exposed to PNOR via inhalation. Furthermore, the 50th and 95th percentiles of the PNOR total dust 8-hour TWA PBZ inhalation exposure concentrations of these workers are 2.5 and 15 mg/m ³ , respectively. EPA multiplied these concentrations with the greatest mass fraction of TBBPA in a product that is reported in the literature, which is 22% by weight (ECB, 2006a), to estimate the 50th and 95th percentiles of the 8-hour TWA TBBPA PBZ inhalation exposure concentrations of this OES. <i>ONUs:</i> The Agency used a default assumption of the central tendency from modeled workers inhalation exposures to represent ONU inhalation exposures.
ACC = American Chemistry Council; CEHD = Chemical Exposure Health Data; ; ECB = European Chemicals Bureau; NAICS = North American Industry Classification System; NIOSH = National Institute for Occupational Safety and Health; OES = occupational exposure scenario; ONU = occupational non-user; OSHA = Occupational Safety and Health Administration; PBZ = personal breathing zone; PNOR = particulates not otherwise regulated; TWA = time-weighted average	

4.1.1.3 Dermal Exposure Assessment Method

TBBPA dermal exposure monitoring data were not available. EPA obtained TBBPA *in vitro* dermal absorption study data ([Charles River Laboratories, 2024](#)) as a result of an order that EPA had issued pursuant to TSCA section 4(a)(2). Using the *in vitro* TBBPA dermal absorption data in the final study report, the Agency assessed worker and ONU dermal exposure to TBBPA-containing material in general by estimating the amount of TBBPA that is dermally transferred into systemic circulation during a day as a result of dermal exposure occurring during that day. Specifically, the Agency calculated a maximal TBBPA dermal absorption flux from the data reported in the final study report and then estimated the amount of TBBPA that is dermally transferred into systemic circulation during a day as follows:

Equation 4-1.

$$\begin{aligned} \text{Quantity of TBBPA absorbed} \\ &= (\text{Maximal TBBPA flux}) \times (\text{Percutaneous absorption period of 24 hrs}) \\ &\times (\text{Exposure surface area}) \end{aligned}$$

Central tendency and high-end values of the amount of TBBPA absorbed were calculated from central tendency and high-end values of exposure surface area, respectively. For all OESs, the Agency conservatively assessed dermal exposures to workers and ONUs using the maximal flux value determined through *in vitro* dermal absorption testing ([Charles River Laboratories, 2024](#)). Therefore, central tendency and high-end dermal exposure estimates for all scenarios were calculated as 3.7 and 7.5 mg/day, respectively. Since there were no dermal data specific to ONUs, the worker central tendency dermal exposure value (*i.e.*, 3.7 mg/day) was assumed to represent ONU dermal exposure from incidental contact with TBBPA dust deposited on surfaces. The dermal exposure values presented in Table 4-7 represent upper bound estimates of dermal exposure to TBBPA since the maximal flux value was used for all estimates, and this approach likely overestimates dermal exposures to workers and ONUs.

4.1.2 Summary of Inhalation and Dermal Exposure Assessments

Table 4-6 summarizes the inhalation exposure estimates for each OES and Table 4-7 summarizes the dermal exposure estimates for each OES.

1500 **Table 4-6. Summary of Inhalation Exposure Estimates for Each OES**

OES	Worker Description	Exposure Days (days/year)	Full-Shift TWA Inhalation Exposure Estimates (mg/m ³)		Intermediate Average Daily Dose (IADD), Non-Cancer (mg/kg-day)		Average Daily Dose (ADD), Chronic Non-Cancer (mg/kg-day)	
			Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
Manufacturing	Average adult worker	250	0.8	2.8	7.7E-02	2.7E-01	6.8E-02	2.4E-01
	ONU ^a	250	0.8		7.7E-02		6.8E-02	
Repackaging of TBBPA Powder	Scenario 1 ^b	250	0.25	0.45	3.6E-02	6.6E-02	2.1E-02	3.9E-02
	Scenario 2 ^b	250	14	39	2.0	5.7	1.2	3.3
	ONU ^a	250	0.25		3.6E-02		2.1E-02	
ACC TBBPA Consortium's Group 1: Production of Formulations (Particulate Solids) from TBBPA Powder	Processing operator	250	0.16	0.31	1.6E-02	3.1E-02	1.4E-02	2.7E-02
	User operator	250	1.9E-02	3.3E-02	1.9E-03	3.2E-03	1.7E-03	2.8E-03
	ONU	250	5.5E-04	6.9E-04	5.3E-05	6.7E-05	4.7E-05	5.9E-05
ACC TBBPA Consortium's Group 2: Production of Intermediate Products (Liquid, Semi-Solid, And Powder) from TBBPA Powder	Processing operator	250	6.5E-03	1.2	6.3E-04	1.1E-01	5.6E-04	1.0E-01
	Laboratory technician	250	2.1E-04	4.2E-04	2.0E-05	4.1E-05	1.8E-05	3.6E-05
	ONU	250	1.4E-03	2.1E-02	1.4E-04	2.0E-03	1.2E-04	1.8E-03
ACC TBBPA Consortium's Group 3: Production of Intermediate Solid Products (Sheet, Film, and Pellet) from the Products of Group 2	Processing operator	250	2.8E-04	4.0E-04	2.7E-05	3.9E-05	2.4E-05	3.4E-05
	User operator	250	6.9E-04	1.1E-02	6.7E-05	1.0E-03	5.9E-05	9.1E-04
	Laboratory technician	250	9.2E-05	2.1E-03	8.9E-06	2.0E-04	7.9E-06	1.8E-04
	Logistics technician	250	2.2E-04	4.4E-04	2.1E-05	4.3E-05	1.9E-05	3.8E-05
	Maintenance technician	250	5.7E-04	8.0E-04	5.5E-05	7.8E-05	4.9E-05	6.8E-05
	ONU	250	1.0E-04	9.5E-04	9.7E-06	9.2E-05	8.6E-06	8.1E-05

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OES	Worker Description	Exposure Days (days/year)	Full-Shift TWA Inhalation Exposure Estimates (mg/m ³)		Intermediate Average Daily Dose (IADD), Non-Cancer (mg/kg-day)		Average Daily Dose (ADD), Chronic Non-Cancer (mg/kg-day)	
			Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
ACC TBBPA Consortium's Group 4: Production of Composite Parts from Prepreg and Adhesive Film	User operator	250	8.5E-05	2.6E-04	8.2E-06	2.5E-05	7.3E-06	2.2E-05
	Logistics technician	250	6.5E-05	1.3E-04	6.3E-06	1.3E-05	5.6E-06	1.1E-05
	Maintenance technician	250	6.5E-05	1.3E-04	6.3E-06	1.3E-05	5.6E-06	1.1E-05
	ONU	250	9.2E-05	9.6E-05	8.9E-06	9.3E-06	7.9E-06	8.2E-06
Recycling	Average adult worker	250	1.4E-06	2.9E-04	1.4E-07	2.9E-05	1.2E-07	2.5E-05
	ONU ^a	250	1.4E-06		1.4E-07		1.2E-07	
Industrial and Commercial Additive Use in Electrical and Electronic Articles	Average adult worker	250	6.6E-02	1.2	6.4E-03	1.2E-01	5.7E-03	1.0E-01
	ONU ^a	250	6.6E-02		6.4E-03		5.7E-03	
Industrial and Commercial Use in Building and Construction Materials	Average adult worker	250	0.53	3.3	5.1E-02	3.2E-01	4.5E-02	2.8E-01
	ONU ^a	250	0.53		5.1E-02		4.5E-02	
Use of Powder Coatings in Electronics	Average adult worker	250	0.20	1.5	1.9E-02	1.5E-01	1.7E-02	1.3E-01
	ONU ^a	250	0.20		1.9E-02		1.7E-02	
Industrial Use in Plastic and Rubber Products	Average adult worker	250	8.5E-05	2.4E-04	8.2E-06	2.4E-05	7.3E-06	2.1E-05
	ONU	250	9.2E-05	9.6E-05	8.9E-06	9.3E-06	7.9E-06	8.2E-06
Commercial Use in Plastic and Rubber Products	Qualitative assessment							
Industrial and Commercial Laboratory Chemical Use	Average adult worker	250	6.5E-05	2.5E-03	6.3E-06	2.4E-04	5.6E-06	2.1E-04
	ONU	250	6.5E-05		6.3E-06		5.6E-06	

OES	Worker Description	Exposure Days (days/year)	Full-Shift TWA Inhalation Exposure Estimates (mg/m ³)		Intermediate Average Daily Dose (IADD), Non-Cancer (mg/kg-day)		Average Daily Dose (ADD), Chronic Non-Cancer (mg/kg-day)	
			Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
Disposal	Average adult worker	250	0.55	3.3	5.3E-02	3.2E-01	4.7E-02	2.8E-01
	ONU ^a	250	0.55		5.3E-02		4.7E-02	

^a Where EPA was not able to estimate ONU inhalation exposure from monitoring data or models, this was assumed equivalent to the central tendency experienced by workers for the corresponding OES.

^b Repackaging was evaluated using 2 scenarios informed by surrogate monitoring data from sites with two different TBBPA transfer processes. These approaches are described in Table 4-5.

Table 4-7. Summary of Dermal Exposure Estimates for Each OES

OES	Worker Description	Exposure Days (days/year)	Dermal Exposure Estimates (mg/day)		Intermediate Average Daily Dose (IADD), Non-Cancer (mg/kg-day)		Average Daily Dose (ADD), Chronic Non-Cancer (mg/kg-day)	
			Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
Manufacturing	Average adult worker	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	ONU ^a	250	3.7		3.6E-02		3.2E-02	
Repackaging of TBBPA Powder	Scenario 1 (worker, full-shift)	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	Scenario 2 (worker, short-term)	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	ONU ^a	250	3.7		3.6E-02		3.2E-02	
ACC TBBPA Consortium's Group 1: Production of formulations (particulate solids) from TBBPA powder	Processing operator	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	User operator	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	ONU ^a	250	3.7		3.6E-02		3.2E-02	

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OES	Worker Description	Exposure Days (days/year)	Dermal Exposure Estimates (mg/day)		Intermediate Average Daily Dose (IADD), Non-Cancer (mg/kg-day)		Average Daily Dose (ADD), Chronic Non-Cancer (mg/kg-day)	
			Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
ACC TBBPA Consortium's Group 2: Production of Intermediate Products (Liquid, Semi-Solid, And Powder) from TBBPA Powder	Processing operator	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	Laboratory technician	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	ONU ^a	250	3.7		3.6E-02		3.2E-02	
ACC TBBPA Consortium's Group 3: Production of Intermediate Solid Products (Sheet, Film, and Pellet) from the Products of Group 2	Processing operator	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	User operator	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	Laboratory technician	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	Logistics technician	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	Maintenance technician	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	ONU ^a	250	3.7		3.6E-02		3.2E-02	
ACC TBBPA Consortium's Group 4: Production of Composite Parts from Prepreg and Adhesive Film	User operator	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	Logistics technician	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	Maintenance technician	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	ONU ^a	250	3.7		3.6E-02		3.2E-02	
Recycling	Average adult worker	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	ONU ^a	250	3.7		3.6E-02		3.2E-02	
Industrial and Commercial Additive Use in Electrical and Electronic Articles	Average adult worker	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	ONU ^a	250	3.7		3.6E-02		3.2E-02	
Industrial and Commercial Use in Building and Construction Materials	Average adult worker	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	ONU ^a	250	3.7		3.6E-02		3.2E-02	
Use of Powder Coatings in Electronics	Average adult worker	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	ONU ^a	250	3.7		3.6E-02		3.2E-02	

OES	Worker Description	Exposure Days (days/year)	Dermal Exposure Estimates (mg/day)		Intermediate Average Daily Dose (IADD), Non- Cancer (mg/kg-day)		Average Daily Dose (ADD), Chronic Non- Cancer (mg/kg-day)	
			Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
Industrial Use in Plastic and Rubber Products	Average adult worker	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	ONU ^a	250	3.7		3.6E-02		3.2E-02	
Commercial Use in Plastic and Rubber Products	Qualitative assessment							
Industrial and Commercial Laboratory Chemical Use	Average adult worker	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	ONU ^a	250	3.7		3.6E-02		3.2E-02	
Disposal	Average adult worker	250	3.7	7.5	3.6E-02	7.3E-02	3.2E-02	6.4E-02
	ONU ^a	250	3.7		3.6E-02		3.2E-02	
OES = occupational exposure scenario; ONU = occupational non-user								
^a Where EPA unable to estimate ONU dermal exposure from monitoring data or models, this was assumed equivalent to the central tendency experienced by workers for the corresponding OES.								

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4.1.3 Estimation of the Number of Workers and ONUs Potentially Exposed

An assessment objective is to estimate the number of workers and ONUs potentially exposed. A primary difference between workers and ONUs is that workers may handle TBBPA and have direct contact with the chemical, while ONUs are working in the general vicinity of workers but do not directly handle TBBPA. Since ONUs do not handle TBBPA directly, dermal exposures would be limited to incidental contact, such as of TBBPA dusts that settle onto surfaces that the ONUs may contact. The size of the area that ONUs may work can vary across each OES and across facilities within the same OES and will depend on the facility configuration, building and room sizes, presence of vapor barrier, and worker activity pattern.

Methodology

Where available, EPA used CDR data to provide a basis to estimate the number of workers and ONUs. Data were available from the 2016 and 2020 CDR for manufacturing sites; however, the Agency determined this was not sufficient to determine the total number of workers for that OES. Additionally, there were no changes from 2020 CDR to the 2024 CDR that are relevant to the risk characterization ([U.S. EPA, 2026a](#)). EPA supplemented the available CDR data using available market data and analyzed U.S. Bureau of Labor Statistics (BLS) and U.S. Census data using the methodology described in the *Draft Occupational Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026v](#)). EPA also determined the number of days per year that workers are potentially exposed to TBBPA. In general, the exposure frequency is the same as the number of operating days per year for a given OES. However, if the number of operating days exceeded 250 days per year, EPA assumed that a single worker would not work more than 250 days per year and therefore EPA still assessed 250 days as the maximum exposure days per year.

Results

Table provides a summary for the number of workers and ONUs potentially exposed to TBBPA per facility. The estimates are provided for a facility within each OES.

Table 4-8. Total Number of Workers and ONUs Potentially Exposed to TBBPA for Each OES

OES	Exposure Days per Year	Potential Number of Sites	Potential Number of Workers per Site ^a	Potential Number of ONUs per Site ^a
Manufacturing	250	1	23	11
Repackaging of TBBPA Powder	250	2	4	2
ACC TBBPA Consortium's Group 1: Production of TBBPA-containing solids	250	3	20	13
ACC TBBPA Consortium's Group 2: Production of Intermediate Products (Liquid, Semi-Solid, And Powder) from TBBPA Powder	250	10	22	11
ACC TBBPA Consortium's Group 3: Production of Intermediate Solid Products (Sheet, Film, and Pellet) from the Products of Group 2	250	8	65	20

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OES	Exposure Days per Year	Potential Number of Sites	Potential Number of Workers per Site ^a	Potential Number of ONUs per Site ^a
ACC TBBPA Consortium's Group 4: Production of Composite Parts from Prepreg and Adhesive Film	250	4	35	29
Recycling Waste Electrical and Electronic Equipment	250	812	1	1
Industrial and Commercial Use in Electrical and Electronic Articles	250	N/A	12	15
Industrial and Commercial Use in Building and Construction Materials	250	1	2	2
Use of Powder Coatings in Electronics	250	N/A	11	7
Industrial Use in Plastic and Rubber Products	250	N/A	46	16
Industrial and Commercial Laboratory Chemical Use	250	N/A	3	7
Disposal	250	11	3	8
OES = occupational exposure scenario; ONU = occupational non-user; N/A = not available ^a Number of workers and ONUs estimates based on U.S. Census Bureau (2017) , U.S. BLS (2023) , and CDR (U.S. EPA, 2022a) data. Note: The Commercial Use in Plastic and Rubber Products OES was qualitatively assessed.				

4.1.4 Weight of Scientific Evidence Conclusions for Occupational Exposure

The weight of the scientific evidence in the case of occupational inhalation exposure is summarized in Table for all OESs except for the four OESs associated with the ACC TBBPA Consortium's final study report ([Integral Consulting, 2025a](#); [Stantec ChemRisk, 2024](#)). With regard to these OESs, the strength of the assessments is the large number of pertinent TBBPA full-shift TWA PBZ worker and ONU monitoring data that are associated with various SEGs. The limitation of the assessment is that few of the monitored workers did non-routine tasks. The uncertainty of the assessment is that EPA assumed that workers work 40-hour weeks on average and 2,000 hours per year, which is equivalent to 8-hour shifts and 250 days per year) irrespective of shift duration. This assumption may result in uncertainty, especially in the case of assessing intermediate risk because a worker conceivably may work more than 40 hours per week for a short period of time if the shift duration is greater than 8 hours.

With regard to the assessment of dermal exposure, estimates are based on an *in vitro* dermal absorption study specific to TBBPA ([Charles River Laboratories, 2024](#)). The study provides dermal absorption data for a wide range of chemical doses and multiple vehicles relevant to occupational exposure scenarios of TBBPA. EPA chose the maximal flux value obtained among the various *in vitro* dermal absorption experiments to demonstrate the potential of dermal exposure at the upper bound. Because the highest measured flux value was used to estimate upper-bound dermal exposures for both workers and ONUs, it is likely that the reported dermal exposure values overestimate occupational dermal exposures. Consequently, EPA has moderate confidence that the results of the occupational dermal exposure assessment represent an upper bound of exposure.

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Table 4-9. Summary of Assumptions, Uncertainty, and Overall Confidence in Occupational Inhalation Exposure Estimates by OES

OES	Weight of Scientific Evidence Conclusion in Occupational Inhalation Exposure Estimates
Manufacturing	EPA assessed inhalation exposure concentrations based on surrogate data that are total dust personal worker monitoring data. These data were collected by monitoring TBBPA manufacturing workers during the manufacture of TBBPA at Albemarle Corporation's Magnolia, Arkansas, site between July 2003–November 2021 and were collected as surrogate TBBPA inhalation exposure surrogate data because a TBBPA-specific sampling and analysis method was lacking. Refer to Section 4.1.1.2.2 for a description of the assessment method. The strength of the assessment is that the data are based on total dust full-shift PBZ worker monitoring data that are of high quality as surrogate monitoring data for the following reasons: 1. TBBPA is primarily found in workplace air in the particle-associated phase according to the scientific literature (Integral Consulting, 2025b). 2. The data were collected during the manufacture of TBBPA at a TBBPA manufacturing facility in the United States. This facility was located separately from other facilities at the same site that were used in the production of other powders (Integral Consulting, 2025b). Also, there is a single TBBPA manufacturing facility in the United States according to the 2023 TRI. 3. Measurements were less than the limits of detection ($<0.01 \text{ mg/m}^3$ and $<0.32 \text{ mg/m}^3$) in the PBZ samples of two workers who worked in areas of the TBBPA production facility that did not contain TBBPA (these areas and all other areas of the TBBPA production facility are contiguous) (Integral Consulting, 2025b). Because no dust was detected on two workers in TBBPA-free areas, the dust detected on workers in TBBPA-manufacturing areas is likely predominantly TBBPA. Another strength is that the job titles of the monitored workers are reported and include various job titles. The limitation of the data are that the data are total dust data and not TBBPA-specific data. Therefore, the exposure concentrations possibly result in an overestimate of TBBPA exposure. The uncertainties of the assessment result from the following factors: 1. The total number of samples is only 10, 2. Worker tasks are not reported, 3. The proportion of TBBPA in the measured dust, and 4. The monitoring data does not include ONU information. Based on these strengths, limitations, and uncertainties, EPA has concluded that the weight of scientific evidence for this assessment is moderate in the case of workers and slight-to-moderate in the case of ONUs due to lack of monitoring or other data about ONUs.
Repackaging	This scenario involves the transloading of TBBPA powder from imported super sacks to trucks. EPA assessed inhalation exposure concentrations based on surrogate data that are TBBPA full-shift TWA and task-based PBZ worker monitoring data. These data were collected by monitoring workers at two TBBPA processing sites during repackaging of TBBPA. At one of these sites, 100% TBBPA powder was repackaged from super sacks into smaller bags using a self-contained machine with dust collection (which is considered a robust engineering control) while at the other site workers transferred 100% TBBPA powder in 2,000 lb super sacks

OES	Weight of Scientific Evidence Conclusion in Occupational Inhalation Exposure Estimates
	into a reactor using a mechanism that automatically empties the super sacks after the worker unties the sack. The Agency assessed two scenarios: robust engineering controls (Scenario 1) and less robust engineering controls (Scenario 2). Refer to Section 4.1.1.2.2 for a description of the assessment method. The strengths of the assessment are as follows: 1. The data source has a high data quality rating from the systematic review process. 2. The surrogate data are TBBPA PBZ worker monitoring data that are associated with worker activities that are similar to the worker activities of the OES. The worker activities of the surrogate data involve the emptying of super sacks of TBBPA powder into other containers, which are small bags in the case of Scenario 1 and a process vessel in the case of Scenario 2. Similarly, the worker activity of the OES is emptying super sacks into a truck. 3. For Scenario 1, the surrogate data are full-shift PBZ worker monitoring data. 4. For Scenario 2, the surrogate data are task-length PBZ worker monitoring data, and the sampling duration of each sample is equal to the duration of emptying a single super sack. EPA combined these task-length PBZ worker monitoring concentrations to estimate full-shift PBZ exposure concentrations. In general, the estimation of full-shift exposure from task-length exposure monitoring data accords with standard industrial hygiene practice. In the case of the assessment of this OES specifically and as explained in Section , EPA combined the task-length concentrations based on information about the truck filling operation that occurred at Albemarle's Arkansas site, which is that a single truck is filled during a period of 4-to-5-hours, and the worker shift is 12 hours. EPA assumed 2 trucks are filled per shift at Albemarle's toll repackaging site. The limitations of the assessment are as follows: 1. The engineering controls of Scenarios 1 and 2 are not engineering controls for transferring material to a truck. In the case of Scenario 1 (robust engineering controls), the controls are engineering controls for repackaging super sacks into smaller sacks and in the case of Scenario 2 less robust engineering controls) the controls are for transferring material to a process vessel. 2. The surrogate full-shift PBZ 8-hour TWA exposure concentration in the case of Scenario1 are associated with not only emptying a super sack but also other worker activities. The duration of emptying a super sack did not exceed 40% of the sampling duration of the full-shift samples. The uncertainties of the assessment are as follows: a) EPA is uncertain about the number of trucks that are filled per day. By assuming that two trucks are filled per day, EPA likely assessed a high-end scenario because the filling of two trucks of the size that were filled at Albemarle's Magnolia, Arkansas site is likely the maximum truck filling rate in a 12-hour shift given that the time to fill a single truck is 4-to-5-hours and workers will take work breaks during the shift. b) There is great variability in the task-length worker monitoring data of Scenario 2. Excluding a concentration value of 2.6 mg/m³ with a sampling duration of 25 minutes, the range of this data are 4.2 mg/m³ to 48 mg/m and the corresponding range of sample duration is 15 minutes to 17 minutes. EPA estimated a full-shift exposure concentration from all of these data which results in uncertainty in the high-end assessed result. The assessed high-end 8-hour full-shift concentration is high compared to values reported in the literature.

OES	Weight of Scientific Evidence Conclusion in Occupational Inhalation Exposure Estimates
	Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for the assessment of workers is moderate in the case of the assessed central tendency exposures and slight for assessed high-end exposures. The weight of scientific evidence for the assessment of ONUs is slight-to-moderate due to lack of monitoring or other data about ONUs.
Recycling	For this OES, EPA identified 860 sites. EPA used PBZ air concentration data from three sources to assess inhalation exposures. EPA considered the assessment approach, the quality of the data, and the uncertainties in the assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates. The primary strength of this approach is the use of directly applicable monitoring data, which is preferable to other potential assessment approaches such as modeling or the use of OELs. EPA used three different studies (Grimes et al., 2019; Beaucham et al., 2018; Rosenberg et al., 2011) and all received ratings of high from EPA's systematic review process. These studies contained five results distributions created from 46 full-shift PBZ samples taken for workers at three facilities. The primary limitations of these data include uncertainty in the representativeness of the monitoring data in capturing the true distribution of inhalation concentrations for this OES. Additionally, the monitoring dataset did not contain ONU information, so the central tendency of worker values was used which is EPA's standard approach. Finally, EPA assumed 8 exposure hours/day and 250 exposure days/year based on continuous TBBPA exposure during each working day for a typical worker schedule. It is uncertain whether this assumption captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence is moderate for the assessment of workers and slight-to-moderate for the assessment of ONUs.
Industrial and Commercial Additive use in Electrical and Electronic Articles	For this OES, EPA used the PNOR Model (U.S. EPA, 2021b) to assess inhalation exposures. EPA considered the assessment approach, the quality of the data, and the uncertainties in the assessment results to determine a weight of scientific evidence conclusion for the inhalation exposure estimates. The strength of the model is that the total dust PNOR range was refined using the Computer and Electronic Product Manufacturing NAICS code (NAICS 334) and the resulting dataset contains 32 discrete sample data points. EPA estimated the highest expected concentration of TBBPA based on an identified product SDS (Panduit, 2017). The SDS has a medium data quality rating from the systematic review process. The primary limitations of these data include uncertainty in the representativeness of the PNOR Model in capturing the true distribution of inhalation concentrations for this OES. The PNOR model uses a OSHA CEHD dataset of PNOR measurements is not specific to TBBPA or sites confirmed to process TBBPA-containing materials. Additionally, the model assumes the percentage of TBBPA in the dust matches the mass concentration in the bulk electronic material (20%). This assumes that all workplace dust originates from the TBBPA-related activities, whereas dust may also arise from other processes and materials used at the facilities. Considering these uncertainties and that the maximum mass concentration identified from electronics products containing TBBPA is used, the estimates are likely to overestimate exposures. Additionally, the monitoring dataset did not contain ONU information,

OES	Weight of Scientific Evidence Conclusion in Occupational Inhalation Exposure Estimates
	so the central tendency of worker values was used. Finally, EPA assumed 8 exposure hours/day and 250 exposure days/year based on continuous TBBPA exposure during each working day for a typical worker schedule. It is uncertain whether this assumption captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate in the case of workers and slight-to-moderate in the case of ONUs.
Industrial and Commercial Use in Building and Construction Materials	For this OES, EPA identified a single site based on TRI data. For this OES, EPA used EPA's PNOR Model (U.S. EPA, 2021b) data for NAICS code 23 (construction of buildings; heavy and civil engineering construction; specialty trade contractors) to assess inhalation exposures. EPA considered the assessment approach, the quality of the data, and the uncertainties in the assessment results to determine a weight of scientific evidence conclusion for the inhalation exposure estimates. A strength of the assessment is that the EPA PNOR model data are total PNOR 8-hour TWA PBZ worker inhalation exposure concentration data for workers associated with NAICS code 23. Another strength is that EPA estimated the concentration of TBBPA in products to be equal to the concentration of TBBPA in ABS which is used pipes and fittings which are used in construction (ECB, 2006a). This source has a high data quality rating from the systematic review process. The limitations of the assessment are that the PNOR Model data are surrogate data and the mass fraction of TBBPA in ABS is the maximum fraction of TBBPA in a product that is possibly used in construction. The includes uncertainty about whether the PNOR Model data are applicable to worker exposure as a result of using products that contain TBBPA. Additionally, the monitoring dataset did not contain ONU information, so the central tendency of worker values was used. Finally, EPA assumed 8 exposure hours/day and 250 exposure days/year based on continuous TBBPA exposure during each working day for a typical worker schedule. It is uncertain whether this assumption captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is slight-to-moderate for workers and slight for ONUs.
Use of Powder Coatings in Electronics	For this OES, EPA used the PNOR Model (U.S. EPA, 2021b) to assess inhalation exposures. EPA considered the assessment approach, the quality of the data, and the uncertainties in the assessment results to determine a weight of scientific evidence conclusion for the inhalation exposure estimates. The strength of the model is that the total dust PNOR range was refined using three NAICS codes: 1) 334 – Computer and Electronic Product Manufacturing; 2) 335 – Electrical Equipment, Appliance, and Component Manufacturing; and 3) 336 – Transportation Equipment Manufacturing. The resulting dataset contains 301 discrete sample data points. EPA estimated the highest expected concentration of TBBPA based on information about an epoxy powder product for the electronics industry (Earthjustice, 2019). This information has high data quality rating from the systematic review process. The primary limitations of these data include uncertainty in the representativeness of the PNOR Model in capturing the true distribution of inhalation concentrations for this OES. Further, the OSHA CEHD dataset used in the PNOR Model is not specific to

OES	Weight of Scientific Evidence Conclusion in Occupational Inhalation Exposure Estimates
	TBBPA. Additionally, the monitoring dataset did not contain ONU information, so the central tendency of worker values was used. Finally, EPA assumed 8 exposure hours/day and 250 exposure days/year based on continuous TBBPA exposure during each working day for a typical worker schedule. It is uncertain whether this assumption captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate for workers and slight-to-moderate for ONUs.
Industrial Use in Plastic and Rubber Products	For this OES, EPA did not identify relevant inhalation monitoring data. Due to expected similarities in process descriptions, the Agency used surrogate monitoring data from ACC TBBPA Consortium's Group 4: Production of TBBPA-containing solids from TBBPA-containing solids. EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates. The primary strengths of these data are the use of PBZ data, the similarity in worker activities between the surrogate data and this OES, and the number of samples available for workers and ONUs. EPA identified 22 worker and 9 ONU full-shift PBZ samples from two industrial use facilities from this dataset to estimate inhalation exposures. The data source has a high data quality rating from the systematic review process. The primary limitation of the data are that these 2 sites may not be representative of all sites. Also, EPA assumed 250 exposure days/year based on TBBPA exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate to robust for both workers and ONUs.
Commercial Use in Plastic and Rubber Products	For this OES, workers are not expected to manipulate the solid articles containing TBBPA in such a way as to generate dust. Thus, worker exposures are limited to any TBBPA that may volatilize from the article or be present on the article surfaces. EPA identified one relevant source for this OES during data extraction and evaluation. These data include a total of 12 8-hour TWA area samples. Based on this data, EPA decided to not quantitatively assess worker exposures for commercial use of plastic and rubber products containing TBBPA, as the low concentrations provided by these samples are not expected to generate considerable exposure and risk to workers. Based on this information, EPA has concluded that the weight of scientific evidence for this assessment is moderate for both workers and ONUs.
Industrial and Commercial Laboratory Chemical Use	For this OES, EPA had inhalation data provided via a test order submission from the ACC, which included processors and users of TBBPA. Inhalation data from the SEG "laboratory technicians" were used in this assessment. EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates. The primary strength of these data are that they are PBZ and capture many tasks that are expected to occur in a commercial laboratory setting. There were four data points for laboratory technicians in Group 2, and five data points for laboratory technicians

OES	Weight of Scientific Evidence Conclusion in Occupational Inhalation Exposure Estimates
	in Group 3. This amounts to a total of 9 data points from 3 sites in the ACC test order data used for this OES. The data source has a high data quality rating from the systematic review process. The primary limitations include: (1) the data are for laboratory technicians in a manufacturing/processing setting, rather than a commercial setting, and so the representativeness of the dataset towards workers in a commercial setting is uncertain; and (2) the lack of data for ONUs. Additionally, EPA assumed 8 exposure hours/day and 250 exposure days/year based on continuous TBBPA exposure during each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate to robust for both workers and ONUs.
Disposal	For this OES, EPA used EPA's PNOR Model (U.S. EPA, 2021b) data for NAICS code 56 (Administrative and Support and Waste Management and Remediation Services) to assess inhalation exposures. EPA considered the assessment approach, the quality of the data, and the uncertainties in the assessment results to determine a weight of scientific evidence conclusion for the inhalation exposure estimates. A strength of the assessment is that the assessed TBBPA inhalation exposure concentrations are based on the subset of EPA's PNOR model data that consisting of total dust 8-hour TWA PBZ worker inhalation exposure concentration measurements for workers at facilities associated with various NAICS codes encompassed by NAICS code 56. These are measurements for a broadly specified group of NAICS codes and are therefore very likely to encompass values that equal total dust concentrations at facilities at which TBBPA containing wastes are disposed of. The limitations of the assessment are as follows: 1. The data of EPA's PNOR Model (U.S. EPA, 2021b) are surrogate data because these data are based on concentrations of total dust measurements made by OSHA in connection with OSHA's PEL for PNOR. 2. The assessed TBBPA 8-hour TBBPA TWA concentrations were calculated by multiplying the relevant central tendency and high-end total dust concentrations of EPA's PNOR Model (U.S. EPA, 2021b) with the greatest mass fraction of TBBPA in products containing TBBPA that are used commercially or by consumers. That is, EPA assumed dust is generated at disposal facilities as the result of the disposal of a single type of products which are those that contain TBBPA. But the dust that workers are exposed to results from the disposal of waste that contains a variety of products and not just products that contain TBBPA. 3. The assessed exposures are not applicable in the case of disposal of waste material that are generated in industrial facilities such as neat TBBPA because such wastes are contained in containers such as filter bags and EPA does not expect the disposal of such containers to result in occupational inhalation exposure to TBBPA. 4. The assessed exposures are not applicable in the case of the disposal of articles that are made using TBBPA reactively because EPA does not expect the disposal of such articles to result in worker inhalation exposure because the concentration of TBBPA in such articles is either nil or very low.

OES	Weight of Scientific Evidence Conclusion in Occupational Inhalation Exposure Estimates
	The uncertainties of the assessment are as follows: 1. There is uncertainty about the accuracy of the assessed TBBPA 8-hour TWA concentrations. 2. The monitoring dataset does not contain information about worker activities, and therefore there is uncertainty about whether the data are applicable for ONUs; accordingly, the central tendency of the dataset was used to assess ONU exposure. 3. EPA assumed 8 exposure hours/day and 250 exposure days/year based on continuous TBBPA exposure during each working day for a typical worker schedule. It is uncertain whether this assumption captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is slight to moderate for workers and slight for ONUs but the Agency has high confidence that the assessment results overestimate actual exposures, especially in the case of the high-end estimate.
ACC = American Chemistry Council; CEHD = Chemical Exposure Health Data; NAICS = North American Industry Classification System; OEL = occupational exposure limit; OES = occupational exposure scenario; ONU = occupational non-user; OSHA = Occupational Safety and Health Administration; PBZ = personal breathing zone; PNOR = particulates not otherwise regulated; SEG = similar exposure group; TWA = time-weighted average	

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4.1.5 Consumer Exposures

The following subsections describe EPA's screening approach to assess consumer exposures and summarize the results for each COU. EPA applied a screening-level evaluation because of limited information on TBBPA content in the relevant articles or products and consumer behavior patterns. In the screening assessment, upper-bound exposure scenarios were developed based on a high-end value (95th percentile or maximum, depending on data availability) of critical input parameters. These parameters are further discussed in the subsequent discussions. Refinements to the screening assessment were developed if the upper-bound exposure scenarios indicated risks. The *Draft Consumer and Indoor Dust Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026e](#)) provides additional details on the development of approaches and their results. The consumer exposure assessment evaluated inhalation, dermal, and children's mouthing exposures, when relevant, for each consumer COU.

4.1.5.1 Consumer Test Orders

Following the publication of the final scope document ([U.S. EPA, 2020b](#)), a data gap analysis of the systematic review data pool was undertaken to support the consumer assessment. Data on concentrations of TBBPA in house dust and dermal absorption characteristics were available; however, data on chemical migration to dust on article surfaces and chemical loading on the skin surface were not found. The extent to which gas-phase transfer plays a role in the chemical transfer from chemical articles to settled dust was also unknown. Having data that quantify TBBPA transfer from (1) a known source to settled dust and (2) chemical loading on the skin surface due to direct contact and migration to sweat is important for evaluating potential chemical availability for inhalation, ingestion, and dermal exposure. Because of these data gaps and the value they can add to the assessment, EPA issued a test order under section 4 of TSCA in April 2022. Recipients of the test order were required to test TBBPA migration from electrical and electronic products containing TBBPA to dust, as well as TBBPA migration from dust containing TBBPA to simulated skin and sweat. As provided in the test order, EPA required recipients to follow EPA's Exposure Testing Protocols 6 and 9 for experimental setup and EPA Method 527 for sample extraction and analysis, unless justification can be provided to use alternative methods. All test order recipients submitted a final study plan for EPA review and approval prior to commencement of testing. EPA also reviewed all testing data for quality assurance and adherence to good laboratory practices. The recipients were SolEpoxy, Inc., L3 Harris, NORDAM, and the American Chemistry Council (ACC) that represented 31 companies. Subsequent sections of this document summarize what TBBPA uses were represented by recipients of this order and how the test results were applied in this evaluation. Additional details are available in the *Draft Consumer and Indoor Dust Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026e](#)).

4.1.5.2 Summary of Consumer Exposure Scenarios and Modeling Approach and Methodology

The main steps in performing a consumer exposure assessment are summarized below:

- Identification and mapping of product and article examples following the consumer COU table (Table 1-1), product, and article identification;
- Compilation of products and articles manufacturing use instructions to determine patterns of use;
- Selection of exposure routes and exposed populations according to product/article use descriptions;
- Identification of data gaps and further search to fill gaps with studies, chemical surrogates or product and article proxies, or professional judgment;

- Selection of appropriate modeling tools based on available information and chemical properties;
- Gathering of input parameters per exposure scenario; and
- Parameterization of selected modeling tools and generation of exposure estimates for the relevant scenarios, routes, and population groups.

Consumer products or articles containing TBBPA were matched with the identified consumer COUs. Table 4-10 summarizes the consumer exposure scenarios by COU for each product example(s), the exposure routes, and whether the analysis was conducted qualitatively or quantitatively.

When a quantitative screening analysis of reasonably available information was conducted, exposure from the consumer COUs was estimated by modeling or with test order data. Exposure via inhalation and dust ingestion routes were modeled using EPA's Consumer Exposure Model (CEM) version 3.2 ([U.S. EPA, 2023a](#)). Dermal exposure was calculated using flux-limited dermal absorption approach. Refer to the *Draft Consumer Exposure Analysis and Risk Calculator for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026f](#)) for calculations and inputs and Section 2 for a description of approaches and methodologies. For all COUs, upper-bound or worst-case exposure scenarios were developed based on a high (95th percentile or maximum depending on data availability) value of critical input parameters (e.g., weight fraction, exposure frequency, duration of use, mass of product used, surface area of article, volume of use environment). Some COUs also have a low or medium exposure scenario to account for uncertainties and variations in the critical input parameters. In addition, some parameters are intentionally unrealistic to develop a health protective exposure estimate given the widespread variations and difficulties in characterizing consumer behavior patterns. See the *Draft Consumer and Indoor Dust Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026e](#)) for further details on modeling approaches, data sources, model parameterization and assumptions, methods and inputs.

Exposure via the inhalation route occurs from inhalation of TBBPA gas-phase emissions or when TBBPA partitions to suspended particulates. However, TBBPA's low volatility is expected to result in negligible gas-phase inhalation exposures. Sorption to suspended and settled dust is likely to occur based on monitoring data (summary available in Section 4 of the *Draft Consumer and Indoor Dust Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026e](#))) and its affinity for organic matter that is typically present in household dust. Thus, inhalation and ingestion of suspended and settled dust were considered. Exposure via ingestion can also occur via direct mouthing (i.e., directly putting article in mouth). Exposure via the dermal route can occur from direct contact with solid articles and from TBBPA-laden dust migrating to sweat or skin.

EPA adjusted life stages listed in CEM version 3.2 to match those listed in the U.S. Centers for Disease Control and Prevention (CDC) guidelines ([CDC, 2021](#)) and EPA's *A Framework for Assessing Health Risks of Exposures to Children* ([U.S. EPA, 2006](#)). CEM life stages are re-labeled from this point forward as follows:

- Adult (21+ years) → Adult
- Youth 2 (16–20 years) → Teenager
- Youth 1 (11–15 years) → Young teen
- Child 2 (6–10 years) → Middle childhood
- Child 1 (3–5 years) → Preschooler
- Infant 2 (1–2 years) → Toddler
- Infant 1 (<1 year) → Infant

1648 Acute exposures, which correspond to a duration of one day, were not estimated because acute toxicity
1649 of TBBPA is not expected (see the *Draft Human Health and Environmental Hazard Assessment for*
1650 *Methylethylidene)bis[2,6-dibromophenol]* (TBBPA) ([U.S. EPA, 2026t](#)). Intermediate and chronic
1651 exposure have a duration of 30 days and one year, respectively. Whether intermediate or chronic
1652 exposure estimates were modeled depends on the COU and exposure route as explained later in this
1653 section. Product and article use descriptions, consumer reviews, or professional judgment were used to
1654 estimate the number of events per day, month, or year. Whenever professional judgment was used, EPA
1655 provided a rationale and description of selected parameters.

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Table 4-10. Summary of Consumer COUs, Exposure Scenarios, and Exposure Routes

Consumer Use Category	Consumer Use Subcategory	Product/Article	Exposure Scenario and Route	Evaluated Routes				
				Inhalation	Dermal	Ingestion		
						Dust (Air)	Dust (Surface)	Mouthing
Construction, paint, electrical, and metal products	Additive flame retardant in electrical and electronic articles (<i>i.e.</i> , plastic enclosures)	Electrical and electronic articles with a plastic enclosure	Direct contact during use; Inhalation of emissions/ingestion of airborne particulate; ingestion by mouthing	QT (CEM)	QT (SH, TO)	QT (TO)	QT (TO)	QT (SH)
		Jack modules	Direct contact during use	QL	QL	QL	QL	QL
Construction, paint, electrical, and metal products	Reactive flame retardant in electrical and electronic articles (<i>e.g.</i> , printed circuit boards)	Electrical and electronic articles	Direct contact during use	QL	QL	QL	QL	QL
Construction, paint, electrical, and metal products	Reactive flame retardant in automotive and aviation articles (<i>i.e.</i> , laminate and prepreg material)	Aircraft components	Direct contact during use; inhalation of emissions/ingestion of airborne particulate	QT (CEM)	QT (SH, TO)	QT (CEM)	QT (CEM)	QL
Packaging, paper, plastic, hobby products	Plastic and rubber products	3D printing filament	Inhalation of emissions during printing/ingestion of airborne particulate	QT (CEM)	QL	QT (SH)	QT (SH)	QL
Disposal	Disposal	Land disposal of articles	Down-the-drain and releases to environmental media	QL	QL	QL	QL	QL
CEM = assessed using Consumer Exposure Model version 3.2; QL = qualitative consideration; QT = quantitative consideration; SH = assessed using model implemented in spreadsheet; TO = assessed using test order results								

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4.1.5.2.1 Inhalation and Ingestion Exposure Routes Modeling Approaches

No consumer COUs had empirical test order data for the inhalation route, thus this pathway was modeled using CEM for all COUs. Modeling was conducted for all exposure routes for the plastic and rubber products (3D printing filaments) COU. For the dust ingestion pathway, exposure was modeled for all COUs except for the Additive flame retardant in electrical and electronic articles (*i.e.*, plastic enclosures), which had test order results from ACC.

When modeling was conducted using CEM version 3.2, the model parameters were generally determined based on specific articles and products identified in this assessment. Model defaults were only used where specific information was not available. A list of some of the most important input parameters in developing scenarios for the selected modeling tools and approaches for exposure from articles and products is included below. Of these, the chemical migration rate from articles to saliva and area mouthed are important for mouthing exposure scenarios. Duration and frequency are key determinants of estimated inhalation exposure according to a sensitivity analysis conducted for CEM version 3.2 ([U.S. EPA, 2023a](#)), which included the following:

- weight fraction;
- density;
- duration of use;
- frequency of use;
- article surface area;
- chemical migration rate to saliva;
- area mouthed; and
- use environment volume.

Section 2.3 of the *Draft Consumer and Indoor Dust Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026e](#)) details these parameters and their inputs. Calculations, sources, input parameters and results are also available in *Draft Consumer Exposure Analysis and Risk Calculator for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026f](#)).

For all COUs, an upper-bound or worst-case exposure scenario was developed based on a high (95th percentile or maximum, depending on data availability) value of critical input parameters (*e.g.*, weight fraction, exposure frequency, duration of use, mass of product used, surface area of article, volume of use environment). Upper-bound exposure scenarios were also developed for scenarios that had test order data using maximum concentrations and assuming no dilution in dust concentrations over time. Some COUs also have a low or medium exposure scenario to account for uncertainties and variations in the critical input parameters. In addition, some parameters are intentionally unrealistic to develop a health protective exposure estimate given the widespread variations and difficulties in characterizing consumer behavior patterns. The inputs that were varied for the various intensity use scenarios depended on the route and available data. Not all inputs are applicable to every route and scenario, such as the chemical migration rate from solid to saliva being only applicable to mouthing exposure. See Section 2.1 for weight fraction selection and Section 2.3 for parameterization details in the *Draft Consumer and Indoor Dust Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026e](#)).

4.1.5.2.2 Dermal Exposure Routes Modeling Approaches

For the reactive flame retardant in automotive and aviation articles (*i.e.*, laminate and prepreg material) COU, EPA incorporated empirical data from NORDAM's test order results. Specifically, EPA estimated dermal exposure from direct contact with a solid article, or aircraft components in this COU.

For the Additive flame retardant in electrical and electronic articles (*i.e.*, plastic enclosures) COU, EPA integrated both test order data from ACC and modeled data. ACC's test order data characterized migration of TBBPA from dust-containing TBBPA to simulated sweat. EPA also modeled dermal exposure from direct contact with the solid article, or electrical and electronic articles in this COU. For the Plastics and rubber products (*i.e.*, 3D printing filament COU), EPA had no test order data and modeled dermal exposure. EPA considered the rate of transport of TBBPA across the dermal barrier to be flux limited. Briefly, the physical and chemical properties of TBBPA (high molecular weight, large size, and low water solubility) impede its ability to cross the dermal barrier. Dermal flux values were modeled for solid articles using Equation 3.2 and 3.3 from the *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part E: Supplemental Guidance for Dermal Risk Assessment)* (U.S. EPA, 2004). These equations characterize the dermal uptake of aqueous organic compounds. Specifically, they estimate the dermally absorbed dose (DA_{event} in mg/cm^2) for an absorption event occurring over a defined duration based upon article or product use. An important parameter of these equations is the aqueous permeability coefficient that was informed by empirical data generated through test orders (Charles River Laboratories, 2024). Details on equations and inputs are available in Sections 2.3.1.3 of the *Draft Consumer and Indoor Dust Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* (U.S. EPA, 2026e) and the *Draft Consumer Exposure Analysis and Risk Calculator for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* (U.S. EPA, 2026f). See Section 4.1.5.4 of this document for a discussion of limitations, strengths, and confidence in this approach.

4.1.5.3 Dose Results by Consumer COUs

This section summarizes the dose estimates from inhalation, ingestion, and dermal exposure to TBBPA in consumer products and articles. Exposure via the inhalation route occurs from inhalation of TBBPA gas-phase emissions (though expected to be limited because of the low vapor pressure) or when TBBPA partitions to suspended particulate from direct use of products and articles. Exposure via the dermal route occurs from direct contact with products and articles or when TBBPA migrates from dust to sweat. Exposure via ingestion depends on the product or article use patterns. It can occur via ingestion of suspended and/or settled dust when TBBPA migrates from a product or article to dust or partitions from gas-phase to dust. Oral exposure to TBBPA can also occur through direct mouthing, which primarily pertains to children directly putting electrical toys with a plastic enclosure in the mouth. The mouthing duration for this exposure pathway is based on plastic toys that may or may not include the electrical toys in the assessment. Although electrical toys are not designed for mouthing, the ubiquity of TBBPA in the plastic enclosure and children's propensity to mouth items makes this a possible exposure pathway. Overall, EPA expects the doses calculated for mouthing to be overestimated because the mouthing duration of electrical toys is expected to be lower than that of non-electrical toys.

Acute exposure was not evaluated because acute toxicity of TBBPA is not expected (see the *Draft Human Health and Environmental Hazard Assessment for Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* (U.S. EPA, 2026t)). Intermediate exposures were not estimated for TBBPA's Additive use in electrical and electronic articles and 3D filament. For these scenarios, EPA assumed daily use throughout the year; chronic values are thus expected to adequately capture intermediate exposure. For TBBPA exposure through aircraft components, both intermediate and chronic exposures were assessed under the low and high intensity use scenarios. A small single-engine aircraft was selected

to characterize the low-intensity use scenario, and the world's largest jet represented high intensity. While the volume of the use environment and interior surface area varied substantially between the two scenarios, there were minimal differences in exposure estimates. This is potentially because of the high air exchange rate of the aircraft (10 exchanges per hour in the plane compared to 0.45 in a household from CEM's defaults). As such, results for the low-intensity use scenario will not be further discussed. Detailed tables of the dose results for intermediate and chronic exposures are available in the *Draft Consumer Exposure Analysis and Risk Calculator for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026f](#)).

Intermediate and chronic doses varied across scenarios, lifestages, and exposure routes by orders of magnitude. Inhalation led to the highest exposure among all routes across all COUs, followed by mouthing, dust ingestion, and then dermal. It is important to note that mouthing doses are expected to be overestimated because the mouthing duration is for plastic toys that may or may not be electrical. Across all COUs, exposure estimates ranged from 2.42×10^{-3} to 3.89×10^{-2} mg/kg-day for inhalation, 2.33×10^{-4} to 1.75×10^{-3} mg/kg-day for mouthing, 7.19×10^{-5} to 3.84×10^{-3} mg/kg-day for dust ingestion, and 2.06×10^{-6} to 2.06×10^{-3} for dermal. In general, exposure estimates were highest for children, followed by youth and then adults. Key differences in exposures among lifestages include designation as product user or bystander (only applicable to 3D printing filament under the Plastic and rubber products COU), behavioral differences such as mouthing durations, physiological differences such as skin surface area, inhalation rates, dust ingestion rates, and body weights.

Exposure estimates by COUs are also important to highlight because some scenarios incorporated overly protective, if not unrealistic, assumptions in the screening-level evaluation. For TBBPA's additive use in electronics and electrical articles, EPA equated the cumulative surface area of all electronics and electrical articles in a household to the entire floor surface area of a median home (2,561 ft or 52 85-inch televisions [TVs]). This assumption was made because of TBBPA's widespread use in the plastic enclosure of electronics and electrical articles. This includes computers, mobile phones, TVs, refrigerators, printers, laptops, computer monitors, tablets, electric toothbrushes, hair straighteners, audio and video devices, keyboards, small kitchen appliances (e.g., microwaves, toasters), or garden tools ([NICNAS, 2020](#); [e.V., 2019](#); [TERA, 2015](#)). A comprehensive list of articles containing TBBPA is unavailable to narrow the scope of this assessment. Additionally, the number and types of electronics in a household are both ubiquitous and highly variable. For these reasons, EPA intentionally selected a surface area exceeding reasonable expectations to avoid underestimating exposure. Exposure estimates even with this improbable assumption were still low across all exposure routes, ranging from 1.27×10^{-4} to 2.13×10^{-2} mg/kg-day. Refinements were conducted if this screening assessment indicated risks.

For the aircraft scenarios, EPA assessed consumer exposure according to flight durations for cabin crew members and limits established by the Federal Aviation Administration (FAA). Cabin crew flying patterns were used because no data were available to represent the overall consumer population. However, cabin crew flight times are expected to encompass those of non-crew members. The part-time activity pattern in CEM version 3.2 is the proxy for flight duration. It assumed an individual can reside in the home for up to 14 hours. In the exposure to aircraft components scenario, where the airplane is the home, that translates to a 14-hour flight with 10 hours outside of the home or plane. In between flights longer than nine hours, FAA requires a rest time of at least 11 hours (14 CFR 121.471 and 40 CFR 91.1059), which is close to 10 hours. Because CEM version 3.2 does not have any activity patterns with fewer hours in the house (aircraft in this case), EPA considered this as the most reasonable representation. EPA further assumed that cabin crew members will accrue FAA's limit on monthly or annual flying hours consecutively. This scenario borders on unrealistic because of the extensive flying hours in a short period: 100 hours in 7.1 days for intermediate and 1,000 hours in 100 days for chronic

scenarios. Nonetheless, it consolidates exposure to characterize an upper bound of exposure for both crew members and the non-occupational flying public. Exposure estimates were still low across all exposure routes and durations (2.28×10^{-7} to 9.36×10^{-3} mg/kg-day for intermediate and 2.63×10^{-7} to 3.89×10^{-3} mg/kg-day for chronic). Refinements were conducted if this screening assessment indicated risks.

4.1.5.4 Weight of Scientific Evidence Conclusions for Consumer Exposure

Key sources of uncertainty for evaluating exposure to TBBPA in consumer goods and strategies to address those uncertainties are described in detail in Section 6 of the *Draft Consumer and Indoor Dust Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026e](#)). Generally, designation of robust confidence suggests that the supporting scientific evidence weighted against the uncertainties is adequate to characterize exposure assessments. The supporting weight of scientific evidence outweighs the uncertainties to the point where it is unlikely that the uncertainties could have a significant effect on the exposure estimate. The designation of moderate confidence suggests that the supporting evidence weighed against the uncertainties is reasonably adequate to characterize exposure assessments. The designation of slight confidence is assigned when the weight of scientific evidence may (1) not be adequate to characterize the scenario, and (2) there are additional uncertainties that may need to, but cannot, be considered in the absence of complete information. The designation of slight to moderate confidence suggests that some aspects of the analysis are reasonably adequate but other aspects are not adequate or well understood. The overall confidence to use the results for risk characterization ranges from slight to robust depending on the COU and exposure route.

The exposure assessment of chemicals from consumer products and articles has inherent challenges due to many sources of uncertainty in the analysis, including variations in product formulation, patterns of consumer use, frequency, and duration. The following subsections describe the sources of uncertainty for several parameters that apply across COUs, as well as the strengths and limitations. Table 4-11 summarizes the overall confidence per COU and a discussion of rationale used to assign overall confidence.

Product Formulation and Composition

Variability in the formulation of consumer products, including changes in ingredients, concentrations, and chemical forms can introduce uncertainty. In the consumer assessment, EPA has robust confidence in the data on weight fractions. They were obtained from material safety data sheets for 3D printing filaments and from test orders for articles. For 3D filaments, the highest weight fraction on each of the two available material safety data sheets was assessed to create a medium- and high-intensity scenario. EPA decreased uncertainty in exposure and subsequent risk estimates in the medium- and high-intensity use scenarios by capturing the weight fraction variability and better characterizing the varying composition of products and articles within one COU.

Article or Product Use Patterns

Consumer use patterns such as frequency of use, duration of use, and skin contact area are expected to differ. For all the assessed COUs, EPA incorporated multiple protective assumptions for use in a screening-level analysis. These assumptions, such as 3D printing occurring 365 days a year or crew members accruing FAA's monthly and annual limits consecutively (14 CFR 121.471 and 40 CFR 91.1059) may not represent typical consumer use frequencies. However, accurately capturing a representative distribution of use patterns for these COUs is complicated because printing and flying frequency or durations can vary widely for the assessed populations. As a result, confidence in the use

patterns for modeling is moderate though expected to characterize the upper bound, if not worst-case exposure scenario.

Article Surface Area

The surface area of an article directly affects the potential for TBBPA emissions to the environment. For electrical and electronics articles with plastic enclosure, EPA relied on manufacturer-provided dimensions for TVs across multiple retailers. Overall confidence in surface area of a single TV is robust because these items are relatively standardized in size, and there is a good understanding of their presence and dimensions in indoor environments. However, for the inhalation screening assessment, EPA assumed that the entire floor surface area of a house is covered with a TV. This is to ensure exposure is not underestimated given the prevalence of electronics and electrical articles in a household and the absence of a comprehensive list of all articles containing TBBPA. Confidence in the cumulative surface area is slight because it is unrealistic, albeit protective. Even in this improbable scenario, exposure estimates are low.

Human Behavior

CEM version 3.2 has three different activity patterns: stay-at-home, part-time out-of-the home (daycare, school, or work), and full-time out-of-the-home. The activity patterns were developed based on the Consolidated Human Activity Database. For all products and articles modeled, the stay-at-home or part-time activity pattern was chosen as it is the most protective assumption.

Mouthing durations are a source of uncertainty in human behavior. The data used in this assessment were based on a study in which parents observed children (n = 236) ages one month to five years of age for 15 minutes each session and 20 sessions in total ([Smith and Norris, 2003](#)). There was considerable variability in the data due to behavioral differences among children of the same lifestage. For instance, while children aged six to nine months had the highest average mouthing duration for toys at 39 minutes per day, the minimum duration was zero and the maximum was 227 minutes per day. The observers noted that the items mouthed were made of plastic roughly 50% of the mouthing time. In another study, 169 children aged three months to three years were monitored by trained observers for 12 sessions at 12 minutes each ([Greene, 2002](#)). They reported mean mouthing durations ranging from 0.8 to 1.3 minutes per day for soft plastic toys and 3.8 to 4.4 minutes per day for other soft plastic objects (except pacifiers). EPA assigned a moderate confidence associated with the duration of activity for mouthing because the magnitude of the overestimation is not well characterized. Confidence is also not robust because the mouthing items in the above studies may not represent electrical toys with a plastic enclosure containing TBBPA.

All other human behavior parameters are well understood, or the ranges used capture use patterns representative of various life stages, which results in a robust confidence in use patterns.

Inhalation and Ingestion Modeling Tool

Confidence in the modeling tools considers whether the model has been peer reviewed and whether they are being applied in a manner appropriate to its design and objective. The models used (CEM version 3.2) have been peer-reviewed, are publicly available, and have been applied in their intended manner to estimate exposures associated with uses of household products and/or articles. Default inputs such as building and room volumes, interzonal ventilation rates, and air exchange rates were also used when appropriate. Overall confidence in the proper use of CEM version 3.2 for consumer exposure modeling is robust. In the case of 3D printing, actual emissions during printing could not be found from experimental sources. CEM's product emission model best fits the scenario. The resulting masses emitted during the events are up to a gram, indicating a high-end scenario. Therefore, the confidence in

the emissions is moderate. For modeling done outside of CEM (dermal and mouthing exposure), the underlying methodologies were based on recommendations in a peer-reviewed EPA document, the *Risk Assessment Guidance for Superfund Part E* ([U.S. EPA, 2004](#)). As such, these were also considered robust.

Dermal Modeling for TBBPA

EPA used an assumption of aqueous absorption for modeling direct contact with electrical and electronic articles with a plastic enclosure and aircraft components. This equation requires estimation of the effect of the stratum corneum, the permeability coefficient, the solubility, and the lag time (the time it takes TBBPA to penetrate the stratum corneum). The lag time and effect of the stratum corneum were both estimated using established empirical relationships based on the molecular weight of TBBPA. EPA has moderate confidence in the inputs for these variables. TBBPA is weakly soluble, although the solubility increases with increased pH. Human sweat is slightly acidic rather than basic, so the solubility is expected to provide an accurate estimate for human sweat. For the permeability coefficient, EPA used data from test orders ([Charles River Laboratories, 2024](#)). In the fractional absorption dose experiments, the fraction absorbed was small, suggesting the chemical can be characterized as a flux limited chemical. This is further supported by TBBPA's high molecular weight and high lag time in the stratum corneum. The data from the flux-based dose experiments were used to estimate a permeability coefficient under aqueous absorption conditions for an unoccluded scenario. EPA believes this suits the modeled scenario and has moderate confidence in the permeability coefficient.

Taken together, EPA has moderate confidence in the equation used and its inputs, resulting overall in moderate confidence in the dermal absorption values. However, the scenario was designed to be a screening-level, upper-bound exposure characterization due to the high event durations and frequencies assumed. Thus, EPA has robust confidence that risk numbers generated from these exposure estimates capture the range of potential dermal risks.

Ingestion Via Mouthing Modeling Parameters for TBBPA Chemical Migration

For chemical migration rates from article to saliva, no empirical data were identified during systematic review. A theoretical framework based on physical and chemical properties of TBBPA and the article's solid matrix material was used to estimate chemical migration rates in the absence of empirical data. This model was internally and externally validated against measured diffusion coefficients and shown to have good predictive capability for chemicals with molecular weights between 30 and 1,178 g/mol at temperatures between 4 and 180 °C ([Aurisano et al., 2022](#)), which are well within TBBPA properties and temperatures during article use. There are uncertainties in the estimated chemical migration rate because it may differ among items due to variations in chemical makeup and matrix structure. EPA has moderate confidence in the chemical migration rate value. Confidence in the overall modeling approach is moderate when balancing the moderate confidence in the mouthing durations and other modeling inputs.

1934 Table 4-11. Weight of Scientific Evidence Summary per Consumer COU

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
Construction, paint, electrical, and metal products; Additive flame retardant in electrical and electronic articles (<i>i.e.</i> , plastic enclosures)	One scenario was assessed for all electrical and electronic articles with a plastic enclosure. Inhalation exposure was modeled using CEM. The confidence in the weight fraction for CEM modeling is robust because they were informed by test orders issued to ACC. Confidence in surface area available for chemical emissions is slight because EPA does not expect the floor surface area of an entire house to be covered with TVs. This selection is appropriate for a screening analysis. Parameters related to the use environment and consumer patterns have robust confidence because they are informed by CEM defaults. The overall confidence in the precision of this COU's inhalation exposure estimate is slight because of the inclusion of one unrealistic assumption on article surface area, which is an important input for this scenario. However, confidence is robust that exposure is not underestimated. For dust ingestion, EPA has robust confidence that the exposure estimates are representative of consumer exposure. The source of TBBPA concentrations in indoor dust is ACC test order data, which are measured and directly relevant to the COU. The experimental design and results were all reviewed and approved by EPA for quality assurance and relevance to consumer exposure. Dust ingestion rates are also informed by peer-reviewed literature or EPA's <i>Exposure Factors Handbook</i>. For mouthing, EPA has moderate confidence that the exposure estimates are protective because of uncertainties in how relevant the mouthing durations are to the electrical toys with a plastic enclosure containing TBBPA. For dermal exposure, EPA used an assumption of chemical dissolving in a thin layer of sweat and that aqueous portion being available for absorption. This equation will tend to overestimate exposure by assuming the full amount of chemical in the layer is absorbed, although it does assume a flux limited absorption by incorporating a permeability coefficient. The confidence in the equation used is moderate. The confidence in the estimated permeability coefficient is robust, as the estimate comes from test order data under conditions similar to the expected consumer exposure scenario. Confidence in the estimated lag time, solubility, and the effect of the stratum corneum is moderate. Taken together, the overall confidence in the dermal estimates in this screening scenario is moderate.	Inhalation – Robust confidence that the screening analysis is protective Dust Ingestion – Robust Ingestion through Mouthing – Moderate Dermal – Moderate
Construction, paint, electrical, and metal products; Reactive flame retardant in automotive and aviation articles (<i>i.e.</i> , laminate and prepreg material)	One scenario was assessed under this COU that is expected to cover consumer exposure to aircraft components containing TBBPA (<i>i.e.</i> , cabin windows and interior paneling). The confidence in the weight fraction is moderate because they were informed by test orders issued to NORDAM. It is not robust because EPA intentionally used the weight fraction in the starting prepreg rather than the weight fraction in the final bonded composite. The weight fraction in the final composite is three orders of magnitude lower than in the starting material but was selected for a screening assessment. Confidence in the air exchange rates and aircraft sizes is robust because they were reported by	Inhalation – Moderate

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
	regulatory agencies, global leader in indoor air quality standards, and aircraft manufacturers. Confidence in the behavior patterns is moderate because EPA expects cabin crew members to rest more than 10 hours in between flights. As such, they likely need more than the 7.1 or 100 days parameterized in CEM to accrue their monthly or annual limit of 100 and 1,400 hours, respectively. However, this selection is appropriate for a screening analysis. The overall confidence in this COU's inhalation exposure estimate is moderate when considering all inputs and parameters. The ingestion estimates are based on CEM estimates that calculate both dust and air concentrations, as with inhalation. Given that inhalation is moderate, the overall ingestion confidence is also moderate. For dermal exposure, EPA used test order results on characterizing TBBPA migration from solid article to surrogate skin. The chemical load on the skin was assumed to be 100% absorbed and bioavailable. This will overestimate dermal exposure because multiple factors like the skin barrier and the TBBPA's chemical characteristics (e.g., large size) will likely reduce absorption. While this assumption of full absorption lowers confidence in the dermal exposure estimates, it is also balanced by using empirical data from test orders. Taken together, the overall confidence in the dermal estimates in this screening scenario is moderate.	Ingestion – Moderate Dermal – Moderate
Packaging, paper, plastic, hobby products; Plastic and rubber products	One scenario was assessed under this COU – 3D printing filament. The confidence in the weight fractions is robust because they were informed by material safety data sheets. Confidence in mass of product/event and duration of product use/event is moderate because the inputs can vary widely based on project specifications, and no human use pattern surveys exist; however, the inputs were calculated based on printing a realistic object for the 3D printing filament type and similar printing times were observed on multiple 3D printing discussion forums. The confidence in the emission model used is moderate as actual emissions from printing could not be found from experimental sources. Thus, the emissions from the CEM model selected could not be ground truthed. Confidence is reduced overall due to the lack of experimental data to confirm if/how much TBBPA decomposes during the printing process, which would lower exposure levels for all routes. The overall confidence in this COU's inhalation exposure estimate when considering it as a screening, worst-case scenario is moderate when considering all inputs and parameters. For ingestion exposure, a partition coefficient method was used. The very large octanol/air partition coefficient estimated with EPI Suite™ results in a very large dust-air partition coefficient, while estimating a dust-air partition coefficient using CEM results in a coefficient 6 orders of magnitude lower. Confidence in both of these estimates is slight because the very large octanol/water coefficient may mean the equations and model are not yielding physically plausible results.	Inhalation – Moderate Dust ingestion – Moderate

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
	Instead, EPA used an empirical dust-air partition coefficient. The coefficient was calculated from only 2 data points in a single study that measured simultaneous vapor and dust concentrations. However, using this partition coefficient results in physically plausible dust concentrations, and to ground truth the value, EPA noted that the ratio of the inhalation to ingestion doses is similar across all scenarios when assuming the empirical dust-air partition coefficient. The confidence in the empirical estimate and resulting ingestion doses are considered moderate.	

4.1.6 General Population Exposures

General population exposures occur when TBBPA is released into the environment, and the environmental media becomes a pathway for exposure. As described in the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)) and summarized in Table 4-12 releases of TBBPA are expected to occur to air, water, and land. Figure 4-1 provides a graphic representation of where and in which media TBBPA is estimated to be found due to environmental releases and the corresponding route of exposure.

EPA began its TBBPA general exposure assessment using a screening-level approach that relies on health-protective assumptions. Conservative assumptions help characterize exposure resulting from the high-end of the expected distribution. All but one of the COUs (*i.e.*, Electrical and electronics waste recycling) presented in Table 1-1 report facility location data and releases in TRI. When facility location- or scenario-specific information was unavailable, EPA used generic EPA models and default input parameter values as described in the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)). Details on the use of screening-level analyses in exposure assessment can be found in the *Guidelines for Human Exposure Assessment* ([U.S. EPA, 2019b](#)).

EPA considered a subset of the general population living near facilities releasing TBBPA to the ambient air, which includes fenceline communities, as part of the ambient air exposure assessment. EPA used a prescreening methodology described in EPA's *Draft TSCA Screening Level Approach for Assessing Ambient Air and Water Exposures to Fenceline Communities (Version 1.0)* ([U.S. EPA, 2022c](#)) for the ambient air exposure risk assessment. For other exposure pathways, EPA's screening method assessing high-end exposure scenarios used release data that reflect exposures expected to occur in proximity to releasing facilities, which include fenceline populations.

EPA evaluated the reasonably available information for releases of TBBPA from facilities that use, manufacture, or process TBBPA under industrial and/or commercial COUs subject to TSCA regulations detailed in the *Draft Release Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)). As described in Section 3.3, using the release data, EPA modeled predicted concentrations of TBBPA in surface water, sediment, drinking water, and ambient air in the United States. Section 3.3 summarizes the high-end TBBPA concentrations in environmental media from environmental releases. The reasoning for assessing different pathways qualitatively or quantitatively is discussed briefly in the subsequent subsections, and additional details can be found in the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)).

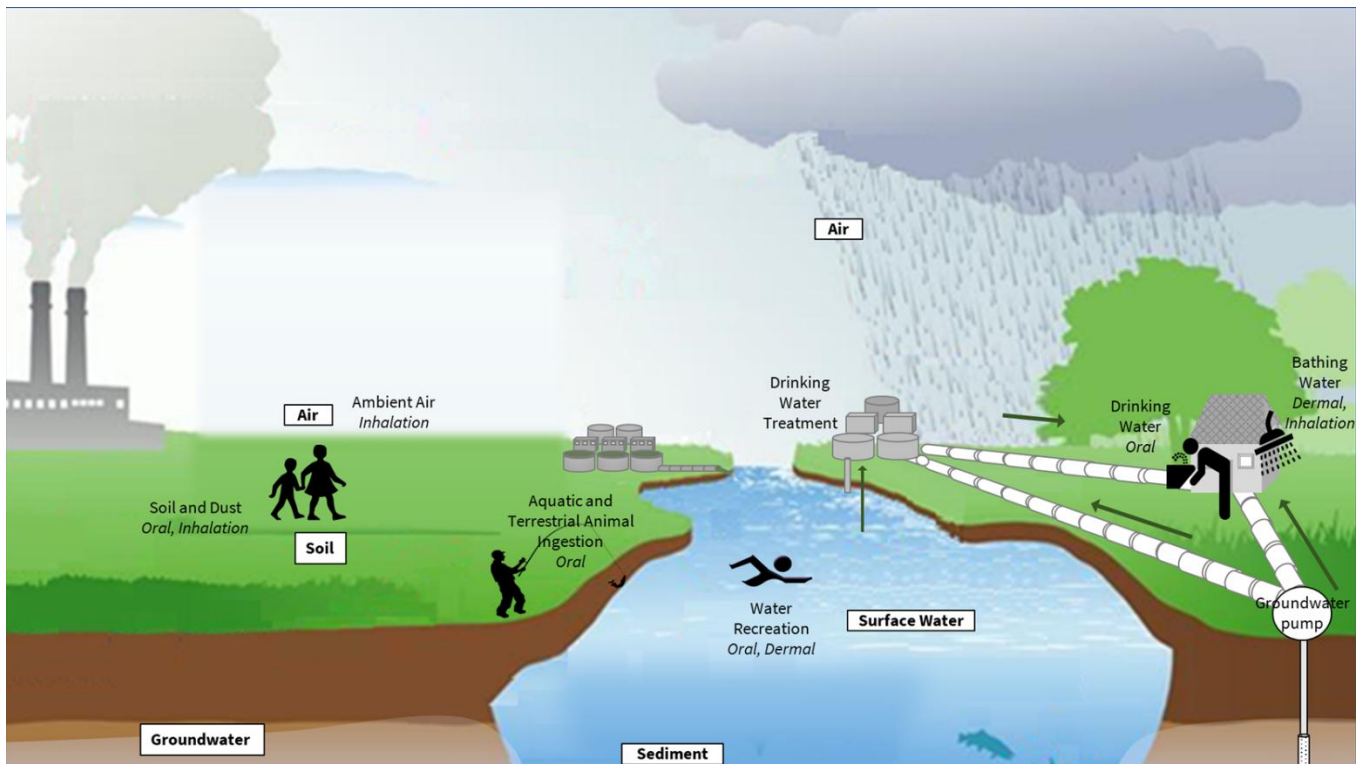


Figure 4-1. Potential Human Exposure Pathways to TBBPA for the General Population
Potential routes of exposure are shown in italics under each potential pathway of exposure

4.1.6.1 Summary of General Population Exposure Scenarios

For a screening-level analysis, upper-bound exposures were estimated for each assessed exposure pathway. EPA's *Guidelines for Human Exposure Assessment* defines upper-bound exposure estimates as a "plausible estimate of individual exposure for those individuals at the upper end of an exposure distribution, the intent of which is to convey an estimate of exposure in the upper range of the distribution while avoiding estimates that are beyond the true distribution" ([U.S. EPA, 2019b](#)). EPA also considered fenceline populations in proximity to releasing facilities as part of the ambient air exposure assessment by using prescreening methodology described in EPA's *Draft TSCA Screening Level Approach for Assessing Ambient Air and Water Exposures to Fenceline Communities (Version 1.0)* ([U.S. EPA, 2022c](#)). For other exposure pathways, EPA's screening method assessing high-end exposure scenarios used release data that reflect exposures expected to occur in proximity to releasing facilities, which would include fenceline populations.

Table 4-12 summarizes the upper-bound exposure scenarios that were considered in the screening-level analysis including the life stages assessed as the highest exposed populations based on intake rate and body weight. Exposure scenarios were assessed quantitatively only when environmental media concentrations were quantified for the appropriate exposure scenario. Because TBBPA environmental releases from landfills and landfill leachate (and therefore, resulting groundwater concentrations) were not quantified, oral exposure from groundwater resulting from TBBPA release to the environment via landfill leachate was not quantitatively assessed. However, the scenarios were assessed qualitatively for exposures potentially resulting from landfills. Additionally, the assessment focused solely on scenarios leading to intermediate and chronic exposure because acute toxicity of TBBPA is not expected ([U.S. EPA, 2026t](#)).

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Table 4-12. Exposure Scenarios Assessed in General Population Screening-Level Analyses

COU	Exposure Pathway	Exposure Route	Exposure Scenario	Lifestage	Analysis (Quantitative or Qualitative)
All	Biosolids	No specific exposure scenarios were assessed for qualitative assessments			Qualitative
All	Landfills	No specific exposure scenarios were assessed for qualitative assessments			Qualitative
All	Surface water	No specific exposure scenarios were assessed for qualitative assessments			Qualitative
- Processing – As a reactant – Flame retardant in plastic material and resin manufacturing - Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; paint and coating manufacturing - Disposal	Drinking water	Oral	Ingestion of drinking water	Adult, youth, and children	Quantitative
	Fish ingestion	Oral	Ingestion of fish for tribal populations	Adult	Quantitative
- Manufacture – Domestic manufacture - Processing – As a reactant – Flame retardant in plastic material and resin manufacturing - Processing – As a reactant – Intermediate in all other chemical product and preparation manufacturing - Processing – Incorporation into formulation, mixture, or reaction product – flame retardant in plastic material and resin manufacturing; plastics product manufacturing; custom compounding of purchased resins; paint and coating manufacturing - Processing – incorporation into formulation, mixture, or reaction product – Adhesive manufacturing - Processing – Incorporation into article – Reactive flame retardant in computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., printed circuit boards and semiconductor packages) - Processing – Incorporation into article – Reactive flame retardant in transportation equipment manufacturing (e.g., interior material for automotive and aviation articles) - Processing – Incorporation into article – Additive flame retardant in computer and	Ambient air	Inhalation	Inhalation of ambient air concentration for general population	Adult, youth, and children	Quantitative
		Oral	Soil ingestion from air deposition for general population	Children	Quantitative

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COU	Exposure Pathway	Exposure Route	Exposure Scenario	Lifestage	Analysis (Quantitative or Qualitative)
electronic product manufacturing; electrical equipment, appliance, and component manufacturing; plastic product manufacturing (e.g., plastic electronic enclosures) - Industrial and commercial use – Construction, paint, electrical, and metal products – Reactive flame retardant in automotive and aviation articles (i.e., laminate and prepreg material) - Disposal - Electrical and electronics recycling					
All	Human milk	Oral	Human milk ingestion for general population	Infants (<1 year old)	Quantitative

4.1.6.2 Land Pathway

As described in the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)), EPA searched peer-reviewed literature, gray literature, and databases of environmental monitoring data identified during systematic review to obtain concentrations of TBBPA in terrestrial land pathways (i.e., biosolids, wastewater sludge, agricultural soils, landfills, and landfill leachate). No monitoring data were available from a review of government regulatory and reporting databases related to soil, landfills, or biosolids (e.g., California Environmental Data Exchange Network [CEDEN], Water Quality Portal [WQP]).

Additionally, EPA does not have any facility specific TBBPA release data since facilities do not report releases of TBBPA to the terrestrial environment from COUs. As such, EPA assessed TBBPA exposure via potential land pathways qualitatively, relying on the fate and physical-chemical characteristics of TBBPA. When possible, data from the existing literature including experimental and field data were used to support the qualitative assessment detailed in the *Draft Environmental Media, General Population, Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)).

Table 4-13. TBBPA Terrestrial TRI Release Data

Receiving Pathway	Annual Release (kg/yr)	Low Daily Release (kg/day)	High Daily Release (kg/day)
RCRA Subtitle C surface impoundments	No submissions	0	0
Land/agricultural application	No submissions	0	0
Other land disposal	0–45	0–12.4	0–23
RCRA Subtitle C landfill	417–48,844	1.1–134	209–24,422
Other landfills	0–82,231	0–226	0–14,161
Other surface impoundments	No submissions	0	0
Transfer to off-site location	1,332–56,065	3.7–154	666–28,032
Discharge to POTW	0–7.7	0–0.02	0–4

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Receiving Pathway	Annual Release (kg/yr)	Low Daily Release (kg/day)	High Daily Release (kg/day)
POTW = publicly owned treatment work; RCRA = Resource Conservation and Recovery Act			

No TRI submissions reported the land disposal, surface impoundment, or land application of TBBPA to the terrestrial environments. As such, the discussion of biosolids relies on estimates of TBBPA in wastewater sludges reported in literature. TBBPA is regularly deposited into landfills. Annually, 417 to 48,844 kg is deposited into the Resource Conservation and Recovery Act (RCRA) Subtitle C landfills while an additional 0 to 82,231 kg has been deposited into other landfills between 2014 and 2023 ([U.S. EPA, 2026q](#)).

Land Pathway – Biosolids

There are data regarding the concentration of TBBPA in wastewater solids, but limited information is available related to the treatment capacity for the removal of TBBPA from wastewater sludge through the application of sludge stabilization. Additionally, there is uncertainty in the relevancy of the biosolids monitoring data to the COUs considered in this evaluation.

Details of the sources of TBBPA in biosolids, land application practices of biosolids, and monitoring data on TBBPA concentration in biosolids are described in the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)). Overall, TBBPA is not expected to pose significant exposure potential from the land application of biosolids. Current TRI release data suggest TBBPA is not being actively and knowingly applied to agricultural, residential, or public lands. Although TBBPA may be present in wastewater sludge, current sludge stabilization technologies required for the land application of biosolids significantly reduce the mass of TBBPA incorporated into final biosolids. Applied TBBPA is expected to be readily degradable in aerobic and anaerobic soils. TBBPA is not expected to accumulate in applied soils if aerobic conditions are maintained and reapplication is limited to the recommended guidelines. Anaerobic soils may pose a greater likelihood to TBBPA accumulation if applied in extreme cases. However, most of the available data suggest anaerobic biodegradation will occur at comparable rates to aerobic conditions and pose a low likelihood of accumulation with reapplication. Some exposure may occur from the mechanical transport of TBBPA through atmospheric uplift or runoff conveyance; however, the extent of exposure is unknown with the limited data available and no reported TRI land applications of TBBPA. Finally, land application of TBBPA may result in crop uptake of TBBPA during the growing process. However, the extent of exposure is unknown due to the limited reporting data and extent of surveyed literature. There is no evidence to suggest that TBBPA will accumulate in exposed organisms resulting from the direct application of TBBPA through biosolids applied in fertilizers.

Land Pathway – Landfills

Landfills are a potential source of chemicals in the environment. TBBPA may be deposited into landfills through various waste streams: consumer waste, residential waste, industrial waste, electronic waste (e-waste), and municipal waste including dewatered wastewater biosolids or non-recyclable plastics from e-waste recycling operations. Details of the sources of TBBPA in landfills, behavior of TBBPA in the various zones of a landfill (daily cell, upper landfill, and lower landfill), and landfill leachate monitoring data are described in the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)).

In general, there is uncertainty in the relevancy of the landfill leachate monitoring data to the COUs considered in the evaluation. Based on the biodegradation data for conditions relevant to landfills, there

is high confidence that TBBPA will not be persistent in landfills. TBBPA in the exposed sections of a landfill may pose some exposure potential due to mechanical transport processes, which may result in TBBPA's conveyance to surrounding areas through atmospheric and stormwater runoff conveyance. Overall, due to high-quality physical and chemical property data, there is robust confidence that TBBPA is likely to readily degrade in the landfill and not be persistent. TBBPA may be present in landfill leachate but is not likely to be persistent with appropriate leachate capture and treatment systems with high removal rates in treated leachate. Any uncaptured leachate is not expected to mobilize TBBPA due to its physical and chemical characteristics causing it to bind strongly to the soil particulate.

4.1.6.3 Surface Water Pathway

As discussed in the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)), concentrations of TBBPA in surface water can lead to different exposure scenarios including dermal exposure or incidental ingestion exposure to the general population swimming in affected waters. Additionally, surface water concentrations may impact drinking water exposure and fish ingestion exposure. Incidental ingestion and dermal contact from swimming is discussed qualitatively below while drinking water exposure is quantitatively assessed using surface water concentrations presented in Section 3.3.

Incidental Ingestion and Dermal Contact from Swimming

Incidental oral or dermal exposures due to swimming is not quantitatively evaluated because acute toxicity of TBBPA pertaining to an exposure duration of one day is not expected ([U.S. EPA, 2026t](#)). For chronic exposures, EPA acknowledges that some populations may swim in or access open bodies of water (e.g., rivers and lakes) regularly in warmer climates or intermittently during the warm seasons. However, EPA expects only limited exposure through incidental exposure to surface water. Intake from drinking water quantified below is higher than incidental exposure to surface water and therefore is expected to be inclusive of a swimming scenario.

Dermal exposure via swimming is also expected to be lower than drinking water because of a low permeability coefficient (K_p). The permeability quantifies how easily a chemical penetrates the skin, which is crucial for calculating an absorbed dose for evaluating systemic effects. The K_p for TBBPA was determined to be a low value of 3.72×10^{-7} cm/h. This originates from a dermal TBBPA absorption analysis conducted by Charles River Laboratories ([2024](#)) in response to an EPA Test Order issued under TSCA section 4(a)(2). Details on the experimental design and conditions can be found in the *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026t](#)).

Drinking Water

For the drinking water pathway, EPA used modeled surface water concentrations presented in Section 3.3.1 to estimate drinking water exposures. TBBPA is not expected to significantly migrate from landfills through groundwater infiltration because high hydrophobicity and high affinity for soil sorption is expected to retard or immobilize TBBPA in the surrounding soil. Therefore, drinking water exposure in this assessment is focused on drinking water sourced from surface water.

For this screening analysis, no further removal from drinking water treatment was applied. Acute toxicity of TBBPA pertaining to an exposure duration of one day is not expected ([U.S. EPA, 2026t](#)) and thus not calculated. Intermediate toxicity with an exposure duration of up to 30 days is expected. EPA derived intermediate drinking water exposures from the 30Q5 flow concentrations and derived chronic drinking water exposures from the harmonic mean (HM) flow concentrations. This approach follows

guidance established in 40 CFR part 131 for water quality standards, whereby shorter and longer-term exposures are paired with a lower (*i.e.*, 30Q5) and more average flow rate, respectively. Section 3.3 and the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026g](#)) detail the estimation of surface water concentrations for use in this screening-level assessment. Drinking water intake was estimated for three COUs, two of which reported direct releases to TRI, as well as one POTW that indirectly received industrial waste containing TBBPA according to TRI. As discussed in Section 3.3.1, the HM was not estimated for COUs with a low number of release days (*i.e.*, less than a month) because the HM represents long-term average conditions. For those COUs without a HM, the chronic drinking water exposure was not calculated.

As discussed in the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026g](#)), a key input for assessing exposure is the drinking water intake rate for various age groups. Since intermediate duration ingestion rates are not available, the scenarios assessed rely on ingestion rates consistent with an acute duration. Using these acute exposure factors are likely to overestimate exposure for the intermediate scenarios. However, in the absence of more specific exposure factors, EPA selected the acute intake rates to be health protective. Drinking water exposure estimates using an acute dose rate is presented as the intermediate dose in Table 4-14 to align with human hazard values even though an acute drinking intake rate was used. Potential average daily doses, which correspond to the chronic drinking water exposures, are also presented in Table 4-14.

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Scenario	Release Days	Water Column Concentrations		Adult (21+ years)		Infant (Birth to <1 year)		Toddler 1–5 years)	
		30Q5 Conc. (µg/L)	HM Conc. (µg/L)	Int. (mg/kg-day)	ADD (mg/kg-day)	Int. (mg/kg-day)	ADD (mg/kg-day)	Int. (mg/kg-day)	ADD (mg/kg-day)
Processing – As a reactant – Flame retardant in plastic material and resin manufacturing	350	3.59E–04	1.56E–04	1.44E–08	1.64E–09	5.07E–08	4.20E–09	1.80E–08	1.80E–09
	4	3.14E–02	N/A ^a	1.26E–06	N/A ^a	4.43E–06	N/A ^a	1.58E–06	N/A ^a
Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing	12	9.39	N/A ^a	3.78E–04	N/A ^a	1.33E–03	N/A ^a	4.71E–04	N/A ^a
Disposal	12	8.52	N/A ^a	3.43E–04	NA ^a	1.20E–03	NA ^a	4.28E–04	NA ^a
30Q5 = 30 consecutive days of lowest flow over a 5-year period; ADD = average daily dose; HM = harmonic mean; Int. = intermediate dose ^a HM was not calculated using these release days because the HM represents long-term average flow conditions. Therefore, the average daily doses for chronic exposure durations that are estimated using a HM were not calculated either.									

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4.1.6.4 Fish Ingestion Pathway

TBBPA has low bioaccumulation potential in fish but is considered a lipophilic organic compound ($\log K_{ow} = 4.75$ at pH 7.53 and 25 °C) (U.S. EPA, 2026w). Because of the latter chemical property, EPA quantitatively estimated human exposure to TBBPA through fish ingestion. Calculating TBBPA concentrations in fish tissue is determined by the surface water concentrations of TBBPA and a bioaccumulation factor (BAF). The surface water concentrations based on a harmonic mean flow is typically used to estimate fish tissue concentrations because it represents long-term average conditions, and it takes time for chemical concentrations to accumulate in fish. However, the harmonic mean is not appropriate for COUs with few release days (*i.e.*, less than a month). In those instances, EPA used the 30Q5 as a conservative screening-level analysis even though the 30Q5 is expected to occur less frequently and unlikely to be sustained long-term. Section 3.3 and the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* (U.S. EPA, 2026q) detail the estimation of surface water concentrations for use in this screening-level assessment.

Fish tissue concentrations were estimated for three COUs, two of which reported direct releases to TRI, as well as one POTW that indirectly received industrial waste containing TBBPA according to TRI. The BAF for TBBPA using the Arnot-Gobas method for upper trophic organisms is 153 L/kg wet weight (ww) (see *Draft Physical Chemistry and Fate Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* (U.S. EPA, 2026w)). This low BAF indicates TBBPA's low potential for bioconcentration and bioaccumulation. The computed concentrations of TBBPA in fish tissue are based on a wet weight equivalent and presented in Table 4-15 and detailed in *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* (U.S. EPA, 2026q).

EPA estimated exposure from fish consumption for only tribal populations to characterize the upper-bound of exposure. Tribal populations have the highest fish ingestion rates among the general population even when including subsistence fishers. U.S. EPA (2011a) (Chapter 10, Table 10-6) summarizes relevant studies on current tribal-specific fish ingestion rates that covered 11 tribes and 94 Alaskan communities. The highest central tendency value (a mean) ingestion rate per kilogram of body weight was reported in a 1997 survey of adult members (16+ years) of the Suquamish Tribe in Washington. Adults from the Suquamish Tribe reported a mean ingestion rate of 2.7 g/kg-day, or 216 g/day, assuming an adult body weight of 80 kg. In comparison, the ingestion rates for the adult subsistence fishers and general population are 142.2 and 22.2 g/day, respectively. A total of 92 adults responded to the survey funded by the Agency for Toxic Substances and Disease Registry (ATSDR) through a grant to the Washington State Department of Health.

In addition to the current mean fish ingestion rate, EPA reviewed literature and surveys to identify a high-end (*i.e.*, 90th or 95th percentile) current fish ingestion rate. The surveys asked participants to estimate their daily fish consumption over the course of a year by meal size and meal frequency. The highest 95th percentile fish and shellfish ingestion rate was 874 g/day, or 10.9 g/kg-day assuming a body weight of 80 kg, for male adults (18+ years) of the Shoshone-Bannock Tribes in Idaho (Polissar et al., 2016). The 95th percentile ingestion rate for males and females combined was not much lower at 10.1 g/kg-day. The Suquamish Tribe also reported similar high-end (90th percentile) current ingestion rates for adults ranging from 8.56 to 9.73 g/kg-day (Duncan, 2000). Estimated high-end fish ingestion rates were lower for other tribes in Alaska, the Pacific Northwest, Great Lakes region, and northeastern North America. To evaluate the current high-end exposure scenario, EPA used the highest 95th percentile ingestion rate of 10.9 g/kg-day.

EPA proceeded with using two current ingestion rates: 216 g/day (2.7 g/kg-day) for a central tendency and 874 g/day (10.9 g/kg-day) as a high-end or 95th percentile. The same ingestion rate was used to estimate both the intermediate and average daily dose (ADD) for tribal populations. U.S. EPA (2011a) provides fish ingestion rates specific to younger life stages for select tribes, but adults still consume higher amounts of fish per kilogram of body weight at the 50th and 95th percentiles. As a result, exposure estimates focused on adults. See *Draft Fish Ingestion Risk Calculator for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* (U.S. EPA, 2026s) for all exposure estimates.

Table 4-15 presents the exposures calculated with modeled surface water concentrations based on TRI reported releases for three COUs and an estimated BAF.

Table 4-15. Fish Ingestion for Adults in Tribal Populations Summary

COU	Fish Tissue Concentration	Int./ADD (mg/kg-day)	
		Current Mean IR	Current Tribal IR, 95th Percentile
Processing – As a reactant – Flame retardant in plastic material and resin manufacturing	2.39E-05 mg/kg ww based on HM	6.44E-08	2.60E-07
Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing	1.44 mg/kg ww based on the 30Q5 ^a	3.88E-03	1.57E-02
Disposal	1.30 mg/kg ww based on the 30Q5 ^a	3.52E-03	1.42E-02
ADD = average daily dose; HM = harmonic mean; Int. = intermediate exposure estimate; IR = ingestion rate; ww = wet weight ^a HM flow is typically used to estimate fish tissue concentrations because it represents long-term average flow conditions, and it takes time for chemical concentrations to accumulate in fish. However, HM is not appropriate for this COU with only 12 release days. EPA used the 30Q5 as a conservative screening-level analysis, even though the 30Q5 is expected to occur less frequently and unlikely to be sustained long-term.			

4.1.6.5 Ambient Air Pathway

The ambient air exposure assessment used a previously peer-reviewed screening-level analysis to evaluate exposures to the general population in proximity to releasing facilities, including fenceline communities. The approach used is described in EPA's *Draft TSCA Screening Level Approach for Assessing Ambient Air and Water Exposures to Fenceline Communities (Version 1.0)* (U.S. EPA, 2022c). EPA modeled ambient air concentrations to assess inhalation exposure to TBBPA in ambient air and ingestion exposure to TBBPA in soil from air deposition. EPA's modeling estimates both short-term and long-term concentrations in ambient air as well as dry, wet, and total deposition rates as described in Section 3.3.2 for a selection of COU leading to the highest ambient air and soil concentrations.

Since TBBPA is not expected to be acutely toxic as detailed in Section 4.2, only the chronic risk estimates were calculated for both the inhalation and oral pathways. To assess chronic non-cancer exposures to the general population, the total annual average modeled ambient air concentrations from IIOAC (Table 3-13 described in Section 3.3) were used to derive exposure estimates.

Inhalation of Ambient Air

EPA assumed continuous exposure to the TBBPA concentrations modeled in ambient air (*i.e.*, 24 hours per day, 7 days per week, and 365 days per year). Risk estimates for exposure to the modeled ambient air concentrations are based on comparing the ambient air concentrations to the inhalation human equivalent concentration (HEC) described in Section 4.2.1. Therefore, no exposure estimates are presented in this section for inhalation of ambient air but the risk estimates are presented in Section 4.3.4.3 in Table 4-26 (below).

Ingestion of Soil from Air Deposition

TBBPA may be introduced to soils through a variety of mechanisms, such as dry deposition of TBBPA emitted into the atmosphere in its solid particulate form or bound to atmospheric particulates. In Section 3.3 and the *Draft Environmental Media, General Population, and Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol]* (TBBPA) ([U.S. EPA, 2026q](#)), EPA details the use of IIOAC to model total deposition rates at 100 m from a releasing facility. Using the total deposition rates, EPA estimated soil concentrations of TBBPA and associated chronic doses in Table 4-16.

Table 4-16. Exposure Estimates for Ingestion of Soil from Air Deposition

COU	Data Source	Assessed Population	Soil Concentration (mg/kg)	Chronic Doses (mg/kg-day)
• Manufacture – Domestic manufacture • Processing – As a reactant – Flame retardant in plastic material and resin manufacturing • Processing – As a reactant – Intermediate in all other chemical product and preparation manufacturing • Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in plastic material and resin manufacturing; Plastics product manufacturing; custom compounding of purchased resins; paint and coating manufacturing • Processing – Incorporation into formulation, mixture, or reaction product – Adhesive manufacturing • Processing – Incorporation into article – Reactive flame retardant in computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (<i>e.g.</i>, printed circuit boards and semiconductor packages) • Processing – Incorporation into article – Reactive flame retardant in transportation equipment manufacturing (<i>e.g.</i>, interior material for automotive and aviation articles) • Processing – Incorporation into article – Additive flame retardant in computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (<i>e.g.</i>, plastic electronic enclosures) • Industrial and commercial use – Construction, paint, electrical, and metal products – Reactive flame	TRI	Children 1 to <2 years of age	3.10E-03	2.42E-08

COU	Data Source	Assessed Population	Soil Concentration (mg/kg)	Chronic Doses (mg/kg-day)
retardant in automotive and aviation articles (<i>i.e.</i> , laminate and prepreg material) • Disposal				
Electrical and electronic waste recycling	EPA estimated		7.89E-03	6.15E-08

4.1.6.6 Human Milk Exposure

Infants are potentially more susceptible than older children, teens, and adults for various reasons, including their higher exposure per body weight, immature metabolic systems, and the potential for chemical toxicants to disrupt sensitive developmental processes. EPA considered the available hazard data to determine if there is evidence of increased susceptibility associated with infant exposure to TBBPA. Across available gestational one- and two-generation exposure studies, the hazard point of departure (POD) for intermediate exposure durations are based upon increased incidence of polycystic kidney lesions in young male rats. It was derived from a study accounting for potential early life stage sensitivity (*i.e.*, neonatal exposure) and determined to be the most robustly supported health endpoint that considered enhanced sensitivity. For chronic scenarios, EPA's selected POD is based upon uterine tumor formation in adult female rats. See Section 4.2 for further details on the human health studies and how they were used to derive relevant PODs.

In addition to hazard data indicating some potential for early life stage susceptibility, TBBPA has the potential to accumulate in human milk because of its lipophilicity ($\log K_{ow} = 4.75$). Eighteen biomonitoring studies from reasonably available information provide empirical evidence of TBBPA's presence in human milk. None of the studies characterized specific study participant exposure sources (*e.g.*, occupational). There was a large variability in TBBPA concentration reported across the literature. Many studies report levels below the level of quantification/detection, but the maximum reported value was 2,209 ng/g lipid weight. It is also important to note that biomonitoring data do not distinguish between exposure routes or pathways and do not allow for source apportionment. In other words, biomonitoring data reflect total infant exposure through human milk ingestion and the contribution of specific COUs to overall exposure cannot be determined.

EPA estimated intermediate and chronic non-cancer risks for a nursing infant using biomonitoring data. Acute exposure was not considered because TBBPA is not expected to be acutely toxic across all exposure routes ([U.S. EPA, 2026t](#)) and the absence of milk ingestion rates to characterize a peak daily exposure. While chronic exposure represents repeated exposures covering at least 10% of lifetime in adults, EPA estimated chronic risks to a nursing infant because of uncertainties as to whether exposure during the first year of life will result in developmental effects through adulthood. Therefore, chronic non-cancer risks were considered for infant doses in the first year of life. For cancer risks, TBBPA's potential cancer effects are not mediated through direct DNA damages (*i.e.*, no genotoxic mode of action), where any exposure would be associated with some positive risk of developing cancer (see *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol]* (TBBPA) ([U.S. EPA, 2026t](#))). In other words, TBBPA is not considered genotoxic or mutagenic.

Screening-level exposure estimates using the maximum measured TBBPA concentrations in human milk are presented in Table 4-17. Details of all biomonitoring data for human milk can be found in the

Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA) ([U.S. EPA, 2026q](#)). Because only one U.S. study was identified and samples were collected 20 years ago, the degree to which these milk samples represent current TBBPA exposures in the United States is not known. Instead, to calculate a nursing infant's exposure, the maximum measured concentrations from Fujii et al. ([2018](#)) was used to calculate a nursing infant's exposure and for the purpose of a screening analysis.

Table 4-17. Screening-Level Exposure from Human Milk Ingestion Based on Biomonitoring Data

Age Group	Intermediate Exposure Estimates	
	Lipid Weight (mg/kg-day)	Wet Weight (mg/kg-day)
Birth to <1 month ^a	1.98E-02	3.56E-03
Birth to <1 year ^b	1.41E-02	2.47E-03

^a Intermediate risks are only estimated for the infant's first month of life, which had the highest doses because of the highest milk ingestion rate per kg of body weight. It is thus most protective for estimating shorter exposures. Furthermore, chronic risks cover much longer exposure durations (*i.e.*, at least 10% of lifetime in adults) than the 1 month represented by this exposure estimate.

^b The exposure duration for an intermediate exposure is up to 30 days. The exposure duration for this age group exceeds 30 days.

4.1.6.7 Weight of Scientific Evidence Conclusions for General Population Exposure

The weight of scientific evidence supporting the general population exposure to environmental releases estimate is decided based on the strengths, limitations, and uncertainties associated with the exposure estimates—all of which are discussed in detail for the land, surface water, fish ingestion, ambient air, and human milk pathways in the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)). EPA summarized its weight of scientific evidence using the following confidence descriptors: robust, moderate, slight, or indeterminate. The Agency used general considerations (*i.e.*, relevance, data quality, representativeness, consistency, variability, and uncertainties) as well as chemical-specific considerations for its weight of scientific evidence conclusions.

EPA determined robust confidence through its qualitative assessment of biosolids and landfills that overall, TBBPA is not expected to pose significant exposure potential from the land application of biosolids and TBBPA is likely to readily degrade in the landfill and not be persistent based on high-quality physical and chemical property data. For its quantitative assessment of exposure via drinking water, fish ingestion, and ambient air, the Agency modeled exposure for the general population resulting from the different pathways of exposure based on reported releases. For the human milk pathway, EPA conducted a quantitative screening-level analysis with high-end biomonitoring data. Exposure assessments used high-end inputs for risk screening to provide upper-bound exposure and risk estimates (Section 4.3.4). The Agency has robust confidence that the EPA exposure scenarios are appropriately conservative for a screening-level analysis. Therefore, the Agency has robust confidence that no exposure scenarios will lead to greater doses than those presented in this section.

4.1.6.8 Aggregate and Sentinel Exposure

TSCA section 6(b)(4)(F)(ii) (see 15 U.S.C. § 2605(b)(4)(F)(ii)) requires EPA, in conducting a risk evaluation, to describe whether aggregate and sentinel exposures under the COUs were considered and the basis for their consideration.

EPA defines aggregate exposure as “the combined exposures to an individual from a chemical substance across multiple routes and across multiple pathways (40 CFR § 702.33).” For the TBBPA risk evaluation, the Agency considered aggregate risk across all routes of exposure for each individual consumer and occupational COU evaluated for intermediate and chronic exposure durations. EPA did not consider aggregate exposure for the general population exposed to environmental releases. As described in Section 4.1.6, the Agency employed a screening-level approach for the general population exposure assessment. Based on results from the risk screen, no pathways of concern (*i.e.*, ambient air, surface water, drinking water, and fish ingestion) to TBBPA exposure were identified for the general population, including PESS.

EPA did not consider aggregate exposure scenarios across COUs because the Agency did not find any evidence to support such an aggregate analysis after considering the reasonably available information, such as statistics of populations using certain products represented across COUs or workers performing tasks across COUs. However, EPA considered combined exposure across all routes of exposure for each individual occupational and consumer COU to calculate aggregate risks (Sections 4.3.2 and 4.3.2.4).

EPA defines sentinel exposure as “the exposure to a chemical substance that represents the plausible upper-bound of exposure relative to all other exposures within a broad category of similar or related exposures (40 CFR § 702.33).” In terms of this risk evaluation, the Agency considered sentinel exposures by considering risks to populations who may have upper-bound exposures; for example, workers and ONUs who perform activities with higher exposure potential or consumers who have higher exposure potential or certain physical factors like body weight or skin surface area exposed. EPA characterized high-end exposures in evaluating exposure using both monitoring data and modeling approaches. Where statistical data were available, the Agency used the 95th percentile value of the available dataset to characterize high-end exposure for a given condition of use. For general population and consumer exposures, EPA occasionally characterized sentinel exposure through a “high-intensity use” category based on elevated consumption rates, breathing rates, or user-specific factors.

4.2 Summary of Human Health Hazard

This section briefly summarizes the non-cancer and cancer human health hazards of TBBPA. Additional information on the human health hazards is provided in the *Draft Human Health and Environmental Hazard Assessment for Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026t](#)).

4.2.1 Non-Cancer Human Health Hazards of TBBPA

The majority of toxicokinetic data for TBBPA is derived from oral exposure studies, and toxicokinetic data on non-oral routes of exposure (inhalation and dermal) remains limited. Following oral exposure, TBBPA rapidly undergoes Phase II metabolism via primary conjugation to create glucuronidation and/or sulfation metabolites (TBBPA-glucuronide, TBBPA-sulfate, TBBPA-glucuronide/sulfate, and TBBPA-diglucuronide), as well as enterohepatic circulation and biliary excretion. Across the available rat oral exposure toxicokinetic studies, TBBPA-glucuronide and TBBPA-sulfate have been reported as major metabolites. In the one identified toxicokinetic intentional human dosing study, TBBPA-glucuronide was recovered as the major metabolite. TBBPA metabolites appear to have a short half-life, with the majority of elimination occurring through feces and urine within 72 hours. Available data suggests TBBPA does not accumulate systemically in tissues. EPA did not identify reasonably available studies that provide toxicokinetic data of TBBPA for the inhalation route of exposure. For the dermal route of exposure, EPA previously determined that reasonably available studies that provide toxicokinetic data of TBBPA for the dermal route of exposure did not fully address the occupational conditions of use being evaluated for the TSCA risk evaluation for TBBPA (as described previously in Section 4.1.1). Thus, EPA utilized test order data for TBBPA obtained from OECD-compliant human skin experiments

([Charles River Laboratories, 2024](#)). Various fractional absorption and flux-based dosing conditions were conducted and considered in assessing the TBBPA dermal absorption profile. Overall, results from the dermal TBBPA absorption analysis in human skin suggest low dermal permeation. As stated in the *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026t](#)), EPA is utilizing TBBPA test order data ([Charles River Laboratories, 2024](#)) to estimate dermal permeation (as described previously in Section 4.1.1.3). Regarding inhalation route, no toxicokinetic data or physiologically-based pharmacokinetic (PBPK) or pharmacodynamic (PD) model are reasonably available to support refining absorbed dose via these inhalation pathways. Thus, EPA is assuming 100% absorption for oral and inhalation routes of exposure and is extrapolating the oral HEDs to inhalation HECs per EPA's *Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry* ([U.S. EPA, 1994](#)) using the updated human body weight of 80 kg and breathing rate relevant to continuous exposure of an individual at rest provided in EPA's *Exposure Factors Handbook* ([U.S. EPA, 2011b](#)). Confidence in route-to-route extrapolation in POD selection is discussed in POD weight of scientific evidence sections below.

In evaluating toxicity effects relevant to acute exposure durations, EPA considered available acute exposure (*i.e.*, single dose) studies, as well as one-generation and two-generation exposure studies reporting apical developmental outcomes (*e.g.*, no effects on decreased offspring body weight, gross malformations, or altered maturation markers such as preputial separation or anogenital distance). Single exposure studies did not demonstrate toxicity effects useful in informing an acute POD. Assessment of gestational exposure studies indicated TBBPA did not impact offspring survival, body weight or weight gain, or other malformations/maturation markers (*i.e.*, anogenital distance and preputial separation). There were no hazard data to indicate specific gestational effects, fertility marker changes, or adverse developmental outcomes associated with TBBPA exposure. In considering all reasonably available information, EPA determined that the evidence suggests TBBPA is not acutely toxic and that it is unlikely any adverse effects will result following a single exposure to TBBPA at concentrations relevant to human exposures. Therefore, the Agency decided not to propose an acute exposure POD human hazard value. Studies supporting this determination are discussed in the *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026t](#)).

EPA identified the non-cancer kidney outcome of polycystic kidney lesions in neonatal male rats as the most robust endpoint to inform the selected oral intermediate exposure duration POD ([Fukuda et al., 2004](#)). Additional potentially sensitive non-cancer health effects identified for liver, neurological, and thyroid toxicity were also considered but were not selected for POD derivation due to lower confidence in health outcomes or less sensitive health effect levels (no-observed-adverse-effect level, NOAEL or lowest-observed-adverse-effect level, LOAEL). Effects on the kidney were also identified among the most robust non-cancer effects following oral exposure to TBBPA within other existing assessments of TBBPA, including those by Australia's National Industrial Chemicals Notification and Assessment (NICNAS) ([2020, 2001a](#)), the European Chemical Bureau (ECB) ([2008, 2006a, b](#)), and Health Canada's Environment Canada (EC/HC) ([2013](#)). EPA also considered epidemiological evidence of health effects associated with TBBPA exposure. However, the Agency did not use epidemiology studies quantitatively or in the weight of scientific evidence as the selected non-cancer health effect (kidney) was not evaluated in the reasonably available epidemiological literature, and existing epidemiological evidence had uncertainty associated with sample size, generalizability, timing of exposure, dose-response, and confounding factors. Further discussion of the non-cancer human health hazards of TBBPA is discussed in the *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026t](#)).

Results by Fukuda et al. (2004) relevant to the selected intermediate exposure duration support a no-observed-adverse-effect-level (NOAEL) of 40 mg/kg-day for polycystic kidney lesions in neonatal male SD rats exposed orally from postnatal day 4 to 21. In refining the identified intermediate exposure duration NOAEL from the most robust endpoint identified for POD selection, EPA conducted benchmark dose (BMD) modeling consistent with EPA's *Benchmark Dose Technical Guidance* (U.S. EPA, 2012) using the most recent EPA BMD software (BMD Online version 25.1). This resulted in an oral intermediate exposure duration POD of BMDL₁₀ (95% lower confidence limit on the BMD associated with a benchmark response of 10%) of 28.8 mg/kg-day. EPA performed allometric scaling across species using a $\frac{3}{4}$ body weight scaling ($BW^{3/4}$) for oral data to yield a human equivalent dose (HED) of 6.8 mg/kg-day. Body weight scaling to the $\frac{3}{4}$ -power is EPA's default approach for deriving an HED in the absence of more chemical-specific information (e.g., PBPK model or data-derived extrapolation factor) for such an extrapolation as described in EPA's *Guidance, Recommended Use of Body Weight $\frac{3}{4}$ as the Default Method in Derivation of the Oral Reference Dose* (U.S. EPA, 2011c). No reasonably available human hazard data were identified for the dermal or inhalation routes that are suitable for deriving route-specific PODs, and thus the oral HED underwent route-to-route extrapolation to inform the dermal HED and inhalation human equivalent concentration (HEC) calculation. A total uncertainty factor (UF) of 30 was selected for use as the benchmark margin of exposure (MOE) for the intermediate exposure duration POD (based on an interspecies UF [UF_A] of 3 and intraspecies UF [UF_H] of 10). The UF_H of 10 accounts for variability in toxicokinetics and toxicodynamics within the human population to account for differences in sensitivity. Data were not available to characterize the magnitude of variability/sensitivity across the human population. Therefore, consistent with Agency guidance (U.S. EPA, 2002), EPA selected a default UF_H of 10. Consistent with Agency guidance (U.S. EPA, 2011c), the UF_A was reduced from a factor of 10 to 3 because allometric body-weight scaling was used to derive an HED, which accounts for toxicokinetic differences between species. The remaining UF_A of 3 accounts for species differences in toxicodynamics.

Data that evaluated chronic exposures via any route of exposure are limited to one study (the 2-year National Toxicology Program (NTP) TBBPA cancer bioassay (NTP, 2014)), which included endpoints considered relevant for chronic non-cancer and cancer effects. The most robustly supported effect informing chronic duration POD selection found from the NTP report (NTP, 2014) was atypical endometrial hyperplasia associated with uterine tumor formation in female Wistar Han rats, as discussed below in Section 4.2.2 on cancer human health hazards.

4.2.1.1 Non-Cancer Weight of Scientific Evidence Conclusions

Overall, based on the strengths, limitations, and uncertainties discussed in the *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol]* (TBBPA) (U.S. EPA, 2026t), EPA reviewed the weight of the scientific evidence and has robust overall confidence in kidney effects (specifically the selected endpoint of polycystic kidney lesions in neonatal male SD rats) for deriving the selected POD for use in characterizing risk from exposure to TBBPA for intermediate exposure scenarios. In considering all reasonably available information, EPA has determined evidence suggests TBBPA is not acutely toxic and that it is unlikely any adverse effects will result following a single exposure to TBBPA at concentrations relevant to human exposures. Furthermore, when comparing health outcome across studies, rodents exposed *in utero* or during neonatal periods appear more sensitive to TBBPA-induced toxicity than adult rodents, and LOAELs for additional identified non-cancer health effects (i.e., liver, neurological, and thyroid) were determined to consistently occur at levels above the intermediate exposure duration POD. Effect levels in Fukuda et al. (2004) are derived from a study with consideration of additional potential early life stage susceptibility (i.e., neonatal rat exposure paradigm). Thus, EPA was able to incorporate potential life stage susceptibility into hazard values for intermediate exposure duration scenarios through selection of an endpoint measured in

rodents exposed during the neonatal period. Therefore, EPA considers the POD to be protective of all relevant intermediate duration non-cancer health effects across PESS and life stages, including infants.

In determining the POD selection confidence, EPA considered that no data were available for the dermal or inhalation routes that were suitable for deriving route-specific PODs. Therefore, EPA used the intermediate oral POD to evaluate risks from dermal exposure to TBBPA. Using available test order data, EPA utilized TBBPA-specific dermal absorption data to account for differences in absorption between oral and dermal routes and is confident that its human health risk characterization via the dermal route for TBBPA is health protective. However, no studies investigating the toxicokinetics of TBBPA via the inhalation route are available and there is uncertainty as to whether differences in metabolism and absorbed dose between the oral and inhalation routes exist. Regarding the inhalation route of exposure for TBBPA that exists as a particle, in addition to potential respirable lung absorption, inhalable non-respirable fractions may contribute to exposed total dose via swallowing and gastrointestinal absorption following mucociliary clearance. However, as particle size distribution of TBBPA as particles or TBBPA adhered to dust as particle aggregates is unknown, there is uncertainty in site-specific deposition or the ability of mucociliary clearance to occur for larger dust particle fractions that would contribute to total dose. No toxicokinetic data or PBPK/PD model are reasonably available to support refining absorbed dose via these inhalation pathways.

To extrapolate inhalation HECs from oral HEDs, EPA assumed similar absorption metabolism of TBBPA via the oral and inhalation routes (*i.e.*, 100%). Thus, EPA acknowledges increased uncertainty based upon lack of route-specific absorption, distribution, metabolism, and elimination (ADME) data to support the current approach for route-to-route extrapolation or to support refining inhalation HECs. If absorption of inhaled TBBPA is less than 100%, then the resulting inhalation POD and risk estimates would shift proportionally. For example, if absorption via inhalation were 50%, then the corresponding shift in the inhalation POD would result in a 50% reduction in risk. For the inhalation route, EPA is extrapolating the oral HED to an inhalation HEC per EPA's *Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry* ([U.S. EPA, 1994](#)) using the updated human body weight of 80 kg and breathing rate relevant to continuous exposure of an individual at rest provided in EPA's *Exposure Factors Handbook: 2011 Edition* ([U.S. EPA, 2011b](#)). Based on the factors discussed above, EPA has robust overall confidence in the proposed intermediate HED to inform quantitative human health hazard risk estimates from oral and dermal routes of exposure. Based on the above factors and due to the derivation of an inhalation HEC from route-to-route extrapolation of oral data, EPA has moderate overall confidence in the proposed intermediate HEC to inform quantitative human health hazard risk estimates from inhalation routes of exposure. Table 4-18 summarizes the proposed intermediate duration POD (and corresponding HEDs, HECs, and UFs) that EPA is using in the TBBPA risk evaluation to estimate risk for intermediate exposure duration scenarios. EPA is confident that its human health risk characterization via the dermal route for TBBPA is health protective.

4.2.2 Cancer Human Health Hazards of TBBPA

As discussed in the *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol]* (TBBPA) ([U.S. EPA, 2026t](#)), available *in vivo* and *in vitro* genotoxicity assays of TBBPA indicate TBBPA is not a direct acting genotoxicant or mutagen.

One NTP 2-year chronic oral gavage cancer bioassay in rats and mice was identified that evaluated the carcinogenicity of TBBPA ([NTP, 2014](#)). In the NTP two-year cancer bioassay, male and female Wistar Han rats and male and female B6C3F1 mice were exposed to levels up to 1,000 mg/kg-day via corn oil gavage for 105 weeks. Upon review of NTP tumor findings in Wistar Han rats and B6C3F1 mice, EPA

determined there were significant treatment-related cancer effects of uterine tumor formation associated with chronic oral TBBPA exposure in female Wistar Han rats observed through combined uterine adenoma, adenocarcinoma, or malignant mixed mullerian tumors (MMMT), as well as associated uterine tumor precursor atypical endometrial hyperplasia lesion data. EPA further considered available mechanistic evidence relating to TBBPA's uterine tumor carcinogenic mode of action (MOA) (uterine tumor carcinogenic MOA analysis and evidence data are discussed as part of cancer hazard assessment in the *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol]* (TBBPA) ([U.S. EPA, 2026t](#))). Available mechanistic evidence indicates TBBPA uterine effects arise from a non-genotoxic sulfotransferase family 1E member 1 (SULT1E1) enzyme inhibition MOA, leading to increased uterine estrogen bioavailability and estrogen receptor signaling activity to initiate subsequent key events that lead to tumor precursor lesions (*i.e.*, atypical endometrial hyperplasia) and eventual uterine tumor formation (*i.e.*, observance of adenoma, adenocarcinoma, or MMMT). Thus, EPA determined TBBPA-related uterine tumor outcomes follow a non-genotoxic threshold of biological effects.

Under the *Guidelines for Carcinogen Risk Assessment* ([U.S. EPA, 2005](#)), EPA reviewed the weight of the evidence for the carcinogenicity of TBBPA and determined that TBBPA is *Not Likely Carcinogenic to Humans* at doses below levels associated with the chronic POD. The chronic POD based on atypical endometrial hyperplasia adequately accounts for all chronic toxicity, including carcinogenicity, which could potentially result from exposure to TBBPA. EPA's conclusion is based on evidence of uterine epithelial tumors (combined adenoma, adenocarcinoma, or MMMT) in female Wistar Han rats ([NTP, 2014](#)) and an experimentally supported uterine tumor MOA for TBBPA. There were also varying lines of mechanistic evidence associated with *in vitro* potential of receptor-mediated, oxidative stress, and immunosuppressive effects of TBBPA. EPA reviewed evidence and concluded TBBPA follows a SULT1E1 inhibition MOA for TBBPA uterine tumors. Overall, under the *Guidelines for Carcinogen Risk Assessment* ([U.S. EPA, 2005](#)), EPA determined that TBBPA exhibits a non-genotoxic threshold of carcinogenic effects. EPA's cancer analysis and conclusion are generally consistent with existing assessments by EFSA ([2024](#)) and NICNAS ([2020](#)) that conducted more recent analyses of TBBPA carcinogenic outcomes and mechanistic evidence.

EPA identified one study, the 2-year NTP cancer bioassay ([NTP, 2014](#)), that evaluated TBBPA cancer outcomes. Results from this 2-year study provide data that demonstrate chronic TBBPA exposure is associated with uterine tumor formation (LOAEL = 500 mg/kg-day) and the associated preneoplastic lesion of atypical endometrial hyperplasia (LOAEL = 250 mg/kg-day) ([NTP, 2014](#)), which was the most robust chronic health effect identified. In evaluating available genotoxicity data, cancer hazard data, and the uterine tumor formation MOA, EPA determined TBBPA-induced uterine tumors follow a non-genotoxic non-linear biological threshold of effects. Thus, EPA conducted dose-response assessment using atypical endometrial hyperplasia lesion data for consideration in the derivation of a POD for estimating risk from TBBPA in chronic exposure duration scenarios. In refining the identified chronic exposure duration LOAEL from most robust chronic endpoint identified for POD selection (atypical endometrial hyperplasia precursor tumor lesion data), EPA conducted BMD modeling consistent with EPA's *Benchmark Dose Technical Guidance* ([U.S. EPA, 2012](#)) using the most recent EPA BMD software (BMD Online version 25.1). This resulted in an oral chronic exposure duration POD of BMDL₁₀ (95% lower confidence limit on the BMD associated with a benchmark response of 10%) of 18.5 mg/kg-day. EPA performed allometric scaling across species using a ³/₄ body weight scaling (BW^{3/4}) for oral data to yield a HED of 4.4 mg/kg-day. Body weight scaling to the ³/₄-power is EPA's default approach for deriving an HED in the absence of more chemical-specific information (*e.g.*, PBPK model or data-derived extrapolation factor) for such an extrapolation ([U.S. EPA, 2011c](#)). A total UF of 30 was selected for use as the benchmark MOE for the chronic exposure duration POD (based on a UF_A

of 3 and UF_H of 10). The UF_H of 10 accounts for variability in toxicokinetics and toxicodynamics within the human population to account for differences in sensitivity. Data were not available to characterize the magnitude of variability/sensitivity across the human population. Therefore, consistent with Agency guidance ([U.S. EPA, 2002](#)), EPA selected a default UF_H of 10. Consistent with Agency guidance ([U.S. EPA, 2011c](#)), the UF_A was reduced from a factor of 10 to 3 because allometric body-weight scaling was used to derive an HED, which accounts for toxicokinetic differences between species. The remaining UF_A of 3 accounts for species differences in toxicodynamics.

4.2.2.1 Cancer Weight of Scientific Evidence Conclusions

Overall, based on the strengths, limitations, and uncertainties discussed in the *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026t](#)), EPA reviewed the weight of the scientific evidence and has robust overall confidence in atypical endometrial hyperplasia lesion incidence for deriving the proposed POD for use in characterizing risk from exposure to TBBPA for chronic exposure scenarios. EPA's approach of dose-response of uterine tumor cancer effects in chronic POD selection through a non-genotoxic non-linear cancer threshold of effects was conducted in accordance with the *Guidelines for Carcinogen Risk Assessment* ([U.S. EPA, 2005](#)). The chronic POD based on atypical endometrial hyperplasia adequately accounts for all chronic toxicity, including potential non-cancer and cancer outcomes resulting from exposure to TBBPA.

In determining the POD selection confidence, EPA considered that no data were available for the dermal or inhalation routes that were suitable for deriving route-specific PODs. Therefore, EPA used the chronic oral POD to evaluate risks from dermal exposure to TBBPA. Using available test order data, EPA utilized TBBPA-specific dermal absorption data to account for differences in absorption between oral and dermal routes and is confident that its human health risk characterization via the dermal route for TBBPA is health protective. However, no studies investigating the toxicokinetics of TBBPA via the inhalation route are available and there is uncertainty as to whether differences in metabolism between the oral and inhalation routes exist. Regarding the inhalation route of exposure for TBBPA that exists as a particle, in addition to potential respirable lung absorption, inhalable non-respirable fractions may contribute to exposed total dose via swallowing and gastrointestinal absorption following mucociliary clearance. However, as particle size distribution of TBBPA as particles or TBBPA adhered to dust as particle aggregates is unknown, there is uncertainty in site-specific deposition or the ability of mucociliary clearance to occur for larger dust particle fractions that would contribute to total dose. No toxicokinetic data or PBPK/PD model are reasonably available to support refining absorbed dose via these inhalation pathways.

To extrapolate inhalation HECs from oral HEDs, EPA assumed similar absorption metabolism of TBBPA via the oral and inhalation routes (*i.e.*, 100%). Thus, EPA acknowledges increased uncertainty based upon lack of route-specific ADME data to support the current approach for route-to-route extrapolation or to support refining inhalation HECs. For the inhalation route, EPA is extrapolating the oral HED to an inhalation HEC per EPA's *Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry* ([U.S. EPA, 1994](#)) using the updated human body weight and breathing rate relevant to continuous exposure of an individual at rest provided in the *Exposure Factors Handbook: 2011 Edition* ([U.S. EPA, 2011b](#)). Based on the factors discussed above, EPA has robust overall confidence in the proposed chronic HED to inform quantitative human health hazard risk estimates from oral and dermal routes of exposure. Based on the above factors and due to the derivation of an inhalation HEC from route-to-route extrapolation of oral data, EPA has moderate overall confidence in the proposed chronic HEC to inform quantitative human health hazard risk estimates from inhalation routes of exposure.

4.2.3 Points of Departure Used to Estimate Risks from TBBPA Exposure

EPA evaluated reasonably available information for human health hazards and identified hazard PODs for adverse effects following intermediate and chronic exposures. As discussed previously, the evidence suggests TBBPA is not acutely toxic and that it is unlikely any adverse effects will result following a single exposure to TBBPA at concentrations relevant to human exposures. Therefore, the Agency decided not to propose an acute exposure POD human hazard value. After considering human hazard identification and evidence integration, dose-response assessment, and weight of the scientific evidence of POD candidates, EPA preliminarily selected the most robustly supported endpoint of polycystic kidney lesions for use in the TBBPA risk evaluation for estimating risks associated with intermediate exposure duration scenarios. Similarly, EPA preliminarily selected the most robustly supported endpoint of atypical endometrial hyperplasia (associated with uterine tumor formation) for use in the TBBPA risk evaluation for estimating risks associated with chronic exposure duration scenarios, where the chronic POD is expected to account for non-cancer and cancer toxicity effects resulting from chronic exposure.

EPA conducted a cancer hazard assessment of TBBPA and determined that TBBPA is *Not Likely Carcinogenic to Humans* at doses below levels associated with the chronic POD. BMD modeling of preliminarily selected endpoints resulted in a proposed intermediate exposure duration POD of BMDL₁₀ of 28.8 mg/kg-day (HED = 6.8 mg/kg-day) and a proposed chronic exposure duration POD of BMDL₁₀ of 18.5 mg/kg-day (HED = 4.4 mg/kg-day), respectively. EPA identified no reasonably available studies conducted via the dermal route for extrapolating human health risk, and thus the oral HED was used in dermal human health risk estimates. Additionally, in the absence of inhalation studies, EPA performed route-to-route extrapolation to convert the oral HEDs to an inhalation HEC of 1.66 ppm (37.0 mg/m³) for the intermediate exposure duration and HEC of 1.08 ppm (24.0 mg/m³) for the chronic exposure duration. For both the intermediate and chronic duration PODs, a total UF of 30 was selected for use in the benchmark MOE (based on a UF_A of 3 and a UF_H of 10). EPA considers the proposed PODs for use in characterizing risk from exposure to TBBPA to be protective of potentially sensitive subpopulations and life stages, including infants. Table 4-18 summarizes the proposed PODs (and corresponding HEDs, HECs, and UFs) that EPA is using in the TBBPA risk evaluation to estimate risk for intermediate and chronic exposure duration scenarios.

Table 4-18. TBBPA Human Equivalent Doses and Human Equivalent Concentrations Used to Estimate Risk

Exposure Scenario	Target Organ System	Species	Duration	Effect	POD (mg/kg-day)	HED ^a (mg/kg-day)	HEC ^a (ppm) [mg/m ³]	Benchmark MOE ^b	Reference	TSCA Study Quality Rating	POD Selection Confidence ^c
Intermediate – Oral	Kidney	SD rat (male)	PND 4–21	Polycystic kidney lesions	BMDL ₁₀ = 28.8	6.8	N/A	UF _A = 3 UF _H = 10 Total UF = 30	(Fukuda et al., 2004)	High	Robust
Intermediate – Dermal						6.8	N/A				Robust
Intermediate – Inhalation						N/A	1.66 [37.0]				Moderate
Chronic – Oral	Reproductive/cancer	Wistar Han rat (female)	Daily for 105 weeks	Atypical endometrial hyperplasia	BMDL ₁₀ = 18.5	4.4	N/A	UF _A = 3 UF _H = 10 Total UF = 30	(NTP, 2014)	High	Robust
Chronic – Dermal						4.4	N/A				Robust
Chronic – Inhalation						N/A	1.08 [24.0]				Moderate

BMDL₁₀ = lower confidence limit for a benchmark response of 10%; HEC = human equivalent concentration; HED = human equivalent dose; MOE = margin of exposure; N/A = not applicable; POD = point of departure; SD = Sprague-Dawley; UF = uncertainty factor

^a HED and HEC values were calculated based on the respective BMDL₁₀ values.

^b EPA used allometric body weight scaling to the ¾-power to derive the HED. Consistent with EPA Guidance (U.S. EPA, 2011b), the interspecies uncertainty factor (UF_A), was reduced from 10 to 3 to account remaining uncertainty associated with interspecies differences in toxicodynamics. EPA used a default intraspecies (UF_H) of 10 to account for variation in sensitivity within human populations.

^c POD confidence selection is based on an evaluation of the identified POD and the confidence in the alignment of this POD to the assigned route/duration and any uncertainties associated with the POD being used for risk estimates (e.g., strength of identified hazard data, route-to-route extrapolation, etc.).

4.3 Human Health Risk Characterization

This section briefly summarizes the human health risk characterization for TBBPA. Additional information on the human health risk characterization is provided in the *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026t](#)).

4.3.1 Risk Assessment Approach

EPA calculated draft risk estimates for male and female adolescents and adults following intermediate and chronic exposures. Risks were not estimated for acute exposures because sensitive organ-level endpoints are unlikely to result from a single exposure at concentrations relevant to human exposures (see the *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026t](#))). The exposure scenarios, populations of interest, and hazard values (including toxicological endpoints) used for evaluating risks from intermediate and chronic exposures are summarized in Table 4-19.

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Table 4-19. Exposure Scenarios, Populations of Interest, and Hazard Values

Population of Interest and Exposure Scenario	Workers Male and female adolescents and adults (≥ 16 years old) and women of reproductive age directly working with TBBPA under light activity (breathing rate of $1.25 \text{ m}^3/\text{h}$) (for further details see U.S. EPA (2026v)) <u>Exposure Durations</u> • <i>Intermediate</i> – 8 hours per work day for 22 days per 30-day period • <i>Chronic</i> – 8 hours per work day for 250 days per year for 31 or 40 working years <u>Exposure Routes</u> • Inhalation and dermal (includes direct contact with products and mist and dust deposited on surfaces when appropriate for the COU)
	Occupational Non-Users Male and female adolescents and adults (≥ 16 years old) indirectly exposed to TBBPA within the same work area as workers (breathing rate of $1.25 \text{ m}^3/\text{h}$) (for further details see U.S. EPA (2026v)) <u>Exposure Durations</u> • <i>Intermediate and Chronic</i> – same as workers <u>Exposure Routes</u> • Inhalation, dermal (for COUs where mist and dust deposited on surfaces but not direct product contact)
	Consumers Male and female infants (< 1 year), toddlers (1–2 years), preschooler (3–5 years), middle childhood (6–10 years), young teens (11–15 years), teenagers (16–20 years), and adults (21+ years) exposed to TBBPA through product or article use (for further details see U.S. EPA (2026e)) <u>Exposure Durations</u> • <i>Intermediate</i> – 30-day period • <i>Chronic</i> – number of days per year specific to product and article use pattern <u>Exposure Routes</u> • Inhalation, dermal, and oral
	Bystanders Male and female infants (< 1 year), toddlers (1–2 years), and preschooler (3–5 years), middle childhood (6–10 years) incidentally exposed to TBBPA through product use (for further details see U.S. EPA (2026e)) <u>Exposure Durations</u> • <i>Intermediate</i> – 30-day period • <i>Chronic</i> – number of days per year specific to product and article use pattern <u>Exposure Routes</u> • Inhalation
	General Population Male and female infants, children, youth, and adults exposed to TBBPA through drinking water, surface water, ambient air, and fish ingestion (for further details see U.S. EPA (2026q)) <u>Exposure Durations</u>

	<i>Chronic</i> – Exposed to TBBPA continuously for up to 57 years <u>Exposure Routes</u> - Inhalation, dermal, and oral (depending on exposure scenario)
Health Effects, Hazard Values, and Benchmarks	Intermediate Value Sensitive health effect: Kidney toxicity (<i>i.e.</i>, polycystic kidney lesions) (for further details see U.S. EPA (2026t)) <u>HEC Daily</u>^a, continuous (assumes breathing rate of 0.6125 m³/h and 24 hours/day for continuous exposure (U.S. EPA, 2011a)) = 37.0 mg/m³ <u>HED Daily</u> = 6.8 mg/kg-day; dermal and oral Total UF (benchmark MOE) = 30 (UF_A = 3; UF_H = 10) Chronic Value Sensitive health effect: Uterine toxicity (<i>i.e.</i>, atypical endometrial hyperplasia) (for further details see U.S. EPA (2026t)) <u>HEC Daily</u>^a, continuous (assumes breathing rate of 0.6125 m³/h and 24 hours/day for continuous exposure (U.S. EPA, 2011a)) = 24.0 mg/m³ (1.08 ppm) <u>HED Daily</u> = 4.4 mg/kg-day; dermal and oral Total UF (benchmark MOE) = 30 (UF_A = 3; UF_H = 10)
HEC = human equivalent concentration; HED = human equivalent dose; MOE = margin of exposure; UF = uncertainty factor; UF_A = interspecies uncertainty factor; UF_H = intraspecies uncertainty factor ^a For occupational risk calculations, exposure estimates are adjusted by a breathing rate ratio to account for the elevated breathing rate experienced by workers from the breathing rate assumed for the HEC. See equations in Appendix E.1.	

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4.3.1.1 Estimation of Human Hazard Risks

EPA used an MOE approach to identify potential human hazard risks for individual exposure routes (*i.e.*, oral, dermal, inhalation). The MOE is the ratio of the human hazard value (or POD) divided by a human exposure dose. The intermediate and chronic MOEs for inhalation and dermal risks were calculated using Equation 4-2:

Equation 4-2. Margin of Exposure Calculation

$$MOE = \frac{\text{Hazard Value (POD)}}{\text{Human Exposure}}$$

Where:

<i>MOE</i>	=	Margin of exposure intermediate or chronic risk comparison (unitless)
<i>Hazard Value (POD)</i>	=	HED ($\mu\text{g}/\text{m}^3$) or HED ($\text{mg}/\text{kg}\text{-day}$)
<i>Human Exposure</i>	=	Exposure estimate ($\mu\text{g}/\text{m}^3$ or $\text{mg}/\text{kg}\text{-day}$)

MOE risk estimates may be interpreted in relation to benchmark MOEs. Benchmark MOEs are typically the total uncertainty factor for each POD. The MOE estimate is interpreted as a human health risk of concern if the MOE estimate is less than the benchmark MOE (*i.e.*, the total UF). On the other hand, for this screening-level analysis, if the MOE estimate is equal to or exceeds the benchmark MOE, the exposure pathway is not analyzed further. Typically, the larger the MOE, the more unlikely it is that an adverse effect occurs relative to the benchmark. When determining whether a chemical substance presents unreasonable risk to human health or the environment, calculated risk estimates are not “bright-line” indicators of unreasonable risk, and EPA has the discretion to consider other risk-related factors in addition to risks identified in the risk characterization.

4.3.1.2 Estimation of Human Hazard Aggregate Risks

As described in Section 4.1.6.8, EPA considered aggregate risk across all routes of exposure for each individual consumer and occupational COU evaluated for intermediate and chronic exposure durations. To identify potential risks for aggregate exposure scenarios for workers (Section 4.3.2) and consumers (Section 4.3.2.4), EPA used the total MOE approach ([U.S. EPA, 2001](#)). For the total MOE approach, MOEs for each exposure route of interest in the aggregate scenario must first be calculated. The total MOE for the aggregate scenario can then be calculated using Equation 4-3.

Equation 4-3. Total Margin of Exposure Calculation

$$\text{Total MOE} = \frac{1}{\frac{1}{MOE_{\text{Oral}}} + \frac{1}{MOE_{\text{Dermal}}} + \frac{1}{MOE_{\text{Inhalation}}} \dots}$$

Total MOE risk estimates may be interpreted in relation to benchmark MOEs, as described in the preceding Section 4.3.1.1.

4.3.2 Risk Estimates for Workers

This section summarizes risk estimates for workers and ONUs from inhalation, dermal and aggregate exposures to TBBPA that result from each TBBPA COU and OES. This section also provides relevant information on PPE reported under the TBBPA test order and other sources such as OECD emission

scenario documents (ESDs) and EPA generic scenarios (GSs), National Institute for Occupational Safety and Health (NIOSH) Health Hazard Evaluations (HHEs) and published literature. Table 4-22 contains the risk estimates. Risks were calculated based on the TBBPA-derived PODs described in Section 4.2. For additional details on the risk estimates, refer to the *Draft Risk Calculator for Occupational Exposure for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026y](#)).

4.3.2.1 Information on PPE

Under section 4(a) of TSCA, EPA issued a test order requiring manufactures and processors of TBBPA to develop and submit information for TBBPA. In response, ACC TBBPA Consortium monitored workers and ONUs for inhalation exposure to TBBPA and reported the results in a study report ([Integral Consulting, 2025a](#)). As stated in Section 4.1.1.2.1, 21 companies of the consortium conducted operations involving TBBPA at a total of 25 sites in the U.S. Worker and ONU monitoring was done at a total of eight sites. The consortium selected these sites for sampling based on criteria that are summarized in Section 4.1.1.2.1. These criteria do not include any criterion that is related to PPE. The consortium collected information about PPE usage and the consortium's final study report ([Integral Consulting, 2025a](#)) contains information about PPE usage at these eight sites but does not contain any information about PPE usage at the remainder of the 25 sites of the consortium; a summary of this information follows.

There are three categories of PPE that are used at the sites at which worker and ONU monitoring was conducted which are as follows: baseline PPE, task-specific PPE, and emergency operations PPE. Baseline PPE is worn during normal operations on a full to near full-shift basis, task-specific PPE is "that which is used during specific tasks, worn for the duration of the task or during specific steps in the task as specified by a written work procedure", and emergency PPE is "only applied in the event of a disruption or emergent event (e.g., spill, leak) and is typically available in process areas. All the sites at which monitoring was conducted used similar baseline, task-specific, and emergency-use PPE, and each of these categories of PPE is described in Table 3-13 of the study report based on information reported by workers who participated in sampling. The type of PPE used by any given SEG at any of the eight sites, including the use of respirators, was dependent on the area of the site at which the work is done and the specific task performed. For example, maintenance technicians use additional PPE for specific maintenance tasks as necessary. another example is that ONUs used baseline process area PPE when conducting process walkthroughs or other tasks that required them to enter process areas while ONUs who worked as operators in adjacent work areas to those in which TBBPA work was conducted wore PPE specific to their process areas. Tables 3-13 to 3-16 of the final study report provide a compilation of the types of PPE used in production process, logistics, laboratory, and maintenance areas based on information reported by the workers who participated in sampling ([Integral Consulting, 2025a](#)).

Respiratory Protection

Respirators are not included in the baseline PPE and are only included in task-specific and emergency PPE according to Tables 3-13 to 3-16 of the test order report ([Integral Consulting, 2025a](#)). Therefore, none of the workers who participated in sampling was observed using a respirator for the entirety or near-entirety of the duration of their work-shift and these workers were only observed using respirators while conducting certain tasks. Operators at the sites at which sampling was conducted that are associated with Groups 2 and 4 wore half-faced air-purifying respirators during cutting bags of solid powders, loading and unloading tasks involving solid powders, trimming and sanding tasks, clean-up of solid powders, and repacking tasks. This corresponds to an assigned protection factor (APF) 10 or 50 when the employer implements a continuing, effective respiratory protection program under the OSHA Respiratory Protection Standard (29 CFR 1910.134). Operators at the sites at which sampling was conducted that are associated with the ACC TBBPA Consortium's Groups 2 and 3 wore full-face

respirators (APF 50–1,000) during cutting bags of solid powders, compounding and weighing solid powders, loading and unloading tasks involving solid powders and liquids, and cleaning equipment with solvents. ONUs were not reported to wear respiratory protection during any routine daily tasks. Emergency respiratory protections including escape respirators and self-contained breathing apparatus (SCBA) respirators were available in places such as control rooms at only two representative facilities. The use of emergency respirators was not observed during the inhalation sampling study ([Integral Consulting, 2025a](#)).

In addition to the final study report ([Integral Consulting, 2025a](#)), the ACC TBBPA Consortium provided data about Manufacturing and Repackaging OESs and a summary of this information follows. Regarding the manufacturing OES, A half-face respirator with cartridges was used at a former TBBPA manufacturing facility ([Albemarle, 2025b](#)). Regarding the repackaging OES, a half-face respirator with cartridges was used at Albemarle Corporation's Magnolia, Arkansas, site for transloading TBBPA from super sacks to trucks ([Integral Consulting, 2025c](#)). Albemarle currently conducts this transloading of TBBPA only at a toll site (contract facility) ([Albemarle, 2025a](#)). A particulate canister respirator was used while transloading TBBPA from super sacks to tracks at a contractor facility ([Integral Consulting, 2025a](#)). PPE used at a processing facility during the repackaging of TBBPA super sacks using robust engineering controls, which are described in Table 4-5, include N95 respirators. PPE used at another processing facility during the transfer of TBBPA from super sacks to a process vessel using less robust engineering controls, which are described in Table 4-5, include a full-face air-purifying respirator with vapor/acid filters and HEPA filters ([Integral Consulting, 2025c](#)).

Based on all the respiratory protection information provided by the ACC TBBPA Consortium, EPA assumed workers use an APF 10 respirator at the minimum during the period of 10 hours that a worker transloads TBBPA super sacks as part of the repackaging OES.

Dermal Protection

According to the test order final study report, generally, within the production process areas, baseline dermal PPE worn included nitrile, latex, PVC, or cut-resistant gloves and safety glasses, and task-specific PPE included neoprene, leather, or heat-resistant gloves ([Integral Consulting, 2025a](#)). Similarly, in logistics work areas, baseline dermal PPE included nitrile gloves and safety glasses and task specific PPE included cut-resistant gloves. In the laboratory areas, baseline dermal PPE included nitrile or latex gloves and a lab coat. There was no documentation on glove changeout, efficacy, or what was worn relative to each specific task.

In addition to the final study report ([Integral Consulting, 2025a](#)), the ACC TBBPA Consortium provided data about the Manufacturing and Repackaging OESs and a summary of this information follows. Regarding the manufacturing OES, PPEs used at a former TBBPA manufacturing facility included safety glasses, and disposable coveralls ([Albemarle, 2025b](#)). Regarding the repackaging OES, the PPEs that were used at Albemarle's Magnolia, Arkansas, site for transloading TBBPA from super sacks to trucks included a half-face respirator with cartridges, a paper suit outer garment, and gloves ([Integral Consulting, 2025c](#)). PPE used at a processing facility during the repackaging of TBBPA super sacks include leather gloves, and Tyvek suits. PPE used at another processing facility during the transfer of TBBPA from super sacks to a process vessel include fire-resistant uniforms, and chemical-protective gloves. ([Integral Consulting, 2025c](#)).

Information on PPE from Other Sources

OSHA's Respiratory Protection Standard (29 CFR 1910.134) requires employers in certain industries to address workplace hazards by implementing engineering control measures and, if these are not feasible, provide respirators that are applicable and suitable for the purpose intended. Respirator selection provisions are provided in 29 CFR 1910.134(d) and require that appropriate respirators are selected based on the respiratory hazard(s) to which the worker will be exposed and workplace and user factors that affect respirator performance and reliability. Assigned APFs are provided in Table 1 under 29 CFR 1910.134(d)(3)(i)(A) (see also Table 4-20 below) and refer to the level of respiratory protection that a respirator or class of respirators is expected to provide to employees when the employer implements a continuing, effective respiratory protection program according to the requirements of OSHA's Respiratory Protection Standard. OSHA has not established protection factors for gloves.

Table 4-20. Assigned Protection Factors for Respirators in OSHA Standard 29 CFR 1910.134

Type of Respirator	Quarter Mask	Half Mask	Full Facepiece	Helmet/Hood	Loose-Fitting Facepiece
a. Air-purifying respirator	5	10	50	—	—
b. Power air-purifying respirator (PAPR)	—	50	1,000	25/1,000	25
c. Supplied-air respirator (SAR) or airline respirator					
• Demand mode	—	10	50	—	—
• Continuous flow mode	—	50	1,000	25/1,000	25
• Pressure-demand or other positive-pressure mode	—	50	1,000	—	—
d. Self-containing breathing apparatus (SCBA)					
• Demand mode	—	10	50	50	—
• Pressure-demand or other positive-pressure mode (e.g., open/closed circuit)	—	—	10,000	10,000	—

Source: 29 CFR 1910.134(d)(3)(i)(A)

EPA also gathered information on PPE applicable to the OESs assessed in this draft risk evaluation that was available in other sources such as EPA-developed GSs, ACC memos, and OECD ESDs and NIOSH HHEs. This information is summarized below in Table 4-21.

Table 4-21. Other Information on PPE Not Reported by the ACC TBBPA Consortium

OES	PPE Information
Repackaging	The Chemical Repackaging GS indicates that information on typical PPE used at repackaging sites is limited. As examples, 1 chemical wholesaler list commonly used PPE such as safety glasses, face shields, aprons, and gloves, while engineering controls at another site include vacuum system and centrifugal degassing (U.S. EPA, 2022b).
Recycling	Rosenberg et al. (2011) stated that workers at three of the monitored sites wore respirators, but workers at one site did not use respirators. NIOSH HHEs for 2 e-waste recycling facilities both indicated that PPE included safety glasses, steel-toed boots, and cut-resistant gloves. Both HHEs stated that some employees voluntarily wore N95 respirators, but the HHE stated that workers were observed using the respirators incorrectly (Huang et al., 2019 ; Beaucham et al., 2018).

OES	PPE Information
Industrial and Commercial Additive Use in Electrical and Electronic Articles	None identified
Industrial and Commercial Use in Building and Construction Materials	None identified
Use of Powder Coatings in Electronics	None identified
Industrial Use in Plastic and Rubber Products	None identified
Commercial Use in Plastic and Rubber Products	None identified
Industrial and Commercial Laboratory Chemical Use	Use of Laboratory Chemicals GS indicated that the Occupational Exposure to Hazardous Chemicals in Laboratories standard (29 CFR 1910.1450) requires that laboratories have a written CHP (OSHA, 2011). The CHP must include criteria for the use of PPE and engineering controls. Examples of PPE include respirators, face shields, goggles, and disposable gloves. OSHA requires the use of eye or face protection where there is potential exposure from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation. Hand protection, such as gloves, is required when hands are exposed to hazards such as those from skin absorption of harmful substances, severe cuts or lacerations, severe abrasions, punctures, chemical and thermal burns, and harmful temperature extremes. Respiratory protection is required if necessary to protect the health of individuals (U.S. EPA, 2023b).
Disposal	None identified
CHP = chemical hygiene plan; e-waste = electronic waste; GS = generic scenario; HHE = Health Hazard Evaluation; NIOSH = National Institute for Occupational Safety and Health; OES = occupational exposure scenario; PPE = personal protective equipment	

4.3.2.2 Uncertainties with PPE Use and Protection Factors

Respirator APFs have technical significance but are generic values based on assumed workplace conditions, and usage of a specific respirator type does not guarantee achieving the generic APF during all use scenarios. Nevertheless, respirator APFs are based on specific conditions and approved by NIOSH in conjunction with OSHA regulations. Glove protection factors are more subjective than APFs applied to respirators due to the lack of regulatory standards aligning them with actual work practices. Again, OSHA does not have a comparable protection factor designation for dermal exposures.

Regarding the manufacturing COU, packagers/loaders used “dust respirators” prior to the year 2000 and afterwards used a half face respirator with particulate cartridge ([Integral Consulting, 2025b](#)). Regarding the repackaging COU, which is currently done at a toll site ([Albemarle, 2025a](#)), EPA is uncertain about the use of PPE. Regarding the processing and industrial use COUs that are associated with the test order, the test order final study report describes dermal and respiratory PPE used at the sites at which worker monitoring occurred. EPA considered whether the PPE used as reported in the test order final study report provides protection consistent with the Agency’s assessment of the PPE protection factor needed

for acceptable MOEs. Workers do not use respiratory protection PPE for full or near full-shift durations; respirators are only used while doing certain tasks ([Integral Consulting, 2025a](#)). As previously described, varying levels of respirator protection are associated with tasks described in the test order. For example, operators at ACC TBBPA Consortium's Group 2 and Group 4 representative facilities wore half-face air-purifying respirators while performing tasks such as: cutting bags of solid powders, loading and unloading tasks involving solid powders, trimming and sanding tasks, clean-up of solid powders, and repacking tasks, while operators at Group 2 and Group 3 representative facilities were described as wearing full-face respirators during similar tasks. The uncertainties are as follows: first, the reported PPE information is pertinent only in the case of 7 of the 25 sites of the ACC TBBPA Consortium. Second, respiratory PPE is not used by workers in general during an entire shift and is only used while doing certain tasks. Given the variation in tasks and reported respirator use associated with specific tasks, it is difficult to assume a consistent level of respiratory protection for an SEG. In conclusion, EPA is unable to confidently assess a minimum level of full-shift protection for the workers that are associated with the COUs that were assessed by the ACC TBBPA Consortium. However, it should be noted that the proper use of respiratory protection during high-exposure tasks will reduce the overall full-shift exposure. If these high-exposure tasks contribute a large percentage of potential exposure during a shift, then the proper use of PPE will likely reduce full-shift exposures.

4.3.2.3 Occupational Risk Estimates and Effect of PPE

This section provides summary tables for inhalation and dermal metrics and risks. The *Draft Occupational Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol]* (TBBPA) ([U.S. EPA, 2026v](#)) provides more detail on the estimation of the inhalation and dermal exposure metrics. For non-cancer effects, the TBBPA-specific HEC (inhalation) or HED (dermal) values (see Section 4.3.1) were divided by the value of the inhalation or dermal exposure metric for the effect to determine the MOE. This was then compared to the benchmark value to assess risks.

Table 4-22 provides MOEs associated with occupational inhalation, dermal and aggregate exposures, and any MOE value below the benchmark is highlighted in grey. All risk estimates for workers from high-end inhalation exposures are above the benchmark MOE for all COUs and OESs with the following exceptions: the COU of Manufacture, the COU of Repackaging/Scenario 2 (described in Table 4-5), the COU of Industrial and commercial use – Construction, paint, electrical, and metal products – Building/construction materials and the COU of Disposal. All risk estimates for workers from central tendency inhalation exposures are above the benchmark MOE for all COUs and OESs with the following exception: the COU of Repackaging/Scenario 2. All risk estimates for ONUs from inhalation exposures are above the benchmark MOE for all COUs and OESs. In the case of occupational inhalation exposures, the minimum APF needed for an MOE above the non-cancer benchmark is stated. It should be noted that in addition to the use of respirators that achieve a minimum APF, these benchmarks may be met by implementation of other exposure controls (*e.g.*, engineering controls) that may be equally or more effective in reducing worker exposure.

For OESs with inhalation MOEs above the benchmark, aggregate risks were only below the benchmark MOE for high-end chronic risk estimates for ACC TBBPA Consortium's Group 2: Production of Intermediate Products (Liquid, Semi-Solid, And Powder) from TBBPA Powder, Industrial and Commercial Additive Use in Electrical and Electronic Articles, and Use of Powder Coatings in Electronics. However, high-end dermal exposure is based on maximal flux through the surface area of two hands, which is an upper bound that likely overestimates exposure. Additionally, some workers in ACC TBBPA Consortium's Group 2 wore half-face air-purifying respirators or full-face respirators while performing tasks such as: cutting bags of solid powders, loading and unloading tasks involving solid powders, trimming and sanding tasks, clean-up of solid powders, and repacking tasks. Therefore,

EPA does not expect that aggregation of high-end inhalation and dermal exposure estimates correlate with risks to worker populations.

Manufacture

No risk estimates were below the benchmark MOE of 30 for dermal exposures. Inhalation exposures resulted in risk estimates below the benchmark for high-end inhalation intermediate (MOE = 25), and chronic (MOE = 18) exposures. Inhalation exposures were above the benchmark for central tendency inhalation exposures. Inhalation and dermal aggregate exposures resulted in risk estimates below the benchmark MOE of 30 for intermediate (MOE = 20), and chronic (MOE = 15) exposures. The inhalation exposure assessment method is described in Table 4-5. As described in this table, EPA assessed inhalation exposure concentrations based on surrogate data that are total dust personal worker monitoring data. These data were collected by monitoring TBBPA manufacturing workers during the manufacture of TBBPA at Albemarle Corporation's Magnolia, Arkansas, site between July 2003 and November 2021 and were collected by Albemarle Corporation as surrogate TBBPA inhalation exposure surrogate data because a TBBPA sampling and analysis method was lacking ([Integral Consulting, 2025b](#)). The weight of scientific evidence is discussed in Table 4-9. Total dust worker monitoring data were adequate as surrogate data because worker exposure to TBBPA involves mostly exposure to dust, TBBPA is the only powder that was produced in the facility associated with the monitoring data, and the exposure concentrations of workers who worked in this facility in areas that do not contain TBBPA were less than the limit of detection. The monitoring data comprises 10 PBZ samples. Although worker tasks are unknown, the job titles of the monitored workers are known and are as follows: operators, one maintenance worker, one E&I technician, and packagers. The assessed full-shift TWA central tendency and high-end exposure concentrations, which are 0.8 and 2.8 mg/m³, respectively are similar to values reported in the literature ([Integral Consulting, 2025b](#); [ECB, 2008](#)). In conclusion, EPA has moderate confidence that the assessed exposure concentrations, including the assessed high-end value, are representative of the OES and are not overestimates of actual potential exposure because the monitoring data are adequate as surrogate data, the variability in job title of the monitored workers precludes exposure concentrations of the likely highest exposed group such as packagers, and the data are comparable to literature data.

Repackaging

Scenario 2: No risk estimates were below the benchmark MOE of 30 for dermal exposures. Inhalation exposures resulted in risk estimates below the benchmark for central tendency inhalation intermediate (MOE = 3.3), and chronic (MOE = 3.7) exposures, and high-end inhalation intermediate (MOE = 1.2), and chronic (MOE = 1.3) exposures. The inhalation exposure assessment method is described in Table 4-5. As described in this table, EPA assessed inhalation exposure concentrations based on surrogate data that are TBBPA task-length PBZ worker monitoring data. These data were collected by monitoring workers who transferred TBBPA powder from super sacks into a reactor at a TBBPA processing site (Scenario 2, Table 4-22) and were submitted by the ACC TBBPA Consortium as surrogate TBBPA inhalation exposure surrogate data for the OES of Repackaging ([Integral Consulting, 2025c](#)). As stated in the test order, no full-shift PBZ samples were collected for the repackaging OES. These short-term samples were converted to 12-hour TWA full-shift samples by assuming workers would be unloading for 10 hours out of a 12-hour shift at repackaging facilities.

It is important to note that risk estimates associated with this scenario assume that workers are exposed to the same levels as taken during these task-length samples (15–25 minutes) for 10 hours out of the 12-hour work day. In other words, EPA assumes the worker performed unloading/loading tasks for the majority of their work shift. Therefore, EPA conducted a sensitivity analysis varying the time a worker would spend during these tasks, including a 5-hour duration which aligns with the duration reported for

loading one truckload of TBBPA at the manufacturing/repackaging facility prior to cessation of repackaging at that site and moving to the tolling facility. In addition, a 30-minute duration was included which is comparable to the duration of the task-length samples (15–25 minutes) taken at the processing facility.

The risk estimates for these refined analyses of different daily durations are included in Table 4-23. Importantly, even after refining EPA's analysis, risk estimates for repackaging Scenario 2 were still below the benchmark for workers repackaging for:

- 5 hours per day (comparable to the time to unload one truck per day at the repackaging facility) at this exposure level during the 12-hour work day at both central tendency and high-end for intermediate duration (MOE = 2.4 – 6.8) and at central tendency (MOE = 7.5) and high-end (MOE = 2.6) for chronic duration;
- 1 hour per day at this exposure level during each 12-hour work day at high-end for intermediate duration (MOE = 12) and high-end (MOE = 13) for chronic duration; and
- 30 minutes (comparable to the task-based sample duration) each 12-hour work day at high-end for intermediate (MOE = 24) and chronic (MOE = 26) duration.

EPA considers it feasible that workers would be performing repackaging in an environment represented by the surrogate inhalation monitoring data for 30 minutes to 5 hours per day, based on the sample duration for the task based samples and the reported time required for the unloading/repackaging of a truck at the manufacturing/repackaging facility. Importantly, these worker exposure scenarios align with the hazard studies in which polycystic kidney lesions were observed in neonatal male rats exposed to TBBPA via daily oral gavage for intermediate duration (approximately three weeks during lactation), and atypical endometrial hyperplasia in adult female rats following two years of daily oral exposure.

PBZ full-shift inhalation samples were collected at an additional site (Scenario 1, Table 4-22) which showed worker MOEs above the benchmark MOE for all durations (central tendency inhalation intermediate [MOE = 187], chronic [MOE = 206], high-end intermediate inhalation [MOE = 104], chronic [MOE = 114]). Additionally, the short-term and full-shift exposure concentrations from Scenario 1 were one to two orders of magnitude below the inhalation exposures for Scenario 2.

The weight of scientific evidence is discussed in Table 4-9. There is uncertainty in the representativeness of the surrogate worker exposure data to the OES of interest. The similarities of the worker activities, task duration and frequency to the assessed OES at an unknown tolling site cannot be determined with current information. The position of the worker relative to the source of exposure, the location (indoor versus outdoor) of the worker activities at the tolling site and the impacts on exposure are unknown. The performance of the assessed worker tasks in conjunction with other worker activities and the subsequent impacts on the assessed worker tasks exposures are uncertain. Furthermore, the extent of engineering controls at the tolling site is unknown. In conclusion, EPA has moderate confidence that the assessed exposure concentrations, including the assessed high-end value, are representative of the OES and are not overestimates of actual potential exposure because the monitoring data are adequate as surrogate data, and the assessed exposure duration is reasonable.

Industrial and Commercial Use – Construction, Paint, Electrical, And Metal Products – Building/Construction Materials

No risk estimates were below the benchmark MOE of 30 for dermal exposures. Inhalation exposures resulted in risk estimates below the benchmark for high-end inhalation intermediate (MOE = 21), and chronic (MOE = 16) exposures. Inhalation and dermal aggregate exposures resulted in risk estimates below the benchmark MOE of 30 for intermediate (MOE = 17), and chronic (MOE = 13) exposures.

Inhalation exposures were above the benchmark for central tendency inhalation and aggregate exposures. The inhalation exposure assessment method is described in Table 4-5. As described in this table, EPA assessed inhalation exposure concentrations based on (1) surrogate data, which are total dust PNOR PBZ worker monitoring data for workers associated with NAICS code 23 and (2) the maximum possible concentration of TBBPA in pipe and fittings. The weight of scientific evidence is discussed in Table 4-9. As stated in this table, EPA has slight to moderate confidence in the assessment results. For the purpose of risk characterization, EPA discounts the MOEs that EPA calculated from the assessed worker high-end exposure concentration for the following reasons:

1. EPA does not expect the use of pipe and fittings in construction to result in generation of particulate material from the pipe and fittings such that there is worker inhalation exposure to these particulates as dust and the concentration of this dust is equal to the total dust PNOR concentrations of the PNOR model for NAICS code 23, especially the high-end concentration of 15 mg/cm³ given that this concentration is equal to the OSHA total dust PNOR PEL.
2. EPA assessed the high-end exposure concentration from the high-end total dust PNOR concentration and the concentration of TBBPA in pipe and fittings, which is the maximum expected concentration in a product that would be used in construction. This results in an unlikely high-end exposure concentration.
3. As summarized in Table 3-1, the concentration of TBBPA in all other construction products other than pipe and fittings is very low even in the case of additive use of TBBPA and is not expected to result in worker inhalation exposure.

Disposal

No risk estimates were below the benchmark MOE of 30 for dermal exposure. Inhalation exposures resulted in risk estimates below the benchmark for high-end inhalation intermediate (MOE = 21), and chronic (MOE = 16) exposures. Inhalation and dermal aggregate exposures resulted in risk estimates below the benchmark MOE of 30 for intermediate (MOE = 17), and chronic (MOE = 13) exposures. Inhalation exposures were above the benchmark for central tendency inhalation exposures. The inhalation exposure assessment method is described in Table 4-5. As described in this table, EPA assessed inhalation exposure concentrations based on (1) surrogate data which are total dust PNOR 8-hour full-shift PBZ worker monitoring data for workers associated with NAICS code 56 and (2) the greatest mass fraction of TBBPA in products containing TBBPA that are used commercially or by consumers. The weight of scientific evidence is discussed in Table 4-9. As stated in this table, EPA has slight to moderate confidence in the assessment results but the Agency has high confidence that the assessment results overestimate actual exposures, especially in the case of the high-end estimate. For the purpose of risk characterization, EPA discounts the MOEs that EPA calculated from the assessed worker high-end exposure concentration because of the following reasons:

1. EPA does not expect the disposal of articles that are made using TBBPA additively such as waste electrical and electronic equipment to result in the degradation of these articles and the generation of particulate material from them such that there is worker inhalation exposure to these particulates as dust and the concentration of this dust is equal to the total dust PNOR concentrations of the PNOR model for NAICS code 56, especially the high-end concentration of 15 mg/cm³ given that this concentration is equal to the OSHA total dust PNOR PEL.
2. EPA assessed the high-end exposure concentration from the high-end total dust PNOR concentration and the greatest mass fraction of TBBPA in products containing TBBPA that are used commercially or by consumers. This results in an unlikely high-end exposure concentration.

3000

Table 4-22. Occupational Risk Summary Table^a

Life Cycle Stage – Category	Subcategory	OES	Population	Exposure Level	Inhalation Risk Estimates (Benchmark MOE = 30)			Dermal Risk Estimates (Benchmark MOE = 30)		Aggregate Risk Estimates (Benchmark = 30)		
					Int.	Chronic	APF ^b	Int.	Chronic	Int.	Chronic	APF ^b
Manufacture – Domestic manufacture	Domestic manufacture	Manufacturing	Average adult worker	CT	88	65	–	187	137	60	44	–
				HE	25	18	APF 10	93	69	20	15	APF 10
			ONU	CT	88	65	–	187	137	60	44	–
Manufacture – Import	N/A	N/A	N/A ^c									
Repackaging	Repackaging	Repackaging of TBBPA powder	Scenario 1	CT	187	206	–	187	137	93	82	–
				HE	104	114	–	93	69	49	43	–
			Scenario 2	CT	3.3	3.7	APF 10	187	137	3.3	3.6	APF 25
				HE	1.2	1.3	APF 50	93	69	1.2	1.3	APF 50
			ONU	CT	187	206	–	187	137	93	82	–
Processing – Incorporation into formulation, mixture, or reaction product	Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing	ACC TBBPA Consortium’s Group 1: Production of Formulations (Particulate Solids) from TBBPA Powder	Processing operator	CT	427	314	–	187	137	130	96	–
				HE	223	164	–	93	69	66	48	–
			User operator	CT	3.6E03	2.7E03	–	187	137	178	131	–
				HE	2.1E03	1.6E03	–	93	69	90	66	–
			ONU	CT	1.3E05	9.4E04	–	187	137	187	137	–
				HE	1.0E05	7.5E04	–					–

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Life Cycle Stage – Category	Subcategory	OES	Population	Exposure Level	Inhalation Risk Estimates (Benchmark MOE = 30)			Dermal Risk Estimates (Benchmark MOE = 30)		Aggregate Risk Estimates (Benchmark = 30)		
					Int.	Chronic	APF ^b	Int.	Chronic	Int.	Chronic	APF ^b
Processing – As a reactant; Processing – Incorporation into formulation, mixture, or reaction product	Flame retardant in plastic material and resin manufacturing;	ACC TBBPA Consortium’s Group 2: Production of Intermediate Products (Liquid, Semi-Solid, And Powder) from TBBPA Powder	Processing operator	CT	1.1E04	7.9E03	–	187	137	184	135	–
	Intermediate in all other chemical product and preparation manufacturing;			HE	60	44	–	93	69	37	27	–
	Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing;		Laboratory technician	CT	3.3E05	2.5E05	–	187	137	187	137	–
	Adhesive manufacturing			HE	1.7E05	1.2E05	–	93	69	93	69	–
			ONU	CT	5.0E04	3.7E04	–	187	137	186	137	–
				HE	3.4E03	2.5E03	–			177	130	–

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Life Cycle Stage – Category	Subcategory	OES	Population	Exposure Level	Inhalation Risk Estimates (Benchmark MOE = 30)			Dermal Risk Estimates (Benchmark MOE = 30)		Aggregate Risk Estimates (Benchmark = 30)		
					Int.	Chronic	APF ^b	Int.	Chronic	Int.	Chronic	APF ^b
Processing – Incorporation into formulation, mixture, or reaction product; Processing – Incorporation into articles	Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing; Reactive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., printed circuit boards and semiconductor packages); Reactive flame retardant in transportation equipment manufacturing (e.g., interior material for automotive and aviation articles) Additive flame retardant in: Computer and electronic product manufacturing;	ACC TBBPA Consortium’s Group 3: Production of Intermediate Solid Products (Sheet, Film, and Pellet) from the Products of Group 2	Processing operator	CT	2.5E05	1.8E05	–	187	137	187	137	–
				HE	1.7E05	1.3E05	–	93	69	93	69	–
			User operator	CT	1.0E05	7.5E04	–	187	137	187	137	–
				HE	6.6E03	4.9E03	–	93	69	92	68	–
			Laboratory technician	CT	7.6E05	5.6E05	–	187	137	187	137	–
				HE	3.3E04	2.5E04	–	93	69	93	68	–
			Logistics technician	CT	3.2E05	2.3E05	–	187	137	187	137	–
				HE	1.6E05	1.2E05	–	93	69	93	69	–
			Maintenance technician	CT	1.2E05	9.0E04	–	187	137	187	137	–
				HE	8.7E04	6.4E04	–	93	69	93	69	–

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Life Cycle Stage – Category	Subcategory	OES	Population	Exposure Level	Inhalation Risk Estimates (Benchmark MOE = 30)			Dermal Risk Estimates (Benchmark MOE = 30)		Aggregate Risk Estimates (Benchmark = 30)		
					Int.	Chronic	APF ^b	Int.	Chronic	Int.	Chronic	APF ^b
	Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., plastic electronic enclosures)		ONU	CT	7.0E05	5.2E05	–	187	137	187	137	–
				HE	7.4E04	5.4E04	–			186		–
Industrial and commercial use – Construction, paint, electrical, and metal product	Reactive flame retardant in electrical and electronic articles;	ACC TBBPA Consortium’s Group 4: Production of Composite Parts from Prepreg and Adhesive Film	User operator	CT	8.2E05	6.1E05	–	187	137	187	137	–
				HE	2.7E05	2.0E05	–	93	69	93	69	–
	Logistics technician		CT	1.1E06	7.9E05	–	187	137	187	137	–	
			HE	5.4E05	4.0E05	–	93	69	93	69	–	
	Maintenance technician		CT	1.1E06	7.9E05	–	187	137	187	137	–	
			HE	5.4E05	4.0E05	–	93	69	93	69	–	
	ONU		CT	7.6E05	5.6E05	–	187	137	187	137	–	
			HE	7.3E05	5.4E05	–					–	
Processing – Recycling	Recycling	Recycling	Average adult worker	CT	5.0E07	3.7E07	–	187	137	187	137	–
				HE	2.4E05	1.8E05	–	93	69	93	69	–
			ONU	CT	5.0E07	3.7E07	–	187	137	187	137	–
Industrial and commercial use – Construction, paint, electrical, and metal product	Additive flame retardant in electrical and electronic articles (i.e., plastic enclosures)	Industrial and Commercial Additive Use in Electrical and Electronic Articles	Average adult worker	CT	1.1E03	781	–	187	137	159	117	–
				HE	58	43	–	93	69	36	26	–
			ONU	CT	1.1E03	781	–	187	137	159	117	–
Industrial and commercial use – Construction, paint, electrical, and metal products	Building/construction materials	Industrial and Commercial Use in Building and Construction Materials	Average adult worker	CT	132	98	–	187	137	78	57	–
				HE	21	16	APF 10	93	69	17	13	APF 10
			ONU	CT	132	98	–	187	137	78	57	–

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Life Cycle Stage – Category	Subcategory	OES	Population	Exposure Level	Inhalation Risk Estimates (Benchmark MOE = 30)			Dermal Risk Estimates (Benchmark MOE = 30)		Aggregate Risk Estimates (Benchmark = 30)		
					Int.	Chronic	APF ^b	Int.	Chronic	Int.	Chronic	APF ^b
Industrial and commercial use – Construction, paint, electrical, and metal products	Powder coatings	Use of Powder Coatings in Electronics	Average adult worker	CT	350	258	–	187	137	122	90	–
				HE	47	34	–	93	69	31	23	–
			ONU	CT	350	258	–	187	137	122	90	–
Industrial use – Packaging, paper, plastic, hobby products	Plastic and rubber products	Industrial Use in Plastic and Rubber Products	Average adult worker	CT	8.2E05	6.1E05	–	187	137	187	137	–
				HE	2.9E05	2.1E05	–	93	69	93	69	–
			ONU	CT	7.6E05	5.6E05	–	187	137	187	137	–
				HE	7.3E05	5.4E05	–					–
Commercial use – Packaging, paper, plastic, hobby products	Plastic and rubber products	Commercial Use in Plastic and Rubber Products	Qualitative assessment									
Industrial and commercial use – Other	Other	Industrial and Commercial Laboratory Chemical Use	Average adult worker	CT	1.1E06	7.9E05	–	187	137	187	137	–
				HE	2.8E04	2.1E04	–	93	69	93	68	–
			ONU	CT	1.1E06	7.9E05	–	187	137	187	137	–
				HE	1.1E06	7.9E05	–					–
Disposal	Disposal	Disposal	Average adult worker	CT	127	94	–	187	137	76	56	–
				HE	21	16	APF 10	93	69	17	13	APF 10
			ONU	CT	127	94	–	187	137	76	56	–

APF = assigned protection factor; CT = central tendency; HE = high-end; Int. = intermediate dose; MOE = margin of exposure; N/A = not applicable; OES = occupational exposure scenario; PF: protection factor

^a Risk not estimated for acute, non-cancer as no HEC or POD derived.

^b APF/PF listed is the level of protection needed for estimated inhalation MOEs to be above benchmark. Risk estimates that exceed the benchmark (*i.e.*, non-cancer risks < benchmark) are **bolded and shaded**.

^c Importation results in potential exposure once the contents of imported containers are transferred for repackaging or processing. Repackaging of imported containers is part of the repackaging OES and unloading of imported containers for processing is part of the OESs involving TBBPA processing.

“–” Inhalation APF/Dermal PF not needed.

Table 4-23. Additional Risk Estimates to Workers from Repackaging Tasks Ranging from 30 Minutes to 11 Hours of a 12-Hour Workday

Exposure Level	MOEs from Intermediate Duration Exposure				MOEs from Chronic Duration Exposure			
	10-Hour Task	5-Hour Task	1-Hour Task	30-Minute Task	10-Hour Task	5-Hour Task	1-Hour Task	30-Minute Task
CT	3.3	6.8	34	68	3.7	7.5	37	75
HE	1.2	2.4	12	24	1.3	2.6	13	26

CT = central tendency; HE = high-end; MOE = margin of exposure
Risk estimates that exceed the benchmark (*i.e.*, non-cancer risks < benchmark) are **bolded and shaded**.

4.3.2.4 Overall Confidence in Occupational Risk Estimates

Confidence in the inhalation exposure estimates that are based on surrogate inhalation exposure monitoring data are moderate because the data are surrogate data. As discussed in 4.1.1.2.2, these surrogate data include total dust data collected at a TBBPA manufacturing facility, and TBBPA inhalation exposure monitoring data that are test order data. Confidence in the inhalation exposure estimates that are derived from the TBBPA inhalation exposure test order data are robust because the design and execution of the test order study as summarized in 4.1.1.2.1. Although the data are of high quality or medium quality, confidence is only moderate because the data are incorporated into the assessment as surrogate data. That is, there is some uncertainty about whether the data are pertinent. Confidence in the inhalation exposure estimates that are calculated in accordance with EPA's PNOR model are moderate. Overall, EPA has robust or moderate confidence for inhalation risk estimates calculated for workers and ONUs. EPA has moderate confidence in dermal exposure and risk estimates for all OESs. EPA estimated dermal exposures from TBBPA dermal absorption data that was obtained from the test order, and there is moderate confidence that dermal risk estimates for workers and ONUs represent the upper bounds of exposure for these populations. EPA did not present a quantitative risk estimate for inhalation exposure for the Commercial Use in Plastic and Rubber Products because it was assessed qualitatively. That qualitative assessment of the scenario is discussed in *Draft Occupational Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026v](#)).

As described in Section 4.2, EPA has robust overall confidence in the HEDs selected to characterize risk from intermediate and chronic duration oral and dermal exposures to TBBPA, and EPA has moderate overall confidence in the HECs selected to characterize from intermediate and chronic exposures to TBBPA. There is some uncertainty in the assumption that 100% of the inhaled TBBPA will be absorbed. If absorption of inhaled TBBPA is less than 100%, then the resulting inhalation HEC and risk estimates would shift proportionally. For example, if absorption via inhalation were 50%, then the corresponding shift in the inhalation POD would result in a 50% reduction in risk. As described in Section 4.1.4 and the *Draft Occupational Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026v](#)), EPA's confidence in the inhalation exposure estimates varies by OES with confidence that ranges from slight to robust. Further, EPA has moderate confidence that dermal exposure estimates, which are based on maximal measured flux, represent an upper bound of exposure.

4.3.3 Risk Estimates for Consumers

Table 4-24 summarizes the dermal, inhalation, ingestion, and aggregate MOEs that characterize non-cancer risk for intermediate and chronic exposure to TBBPA. Acute risks were not evaluated because acute toxicity of TBBPA is not expected ([U.S. EPA, 2026t](#)). Intermediate exposures were not estimated for TBBPA's Additive use in electrical and electronic articles and 3D filament. For these scenarios, EPA

assumed daily use throughout the year; chronic values are thus expected to adequately capture intermediate exposure. Aggregate MOEs for all COUs and life stages were only calculated for the high intensity use exposure scenario unless MOEs are below the benchmark of 30. Risk characterization is based on the most robust non-cancer endpoint for all relevant exposure durations (*i.e.*, polycystic kidney lesions for intermediate and atypical endometrial hyperplasia uterine lesions for chronic).

No MOEs were below the benchmark of 30 for all consumer COUs and the high-intensity exposure scenarios (Table 4-24). The consumer analysis relies on conservative assumptions to characterize what would be expected to be at the high-end of the expected exposure distribution. The lowest MOE is 106 across all COUs, use intensities, exposure durations, and life stages. That risk estimate corresponds to chronic aggregate exposure for infants under one year of age for the Reactive flame retardant in automotive and aviation articles (*i.e.*, laminate and prepreg material) COU. Exposure and risk estimates for all COUs and life stages are driven by the inhalation route, followed by dust ingestion and mouthing, and then dermal. Inhalation MOEs are still an order of magnitude above benchmark, ranging from 113 to 800 for all COUs. For other exposure routes, MOEs are two, and for some life stages, five orders of magnitude above benchmark.

Risk estimates are important to highlight for the Additive flame retardant use in electronics and electrical articles (*i.e.*, plastic enclosure) COU and the Reactive flame retardant in automotive and aviation articles (*i.e.*, laminate and prepreg material) COU. These two COUs incorporated overly protective if not unrealistic assumptions in the screening-level evaluation. For TBBPA's Additive use in electronics and electrical articles, EPA equated the cumulative surface area of all electronics and electrical articles to the entire floor surface area of a median household (2,561 ft² or 52 85-inch TVs). This assumption was made because of TBBPA's widespread use in the plastic enclosure of electronics and electrical articles. This includes computers, mobile phones, TVs, refrigerators, printers, laptops, computer monitors, tablets, electric toothbrushes, hair straighteners, audio and video devices, keyboards, small kitchen appliances (*e.g.*, microwaves, toasters), or garden tools ([NICNAS, 2020](#); [e.V., 2019](#); [TERA, 2015](#)). A comprehensive list of articles containing TBBPA is unavailable to narrow the scope of this assessment. Additionally, the number and types of electronics in a household are both ubiquitous and highly variable. All risk estimates, even with this improbable assumption, were above the benchmark of 30: MOEs 207 to 800 for inhalation route, MOEs above 1,000 for ingestion, dermal, and mouthing, and aggregate MOEs 152 to 730. The lowest MOEs for this COU are associated with infants under one year of age. A possible reason the risk estimates were above benchmark despite the unrealistic assumption is TBBPA's very low volatility. With a vapor pressure of 4.68×10^{-8} mm Hg at 25 °C (Table 2-1), TBBPA's emissions from solid articles (*e.g.*, mass transfer to air) is limited.

For the reactive flame retardant in automotive and aviation articles (*i.e.*, laminate and prepreg material) COU, EPA assessed consumer exposure according to flight durations for cabin crew members and limits established by FAA. Cabin crew flying patterns were used because no data were available to represent the overall consumer population, but they are expected to encompass those of non-crew members. EPA assumed that cabin crew members will fly 14 hours a day with 10 hours of rest time until they reach FAA's limit on monthly or annual flight hours. This scenario borders on unrealistic because FAA requires a minimum of 11 hours in between such long flights. It also assumed that flight crew will reach their flying maximum in a short period: 100 hours in 7.1 days for intermediate and 1,000 hours in 100 days for chronic durations. However, EPA selected this flying frequency given CEM limitations and to consolidate exposure to capture a possible upper bound from continuous exposure. This assumption still did not result in risk estimates below the benchmark. All MOEs were at least one order of magnitude above the benchmark of 30. For an intermediate duration, MOEs ranged from 727 to 3.30×10^6 across all exposure routes. For chronic, MOEs ranged from 113 to 1.86×10^6 . Chronic aggregate MOEs ranged

3090 from 106 to 426. The lowest MOEs for this COU are associated with infants under one year of age.
3091 Similar to the Additive flame retardant use in electronics and electrical articles (*i.e.*, plastic enclosure)
3092 COU, exposure to TBBPA is likely limited by its very low vapor pressure. It is also important to note
3093 another protective assumption that was integrated into this scenario. The weight fraction of the aircraft
3094 component of the starting prepreg was used rather than the estimated weight fraction of the final aircraft
3095 composite. The former is three orders of magnitude lower than in the final material. Ultimately, MOEs
3096 still were above benchmark of 30 by at least one order of magnitude, and for some life stages and
3097 exposure routes, even five orders of magnitude.

3098 **Table 4-24. Consumer Risk Summary Table**

Consumer Use Category – Subcategory	Product or Article	Duration	Exposure Route ^a	Exposure Scenario ^b	Lifestage (years) MOE (Benchmark MOE = 30)						
					Infant (<1 year)	Toddler (1–2 years)	Preschooler (3–5 years)	Middle Childhood (6–10 years)	Young Teen (11–15 years)	Teenager (16–20 years)	Adult (21+ years)
Additive flame retardant in electrical and electronic articles (i.e., plastic enclosures)	Electrical and electronic articles with plastic enclosures	Chronic	Inhalation	H	207	220	270	388	550	642	800
			Ingestion	H	1.15E03	1.94E03	3.66E03	7.40E03	1.48E04	3.15E04	3.47E04
			Dermal	H	2.14E03	5.01E03	6.40E03	8.33E03	1.07E04	1.18E04	1.11E04
			Mouthing	H	2.51E03	9.58E03	1.89E04	–	–	–	–
			Aggregate	H	152	186	239	353	505	597	730
Reactive flame retardant in automotive and aviation articles (i.e., laminate and prepreg material)	Aircraft components	Intermediate	Inhalation	H	727	771	949	1.36E03	1.93E03	2.26E03	2.81E03
			Ingestion	H	9.22E03	7.45E03	6.59E03	1.88E04	3.36E04	4.23E04	9.45E04
			Dermal	H	6.01E05	1.41E06	1.80E06	2.34E06	3.01E06	3.13E06	3.30E06
			Aggregate	H	Not estimated because all MOEs above benchmark for chronic, which is the more exposed scenario.						
		Chronic	Inhalation	H	113	120	148	212	301	351	438
			Ingestion	H	1.63E03	1.32E03	1.17E03	3.31E03	5.90E03	7.43E03	1.65E04
			Dermal	H	3.38E05	7.91E05	1.01E06	1.31E06	1.69E06	1.76E06	1.86E06
			Aggregate	H	106	110	131	199	286	355	426
Plastic and rubber products	3D printing filament	Chronic	Inhalation	H	137 ^c	145 ^c	179 ^c	257 ^c	201	255	295
			Ingestion	H	1.03E03 ^c	1.00E03 ^c	2.46E03 ^c	4.21E03 ^c	6.98E03	8.80E03	9.84E03
			Aggregate	H	121 ^c	127 ^c	167 ^c	242 ^c	195	248	287

^a An exposure route that is not listed was not evaluated, such as mouthing of aircraft components or 3D printing filament.

^b Exposure scenario intensities included low (L), medium (M), and high (H). However, this table presents only the high intensity use because MOEs were all above benchmark.

^c Modeled as bystanders.

3099

4.3.3.1 Overall Confidence in Consumer Risk Estimates

Variability in MOEs for these high-intensity exposure scenarios results from different exposure factors for each COU and products/articles that led to different exposure estimates. As described in Section 4.1.5.4 of this document and the *Draft Consumer and Indoor Dust Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* (U.S. EPA, 2026e), EPA has slight to robust confidence in the exposure estimates. EPA has robust confidence in the health hazard values used to estimate risks for these COUs (U.S. EPA, 2026t). Confidence in the exposure and risk estimates is slight only for the inhalation route for Construction, paint, electrical, and metal products; additive flame retardant in electrical and electronic articles (*i.e.*, plastic enclosures) COU. This is because of the high uncertainties in using an unrealistic surface area of electrical and electronic articles in the household. While improbable, MOEs are still one order of magnitude above the benchmark of 30. This gives EPA robust confidence that the risk estimates are protective despite slight confidence in the precision of the exposure estimates. Other exposure routes—ingestion of dust or through mouthing and dermal contact—have a robust or moderate confidence because they do not require the surface area of the articles.

For all other assessed COUs and scenarios, EPA has moderate confidence in the risk estimates. This includes exposure to aircraft components that assumed extensive flying within a short period and a high weight fraction in the final aircraft composite. Nevertheless, confidence in other key parameters (*e.g.*, interior surface area and air exchange rates) was robust to result in an overall confidence of moderate for the aircraft scenarios. When not unrealistic, EPA is also confident that the high-intensity use scenarios represent an upper-bound of exposure and provide a health protective risk estimate for consumer exposures.

4.3.4 Risk Estimates for General Population

General population exposure is discussed using a screening approach detailed in Section 4.1.6. EPA qualitatively assessed exposure resulting from biosolid application, landfills, and from swimming in surface waters affected by releases. For its quantitative assessment, EPA used an MOE approach discussed in Section 4.3.1 using upper-bound exposure estimates to screen for potential non-cancer risks. If there is no risk for the general population based on the highly conservative screening approach and upper-bound exposure estimates, then EPA does not expect any exposure estimates based on lower releases and exposure factors will result in risk either. If MOEs below a benchmark of 30 were estimated using these conservative approaches, then additional, more refined analyses for the respective pathway would be conducted using higher tiers of modeling when available, refinement of exposure estimates, and exposure estimates for additional subpopulations and COUs/OES. However, EPA found through its screening-level assessment that all MOEs calculated for each general population exposure scenario including ingestion of drinking water (Section 4.3.4.1), ingestion of fish (Section 4.3.4.2), inhalation of ambient air (Section 4.3.4.3), ingestion of soil from air to soil deposition (Section 4.3.4.3), and ingestion of human milk (Section 4.3.4.4) were above the benchmark MOE of 30. Therefore, no refinements to the screening-level analysis were conducted.

4.3.4.1 Drinking Water Risk Estimates

For the drinking water pathway, EPA used modeled surface water concentrations to estimate drinking water exposures in Section 4.1.6.3. Corresponding screening-level risk estimates are shown in Table . The MOE for general population exposure through drinking water exposure was above the benchmark of 30 for all scenarios assessed (Table 4-24). This screening-level assessment conservatively assumes that concentrations at the point of intake for the drinking water system are equal to the concentrations in the receiving water body at the point of release, where treated effluent is being discharged from a facility. In reality, some distance between the point of release and a drinking water intake would be

3146 expected, providing distance and time for additional reductions in water column concentrations via
3147 degradation, partitioning, and dilution. Some form of additional treatment would typically be expected
3148 for surface water at a drinking water treatment plant, including coagulation, flocculation, sedimentation,
3149 and/or filtration. This treatment would likely result in even greater reductions in TBBPA concentrations
3150 prior to releasing finished drinking water to customers. Based on this screening-level analysis assessing
3151 the COUs associated with the highest release to water, no other COUs are expected to have MOEs
3152 below the benchmark of 30 for an intermediate or chronic exposure scenario.

Scenario	Release Days	Water Column Concentrations		Adult (21+ years)		Infant (Birth to <1 year)		Toddler (1–5 years)	
		30Q5 Conc. (µg/L)	HM Conc. (µg/L)	Int. MOE	Chronic MOE	Int. MOE	Chronic MOE	Int. MOE	Chronic MOE
Processing – as a reactant – flame retardant in plastic material and resin manufacturing	350	3.59E–04	1.56E–04	4.70E08	2.68E09	1.34E08	1.05E09	3.80E08	2.44E09
	4	3.14E–02	N/A ^a	5.38E06	N/A ^a	1.53E06	N/A ^a	4.31E06	N/A ^a
Processing – incorporation into formulation, mixture, or reaction product – flame retardant in plastic material and resin manufacturing; plastics product manufacturing; custom compounding of purchased resins; paint and coating manufacturing	12	9.39	N/A ^a	1.80E04	N/A ^a	5.13E03	N/A ^a	1.44E04	N/A ^a
Disposal	12	8.52	N/A ^a	1.98E04	N/A ^a	5.65E03	N/A ^a	1.59E04	N/A ^a

30Q5 = 30 consecutive days of lowest flow over a 5-year period; ADD = average daily dose; HM = harmonic mean; Int. = intermediate dose; N/A = not applicable

^a The HM was not calculated using these release days because the HM represents long-term average flow conditions. Therefore, the average daily doses for chronic exposure durations that are estimated using a HM were also not calculated.

3155

4.3.4.2 Fish Ingestion Risk Estimates

As discussed in Section 3.3.1, EPA used the modeled surface water concentration based on both the HM and 30Q5. While the HM flow is typically used to estimate fish tissue concentrations because it represents long-term average conditions and it takes time for chemical concentrations to accumulate in fish, the HM was not appropriate for COUs with few release days (*i.e.*, less than a month). For those COUs, EPA used the 30Q5 as a conservative screening-level analysis even though the 30Q5 is expected to occur less frequently and unlikely to be sustained long-term. EPA evaluated exposure to TBBPA through fish ingestion for only Tribal populations because they had the highest fish ingestion rate per kg of body weight among the general population even when including subsistence fishers (see Section 4.1.6.4). Corresponding screening-level risk estimates are shown in Table 4-25. The MOEs for Tribal populations exposure through fish ingestion were above the benchmark of 30 for all scenarios assessed. Based on this screening-level assessment, because MOEs are above the benchmark of 30 for the COUs which resulted in the highest exposures, no other COUs are expected to result in risk estimates below the benchmark.

Table 4-26. Risk Estimates for Fish Ingestion Exposure for Tribal Populations (Benchmark MOE = 30)

Surface Water Concentration and Scenario	Intermediate Non-Cancer MOE		Chronic Non-Cancer MOE	
	Current Mean IR	Current Tribal IR, 95th Percentile	Current Mean IR	Current Tribal IR, 95th Percentile
Processing – As a reactant – Flame retardant in plastic material and resin manufacturing (1.56E–07 mg/L based on HM)	1.06E08	2.61E07	6.83E07	1.69E07
Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing (9.39E–03 mg/L based on 30Q5 ^a)	1.75E03	4.34E02	1.13E03	2.81E02
Disposal (8.52–03 mg/L based on 30Q5 ^a)	1.93E03	4.79E02	1.25E03	3.10E02
30Q5 = 30 consecutive days of lowest flow over a 5-year period; HM = harmonic mean; IR = ingestion rate; MOE = margin of exposure ^a The harmonic mean flow is typically used to estimate fish tissue concentrations because it represents long-term average flow conditions, and it takes time for chemical concentrations to accumulate in fish. However, the harmonic mean is not appropriate for this COU with only 12 release days. EPA used the 30Q5 as a conservative screening-level analysis even though the 30Q5 is expected to occur less frequently and unlikely to be sustained long-term.				

4.3.4.3 Ambient Air Risk Estimates

EPA modeled ambient air concentrations to assess inhalation exposure to TBBPA in ambient air and ingestion exposure to TBBPA in soil from air deposition in Section 4.1.6.5. As described in Section 3.3.2, for air releases, EPA queried both TRI and estimated releases for one COU that does not have TRI data. For TRI facilities, stack and fugitive emissions were combined across facilities as part of a screening assessment. The scenario associated with the TRI reported air release corresponded to the 10 following COUs: (1) Manufacturing; (2) Processing as a reactant in plastic material and resin manufacturing; (3) Processing as a reactant in all other chemical product and preparation manufacturing; (4) Processing: Additive flame retardant in plastic, resin, and paints and coatings; (5) Processing:

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Adhesive manufacturing; (6) Processing: Reactive flame retardant in computer and electronic product manufacturing; (7) Processing: Reactive flame retardant in transportation equipment manufacturing; (8) Processing: Additive flame retardant in plastic products; (9) Reactive use in automotive and aviation articles; and (10) Disposal. For the Electrical and electronic waste recycling COU, environmental releases were estimated using mathematical modeling.

Table 4-26 summarizes the total exposures and the associated risk estimates (MOEs) calculated using the inhalation human equivalent concentration (HEC) described in Section 4.2. Since TBBPA is not expected to be acutely toxic as detailed in Section 4.2, only the chronic risk estimates were calculated for both the inhalation and oral pathways. The HEC is derived in the *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026t](#)) and is based on an 80 kg adult. Based on the 95th percentile air concentrations, MOEs for general population exposure through inhalation of ambient air are 5,126 for the scenario based on TRI reported releases and 906 for the scenario based on a release estimated with mathematical modeling (compared to a benchmark of 30).

Exposure doses for ingestion of soil containing TBBPA from air-to-soil deposition were estimated in Section 4.1.6.5. The corresponding MOEs are presented in Table 4-27. Based on the soil concentrations estimated using ambient air releases reported to TRI or mathematically modeled, MOEs for general population exposure through ingestion exceed the benchmark MOE of 30 by many orders of magnitude.

The risk estimates described in the preceding paragraphs are derived from a highly conservative exposure scenario where such exposures to both fugitive and stack releases cannot physically occur at the same time based on assumptions made around the releases and total exposure. Even under this highly conservative exposure scenario, the derived risk estimates are above relative benchmarks for non-cancer health effects for all assessed COUs. Based on this screening-level assessment, because MOEs are above the benchmark of 30 for the COUs which resulted in the highest exposures, no other COUs are expected to result in risk estimates below the benchmark.

Table 4-27. Risk Estimates for Inhalation of Ambient Air (Benchmark MOE = 30)

COU	Chronic (Annual Average) ^a	
	Air Concentration ^b ($\mu\text{g}/\text{m}^3$)	MOE
• Manufacture – Domestic manufacture • Processing – As a reactant – Flame retardant in plastic material and resin manufacturing • Processing – As a reactant – Intermediate in all other chemical product and preparation manufacturing • Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing • Processing – Incorporation into formulation, mixture, or reaction product – Adhesive manufacturing • Processing – Incorporation into article – Reactive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; plastic product manufacturing (e.g., printed circuit boards and semiconductor packages)	4.68	5,126

COU	Chronic (Annual Average) ^a	
	Air Concentration ^b (µg/m ³)	MOE
- Processing – Incorporation into article – Reactive flame retardant in transportation equipment manufacturing (e.g., interior material for automotive and aviation articles) - Processing – Incorporation into article – Additive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., plastic electronic enclosures) - Industrial and commercial use – Construction, paint, electrical, and metal products – Reactive flame retardant in automotive and aviation articles (i.e., laminate and prepreg material) - Disposal		
Electrical and electronic waste recycling	26.5	906
COU = condition of use; MOE = margin of exposure ^a EPA assumes the general population is continuously exposed (i.e., 24 hours/day, 365 days/year) to outdoor ambient air concentrations. ^b Air concentrations are reported for the high-end (95th percentile) modeled value at 100 m from the emitting facility and stack plus fugitive releases combined.		

Table 4-28. Risk Estimates for Ingestion of Soil from Air Deposition (Benchmark MOE = 30)

COU	Assessed Population	Soil Concentration (mg/kg)	Chronic Doses (mg/kg-day)	Chronic Non-Cancer MOE
- Manufacture – Domestic manufacture - Processing – As a reactant – Flame retardant in plastic material and resin manufacturing - Processing – As a reactant – Intermediate in all other chemical product and preparation manufacturing - Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; custom compounding of purchased resins; Paint and coating manufacturing - Processing – Incorporation into formulation, mixture, or reaction product – Adhesive manufacturing - Processing – Incorporation into article – Reactive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., printed circuit boards and semiconductor tor packages) - Processing – Incorporation into article – Reactive flame retardant in transportation equipment manufacturing (e.g., interior material for automotive and aviation articles)	Children 1 to <2 years of age	3.10E-03	2.42E-08	1.82E08

COU	Assessed Population	Soil Concentration (mg/kg)	Chronic Doses (mg/kg-day)	Chronic Non-Cancer MOE
- Processing – Incorporation into article – Additive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (<i>e.g.</i>, plastic electronic enclosures) - Industrial and commercial use – Construction, paint, electrical, and metal products – Reactive flame retardant in automotive and aviation articles (<i>i.e.</i>, laminate and prepreg material) - Disposal	Children 1 to <2 years of age	3.10E-03	2.42E-08	1.82E08
Electrical and electronic waste recycling		7.89E-03	6.15E-08	7.16E07

4.3.4.4 Human Milk Risk Estimates

As discussed in Section 4.1.6.6 and in more detail in the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* (U.S. EPA, 2026q), EPA concluded that infant exposure to TBBPA through milk is possible. EPA used the maximum human milk concentrations of TBBPA measured from biomonitoring, which represents an aggregate exposure from all TBBPA sources and pathways, including both TSCA and non-TSCA uses, to characterize a nursing infant's exposure to TBBPA for a screening-level analysis. Exposure and risk estimates using the maximum measured TBBPA concentrations in human milk are presented in Table 4-28. The intermediate and chronic non-cancer MOEs do not indicate risks for the nursing infant as they are both one order of magnitude above the corresponding benchmark.

Overall, EPA expects the human health hazard values based on early-life (neonatal) and adult exposure scenarios considered throughout this assessment to be protective of nursing infants. These values are based upon studies that identify the most robustly supported effect levels for respective exposure duration scenarios. Furthermore, risk estimates using the maximum measured concentrations in human milk from available biomonitoring data were an order of magnitude above the benchmark.

Table 4-29. Screening-Level Exposure and Risk Estimates from Human Milk Ingestion Based on Biomonitoring Data

Age Group	Exposure Estimates		Risk Estimates (Benchmark MOE = 30)	
	Lipid Weight (mg/kg-day)	Wet Weight (mg/kg-day)	Intermediate MOE	Chronic Non-Cancer and Cancer MOE
Birth to <1 month	1.98E-02	3.56E-03	343	N/A ^a
Birth to <1 year	1.41E-02	2.47E-03	N/A ^b	313

^a Intermediate risks are only estimated for the infant's first month of life, which had the highest doses because of the highest milk ingestion rate per kg of body weight. It is thus most protective for estimating shorter exposures. Furthermore, chronic risks cover much longer exposure durations (*i.e.*, at least 10% of lifetime in adults) than the one month represented by this exposure estimate.

^b The exposure duration for an intermediate exposure is up to 30 days. The exposure duration for this age group exceeds 30 days.

4.3.4.5 Overall Confidence in General Population Risk Estimates

As described in Sections 3.3 and 4.1.6 and in more technical detail in the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* (U.S. EPA, 2026q), EPA has robust confidence that modeled environmental concentrations based on reported releases are appropriately conservative for a screening-level analysis to assess risks associated with drinking water, fish ingestion, ambient air inhalation, and soil ingestion. Therefore, EPA has robust confidence that no exposure scenarios (*i.e.*, drinking water, fish ingestion, ambient air, human milk) will lead to greater doses than presented in this evaluation. Despite moderate confidence in the precision of the exposure estimates, confidence in exposure estimates capturing high-end exposure scenarios was robust given the conservative assumptions used for the estimates. Along with EPA's robust confidence in the PODs selected to characterize risk from intermediate and chronic duration exposures to TBBPA (see Section 4.2 and U.S. EPA (2026t)), EPA has robust confidence that the risk estimates calculated for the general population in Section 4.3.4 were conservative and appropriate for a screening-level analysis.

For human milk, EPA has moderate confidence that the human health hazard values based on early-life (neonatal) and adult exposure scenarios considered throughout this assessment to be protective of nursing infants. These values are based upon studies that identify the most robustly supported effect levels. Additionally, risk estimates using the maximum measured concentrations in human milk from available biomonitoring data were an order of magnitude above the benchmark. However, it is important to acknowledge uncertainties about the extent to which biomonitoring data captures highly exposed subpopulations such as occupationally exposed individuals. Biomonitoring data also represent total exposure and were not COU-specific.

4.3.5 Risk Characterization for Potentially Exposed or Susceptible Subpopulations

EPA considered PESS throughout the exposure and hazard assessments supporting this analysis. Table 4-29 summarizes how PESS were quantitatively or qualitatively incorporated into the risk evaluation through consideration of increased exposure or biological susceptibility. EPA may have considered these through the use of exposure factors, uncertainty factors, PESS group-specific data. In some cases, information on PESS factors may have supported the weight of scientific evidence for a particular hazard or exposure value. For other factors, EPA was either unable to identify relevant chemical-specific data or could not adequately quantify their contribution. These are addressed in detail in the corresponding hazard and exposure assessment support documents.

The available data suggest that some groups or life stages have greater exposure to TBBPA. In this assessment, EPA evaluated risks anticipated for a range of exposure scenarios resulting from COUs where exposures are expected to be greatest. For example, EPA considered risks for people with high-end exposure to TBBPA through work or through consumer products containing TBBPA. EPA also performed screening-level analysis for general population exposure scenarios for people with frequent or high-intensity contact with environmental media near the highest TBBPA releases, including people who drink water where TBBPA is released, people who breathe air in communities near TBBPA releases, children who ingest soil contaminated through soil deposition, and subsistence fishers or Tribal populations who ingest fish containing TBBPA. As described in Section 4.3.4.4, EPA also considered TBBPA exposures for infants exposed via milk.

Some groups or life stages may be more biologically susceptible to TBBPA. For example, as discussed in the *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* (U.S. EPA, 2026t), rodents exposed *in utero* or during neonatal periods appeared more sensitive to TBBPA-induced kidney and liver toxicity than adult rodents. EPA was able

to incorporate life stage susceptibility into hazard values for intermediate exposure duration scenarios throughout selection of an endpoint measured in rodents exposed during the neonatal period. The intermediate duration hazard value used as the basis for the risk estimates are based on the sensitive and robustly supported kidney outcome (increased incidence of polycystic kidney lesions) that underwent dose-response analysis for intermediate exposure duration following exposure in early-life to TBBPA in rats. Furthermore, chronic duration toxicity evidence demonstrates TBBPA-related uterine tissue-specific tumor formation in female rats associated with an associated non-genotoxic MOA. EPA was able to incorporate sex-related uterine cancer susceptibility into hazard values for chronic exposure duration scenarios. The health effect that underwent dose-response analysis for chronic exposure duration was atypical endometrial hyperplasia, which represents uterine tumor formation effects following chronic TBBPA exposure in female rats.

Other factors that may increase susceptibility include chronic disease, genetic factors, co-exposures, and behavior/lifestyle. A UF_H factor of 10 was applied to account for human toxicokinetic and toxicodynamic variability, which is expected to account for considerations such as genetic polymorphisms and existing disease states. EPA considers the proposed oral PODs for use in characterizing risk from exposure to TBBPA to be protective of potentially sensitive subpopulations and life stages, including infants.

3301 Table 4-30. Summary of PESS Factors Incorporated into Risk Estimates

PESS Categories	Potential Increased Exposures Incorporated into Exposure Assessment	Potential Sources of Biological Susceptibility Incorporated into Hazard Assessment
Lifestage	- Exposure estimates were derived based on exposure factors for specific age groups. Consumer exposure scenarios include life stage-specific exposure factors for adults and children as applicable (Section 4.1.3). Drinking water exposure scenarios include scenarios for formula-fed infants, who have higher water ingestion relative to body weight than other age-groups (Section 4.1.6.3). - EPA concluded that infants may be exposed to TBBPA through milk following maternal exposure. As described in Section 4.1.6.6 and in U.S. EPA (2026g), EPA quantitatively estimate infant exposures via milk using biomonitoring data and concluded that the overall risk estimates based on adult exposures are expected to be protective of infant exposure through milk.	When comparing similar kidney and liver health outcomes across studies, rodents exposed in utero or during neonatal periods appeared more sensitive to TBBPA-induced toxicity than adult rodents. EPA was able to incorporate life stage susceptibility into hazard values for intermediate exposure duration scenarios throughout selection of an endpoint measured in rodents exposed during the neonatal period. The health category that underwent dose-response analysis for intermediate exposure duration represents sensitive kidney outcome (polycystic kidney lesions) following exposure in early-life to TBBPA in rats. EPA applied a $10\times$ UF_H for human variability.
Pre-existing disease	EPA did not identify health conditions that may influence exposure to TBBPA..	Any pre-existing condition affecting a target organ may increase susceptibility to TBBPA in that organ. In the absence of quantitative information on how specific health conditions may contribute to susceptibility, a $10\times$ UF_H was applied for human variability.
Lifestyle activities	EPA did not identify lifestyle factors or behaviors that may influence exposure to TBBPA.	- Heavy smoking and other tobacco usage may increase susceptibility to reproductive/developmental outcomes and cancer throughout the body (CDC, 2023b, g). Alcohol use during pregnancy can cause developmental outcomes (<i>e.g.</i>, fetal alcohol spectrum disorders), and heavy alcohol use may affect susceptibility to liver disease (2023a, e). In the absence of quantitative information on how lifestyle and behavioral factors may influence susceptibility to reproductive effects of TBBPA, a $10\times$ UF_H was applied for human variability. - Insufficient activity may increase susceptibility to multiple health outcomes, including cancer and obesity. Having overweight or low body weight is a risk factor for infertility in women (2023b, c, 2022). In the absence of quantitative information on how lifestyle and behavioral factors may influence susceptibility to reproductive effects of TBBPA, a $10\times$ UF_H was applied for human variability.
Occupational and consumer exposures	EPA evaluated risks for a range of occupational and consumer exposure scenarios that increase exposure to TBBPA, including manufacturing, processing, and use of TBBPA. EPA evaluated risks for both central tendency and high-end exposure estimates	EPA did not identify specific occupational or consumer exposures that are expected to increase susceptibility to TBBPA.

PESS Categories	Potential Increased Exposures Incorporated into Exposure Assessment	Potential Sources of Biological Susceptibility Incorporated into Hazard Assessment
	for workers (Sections 4.3.2) and for low-, medium-, and high-intensity use scenarios for consumers (Section 4.3.2.4).	
Geography/site-specific	EPA evaluated risks to communities in proximity to sites where TBBPA is released to ambient air or surface water (Section 4.3.3.1), including those drinking or swimming in water near release sites and those breathing air near release sites.	EPA did not identify geographic factors expected to increase susceptibility to TBBPA.
Sociodemographic status	EPA did not identify specific sociodemographic factors that influence exposure to TBBPA.	- Individuals with lower incomes may have worse health outcomes due to social needs that are not met, environmental concerns, and barriers to health care access (ODPHP, 2023b). - The most robust chronic toxicity effect associated with TBBPA exposure was identified as uterine cancer in female rats, representing sex-specific tumor formation health effect. Thus, the chronic values used in risk estimates represented the most protective and reliable proposed chronic exposure duration POD based on atypical endometrial hyperplasia (uterine tumor precursor lesion) in female rats.
Nutrition	EPA did not identify nutritional factors influencing exposure to TBBPA.	Poor diets can lead to chronic illnesses such as heart disease, type 2 diabetes, and obesity, which may contribute to adverse developmental outcomes. Additionally, diet can be a risk factor for fatty liver, which could be a pre-existing condition to enhance susceptibility to TBBPA-induced liver toxicity (2023d, f). A $10\times$ UF_H was applied for human variability.
Genetics/epigenetics	EPA did not identify genetic factors influencing exposure to TBBPA.	EPA did not identify specific genetic factors influencing susceptibility to TBBPA. Susceptibility associated with toxicokinetic or toxicodynamic differences among humans associated with genetic factors is expected to be covered by the $10\times$ UF_H.
Unique activities	- EPA evaluated risks for people who consume fish contaminated with TBBPA based on rates of fish consumption rates for subsistence fishers and Tribal populations (Section 0). - Other potential sources of increased exposure to TBBPA due to specific Tribal lifeways have not been identified.	EPA did not identify specific activities expected to increase susceptibility to TBBPA.
Aggregate exposures	EPA considered potential aggregate occupational exposures to TBBPA resulting from dermal and inhalation routes, as well as aggregate consumer exposures from dermal, inhalation, and oral routes.	Exposure to TBBPA through consumer products or other sources that are not assessed under TSCA could contribute to total exposure to TBBPA and increase susceptibility to further exposure associated with COUs.
Other chemical and non-chemical stressors	EPA did not identify chemical and nonchemical stressors influencing exposure to TBBPA.	Poor-quality housing (resulting in exposure to mold, lead, cold, pests, etc.) is associated with a variety of negative health outcomes, including effects on respiratory health (ODPHP, 2023a). Social isolation and other social

PESS Categories	Potential Increased Exposures Incorporated into Exposure Assessment	Potential Sources of Biological Susceptibility Incorporated into Hazard Assessment
		determinants (<i>e.g.</i> , decreased social capital, stress) can lead to negative health outcomes. Physical or emotional stress can be a risk factor for infertility in women (ODPHP, 2023c). A 10× UF _H was applied for human variability.
UF _H = intraspecies uncertainty factor		

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4.3.6 Risk Characterization for Aggregate and Sentinel Exposures

In this assessment, EPA considered the extent to which aggregate exposures to TBBPA from multiple sources, across multiple routes, or across pathways may increase the overall risk for some people.

EPA defines aggregate exposure as “the combined exposures to an individual from a chemical substance across multiple routes and across multiple pathways (40 CFR § 702.33).” EPA did not consider aggregate exposure scenarios across COUs because the Agency did not find any evidence to support such an aggregate analysis, such as statistics of populations using certain products represented across COUs or workers performing tasks across COUs. However, EPA combined exposure across all routes of exposure for each individual occupational and consumer COU to calculate aggregate risks. For occupational exposures, EPA calculated combined risks from dermal and inhalation risks assuming that effects are additive across routes. These aggregate risk estimates are reported Table 4-22. Worker high-end aggregate risk estimates for the OES of Repackaging of TBBPA Powder/Scenario 2 is below benchmark MOEs. Note, however, the high-end dermal exposure is based on maximal flux through the surface area of two hands, which is an upper bound that likely overestimates exposure. Aggregate consumer exposure across dermal, oral, and inhalation routes are all above the benchmark for all consumer COUs and scenarios. EPA did not quantitatively aggregate general population exposure scenarios across routes because the screening-level assessments resulted in MOEs individual routes of exposure that are orders of magnitude above benchmark MOE.

EPA defines sentinel exposure as “the exposure to a chemical substance that represents the plausible upper bound of exposure relative to all other exposures within a broad category of similar or related exposures (40 CFR § 702.33).” In terms of this risk evaluation, EPA considered sentinel exposures by considering risks to populations who may have upper-bound exposures; for example, workers and ONUs who perform activities with higher exposure potential, or consumers who have higher exposure potential or certain physical factors like body weight or skin surface area exposed. The Agency characterized high-end exposures in evaluating exposure using both monitoring data and modeling approaches. Where statistical data are available, EPA typically uses the 95th percentile value of the available dataset to characterize high-end exposure for a given COU. The 95th percentile is defined as an estimate of individual exposure or dose for those persons at the upper end of an exposure or dose distribution, conceptually above the 90th percentile, but not higher than the individual in the population who has the highest exposure or dose (*e.g.*, 99.9th percentile) (2011a; EPA, 1994). As the midpoint of that range, the 95th percentile was selected to be representative of occupational exposures in the upper tail of the distribution. For general population and consumer exposures, the Agency characterized sentinel exposure by conducting a highly conservative screening-level analysis using elevated consumption rates, breathing rates, or user-specific factors. The screening-level analysis did not indicate risks.

3339 **5 ENVIRONMENTAL RISK ASSESSMENT**

**TBBPA – Draft Environmental Risk Assessment (Section 5):
Key Points**

EPA assessed environmental risks of TBBPA exposure to aquatic and terrestrial species. The environmental exposures through water, sediment, soil, and diet via trophic transfer are described in Section 5.1; environmental hazards for aquatic and terrestrial species are described in Section 5.2, and environmental risk characterization is described in Section 5.3.

- The environmental risk characterization of TBBPA was conducted to evaluate whether the potential releases and resultant exposures to TBBPA in water, sediment, or soil will exceed the TBBPA concentrations that result in hazardous effects to aquatic or terrestrial organisms.
- Risk to aquatic organisms was characterized by comparing concentrations of concern (COCs) for aquatic organisms to modeled surface water and sediment concentrations by COU from facility-specific releases (TRI) and modeled data from generic scenarios for COUs without available TRI data.
- Risk quotients (RQs) for aquatic species exceeded 1 for a single COU for acute aquatic species, chronic aquatic invertebrates, sediment-dwelling invertebrates, and amphibians.
- The soil concentration does not exceed hazard thresholds for terrestrial soil invertebrates (0.91 mg/kg dry soil) or terrestrial plants (5 mg/kg dry soil).
- A screening-level trophic transfer risk assessment was conducted for terrestrial invertebrates, mammals, and aquatic-dependent mammals. EPA has robust confidence that TBBPA exposures from the highest release exposure scenarios are well below the hazard thresholds that could present risk.

3340 **5.1 Summary of Environmental Bioconcentration and Trophic Transfer**

3341 EPA assessed environmental concentrations of TBBPA in water, sediment, and soil for use in
3342 environmental exposure. The environmental exposures are described in the *Draft Environmental Media,*
3343 *General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-*
3344 *dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)). TBBPA concentrations in surface water and sediment
3345 were modeled using the Variable Volume Water Model (VWWM) in the Point Source Calculator (PSC)
3346 tool ([EPA, 2019](#)) resulting from COU releases. For COUs (Disposal) that indicated wastewater
3347 treatment removal, a 88.8% removal rate was applied. TBBPA concentrations in surface water and
3348 sediment are described in the *Draft Environmental Media, General Population, and Environmental*
3349 *Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA,](#)
3350 [2026q](#))).

3351
3352 For aquatic dietary exposure, a trophic magnification factor (TMF) was used to determine if TBBPA has
3353 the potential to biomagnify through diet. TMF is the average factor by which the normalized chemical
3354 concentration in biota of a food web increases per trophic level. TMFs are calculated by evaluating the
3355 slope of the linear regression of logarithmically transformed lipid-normalized concentrations of
3356 chemicals with trophic level of organisms in the food web (often determined from stable N¹⁵ isotope
3357 ratios). TMFs provide a characterization of the average degree of biomagnification that occurs in an
3358 entire food web by incorporating multiple food web interactions. A chemical has the potential to
3359 biomagnify when the TMF is greater than 1 ([Powell et al., 2009](#)). Food web studies of TBBPA indicate
3360 no trophic magnification. TMFs were 0.25 in a freshwater e-waste pond web ([Tao et al., 2016](#)) and 0.55
3361 in a marine web ([Choo et al., 2019](#)), which show trophic dilution in the aquatic environment (TMF < 1).

Additionally, fathead minnow and eastern oyster had bioconcentration factors (BCFs) of approximately 160 and 148 L/kg ww respectively, with rapid depuration (1 day in fish and 3–5 days in oyster) (Fackler, 1989; Springborn Laboratories, 1989a). Field BCFs converted to wet weight were 480 L/kg ww for oyster and 920 L/kg ww for mussel, and QSAR estimates were in the same range (EPI Suite™ 632 L/kg; OPERA 269 L/kg) (U.S. EPA, 2026w). Thus, TBBPA is not expected to biomagnify across trophic levels in aquatic food webs.

A screening-level trophic transfer analysis was conducted for terrestrial dietary exposure. Specifically for terrestrial invertebrates, terrestrial mammals (e.g., short-tailed shrew consuming earthworms), and aquatic-dependent mammals (e.g., American mink consuming fish that prey on chironomids). Results for calculated dietary exposures of TBBPA to mammals from modeled concentrations within relevant pathways such as water, sediment, and soil indicated exposure concentrations were below the toxicity reference value (TRV). Trophic transfer analyses for aquatic-dependent mammals with exposure pathways for surface water and sediment are presented within Table 7-1 of the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* (U.S. EPA, 2026q). These results align with previous studies indicating that TBBPA is not bioaccumulative through dietary exposure and will not biomagnify as summarized in the *Draft Physical Chemistry and Fate Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* (U.S. EPA, 2026w). Based on the screening-level trophic transfer assessments EPA has robust confidence that TBBPA exposures from the highest release exposure scenarios are below the hazard thresholds that would present risk.

5.1.1 Weight of Scientific Evidence Conclusions for Environmental Exposures

The trophic transfer assessment for TBBPA is supported by a broad, taxonomically diverse empirical biomonitoring dataset that spans multiple trophic levels in aquatic food webs (invertebrates such as mollusks, worms, insects, echinoderms, and crustaceans; fish; and mammals). For the aquatic-dependent mammalian assessment (e.g., American mink consuming fish that prey on chironomids), and for the soil-based assessment (e.g., earthworms consuming soil and short-tailed shrew consuming earthworms), the quality of the database and consistency is robust. Strength and precision for the aquatic-dependent mammal assessment is robust, and strength and precision is moderate for the soil invertebrate and soil invertebrate-dependent mammal scenario because soil concentrations were derived from air-deposition modeling that aggregated multiple TRI releases rather than a single release value (see *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* (U.S. EPA, 2026q)). Conservative assumptions used for trophic transfer calculations likely overestimate transfer potential but ensure protectiveness. Biological and environmental relevance is robust. Consistently, all the calculated dietary exposure estimates were below the mammalian hazard threshold. The screening-level trophic transfer assessments for terrestrial invertebrates, mammals, and aquatic-dependent mammals have robust confidence that TBBPA exposures from the highest release exposure scenarios are below the hazard thresholds that would present risk.

5.2 Summary of Environmental Hazards

COCs were derived for acute and chronic TBBPA exposures in water and sediment (Table 5-1). Specifically, 63 studies contained relevant acute and chronic aquatic toxicity data for 39 species, including vertebrates, invertebrates, sediment-dwelling invertebrates, and algae. The acute aquatic COC was derived from an SSD that contained lethal concentration at which 50% of test organisms die (LC50s) for 16 vertebrate and invertebrate species comprising 37 endpoints identified in systematic review. SSDs were derived using EPA's SSD Toolbox (v1.3) (Etterson, 2020). The most appropriate

endpoint with a population-level effect was chosen as the chronic aquatic vertebrate, invertebrate, sediment-dwelling invertebrate, amphibian, and algae COCs.

Hazard thresholds were also derived for terrestrial species, including an egg-injection exposure to avian species and soil exposure to terrestrial invertebrates and plants. Similar to the aquatic assessment, the most appropriate endpoint with a population-level effect was chosen as the hazard thresholds for the terrestrial taxa. A description of all studies and the identified COCs can be found in the *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* (U.S. EPA, 2026t). Lastly, no studies were reasonably available for the assessment of TBBPA hazard to wild terrestrial mammals. Therefore, human health rodent model organisms were used as a surrogate to determine terrestrial mammal hazard values.

Table 5-1. Environmental Hazard Thresholds for TBBPA

Receptor Group	Exposure Duration	Hazard Threshold (COC or HV)	Assessment Media	Reference
Acute aquatic vertebrates, invertebrates, amphibians	96 hours	10 µg/L ^a	Water column	SSD
Acute aquatic vertebrates, invertebrates, amphibians	96 hours	110 µg/L ^b	Water column	SSD
Chronic aquatic vertebrates	250 days	0.854 µg/L ^c	Water column	Chen et al. (2016)
Chronic aquatic invertebrates	35 days	0.569 µg/L ^c	Water column	Gong et al. (2017)
Chronic aquatic sediment-dwelling invertebrates	28 days	11.7 mg/kg ^c	Sediment	Wildlife International Ltd (2002)
Chronic amphibians	28 days	1.58µg/L ^c	Water column	Zhang et al. (2018)
Aquatic algae	96 hours	120 µg/L ^c	Water column	Yang et al. (2012)
Terrestrial mammal	105 weeks	250 mg/kg day	Diet	NTP (2014)
Terrestrial invertebrates	56 days	0.91 mg/kg dry soil	Soil	Warbritton et al. (2005)
Avian	14 days	26 mg/kg egg	Egg (injection)	Berg et al. (2001)
Terrestrial plants	14 days	5 mg/kg dry soil	Soil	Ge and Zhang (2017)
COC = concentration of concern; HV = hazard value; SSD = species sensitivity distribution				
^a Represents the lower-bound 95th confidence interval of the HC05 of the SSD.				
^b HC05 of the SSD.				
SSD derived from LC ₅₀ values of 16 species encompassing 37 endpoints.				
^c An assessment factor of 10 for aquatic endpoints was applied to account for variation in species sensitivity and uncertainties in extrapolating from laboratory conditions to environmental concentrations and exposure durations (U.S. EPA, 2026t; Zeeman, 1995).				

5.2.1 Weight of Scientific Evidence Conclusions for Environmental Hazards

Based on the weight of the scientific evidence and uncertainties, a confidence statement was developed that qualitatively ranks (*i.e.*, robust, moderate, slight, or indeterminate) the confidence in the hazard threshold. The evidence considerations and criteria detailed within the 2021 Draft Systematic Review Protocol (U.S. EPA, 2021a) guide the application of strength-of-evidence judgments for environmental hazard effect within a given evidence stream. EPA determined that TBBPA poses hazards from acute and chronic exposures to aquatic vertebrates, chronic exposures to aquatic invertebrates, chronic exposure to sediment dwelling animals, chronic exposure to algae, chronic dietary exposure to terrestrial

mammals, chronic soil exposure to terrestrial invertebrates, embryonic toxicity to terrestrial avian species, and chronic soil exposure to terrestrial plants. EPA has robust confidence in the weight of evidence in these findings. See the *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026t](#)) for more information on the weight of scientific evidence conclusions.

5.3 Environmental Risk Characterization

5.3.1 Risk Assessment Approach

The environmental risk characterization of TBBPA was conducted to evaluate whether the potential releases and resultant exposures to TBBPA in water, sediment, or soil could exceed the TBBPA concentrations that may result in hazardous effects to aquatic or terrestrial organisms. In evaluating the TBBPA environmental risk in surface water and sediments, EPA modeled exposure estimates from known TRI releases and releases based on mathematical modeling. Environmental concentrations in soil were estimated via air deposition to soil. In evaluating the environmental hazard of TBBPA, a weight of scientific evidence approach was used to select hazard threshold concentrations for the derivation of risk quotients for aquatic and terrestrial organisms.

Environmental risk was characterized by calculating risk quotients (RQs) ([U.S. EPA, 1998](#); [Barnthouse et al., 1982](#)). The RQ is defined in Equation 5-1 below.

Equation 5-1. Calculating the Risk Quotient

$$RQ = \frac{\text{Predicted Environmental Concentration}}{\text{Hazard Threshold}}$$

For aquatic organisms, the “effect level” is a derived COC based on a hazard effects concentration. The COC used to calculate RQs for aquatic organisms was derived from hazard values resulting from acute and chronic exposures to TBBPA. Details on the selection of hazard thresholds can be found the *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026t](#)). The benchmark value for RQs in environmental risk characterization is 1. An RQ equal to 1 indicates that the exposures are the same as the concentration that can cause effects. If the RQ is greater than 1, the exposure is greater than the effect concentration. If the RQ is less than 1, the exposure is less than the effect concentration. EPA further characterized risk estimates with the number of days of exceedance when RQ values are greater than 1 to describe and align the estimated durations of TBBPA exposure to the exposure durations that can lead to adverse population effects.

Environmental exposure concentrations in surface water and sediment were based on concentrations of modeled TBBPA using VVWM-PSC Tool ([U.S. EPA, 2026q](#)). RQ values were determined for surface water and sediment exposure to aquatic organisms from three COU releases using TRI reported data and one COUs using generic scenario modeling of TBBPA. The three COUs with TRI-reported release data are:

1. Processing – As a reactant – Flame retardant in plastic material and resin manufacturing;
2. Processing – Incorporation into a formulation, mixture, or reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing; and
3. Disposal.

The COU with generic scenario modeling is the Industrial and commercial use – Other – Laboratory chemical. According to reported data for all other COUs, TBBPA is not released to water for sites mapped to those COUs. The overall confidence in the environmental risk characterization integrated confidence from both environmental exposures and environmental hazards. Monitored environmental exposure data that were linked with TBBPA COU were not reasonably available. Thus, EPA relied on predicted exposure concentrations that were derived through modeling of COU-specific environmental concentrations. When available, the modeled concentrations incorporated daily water releases per site using a combination of empirical data from TRI and test orders (Section 3.1.1.3.1). Site-specific information reported in TRI also allowed EPA to input a flow rate that reflects the actual receiving water body or the facility's effluent rate, whichever is higher, to avoid overestimating surface water concentrations. EPA reviewed and screened environmental monitoring data to consider terrestrial exposure to TBBPA through direct soil exposure to terrestrial invertebrates and plants. EPA also considered dietary exposure to terrestrial mammals through bioaccumulation and trophic transfer.

5.3.2 Risk Estimates for Aquatic Receptors

Risk to aquatic organisms was characterized by comparing COCs for aquatic organisms ([U.S. EPA, 2026t](#)) to modeled surface water and sediment concentrations by COU from facility specific releases (TRI) and modeled data from generic scenarios for COUs without available TRI data {U.S. EPA, 2026, 13283043. Of the 18 total COUs, 15 had reported facility specific releases, one was assessed via generic scenario modeling, and two were not assessed quantitatively because EPA does not expect releases to water during activities under these COUs (Recycling and Industrial & commercial use of products). For chronic vertebrates, the days of exceedance from modeling, where RQs are greater than 1 (COUs: Processing – Incorporation into article – Additive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, Appliance, and component manufacturing; plastic product manufacturing (e.g., plastic electronic enclosures); and Disposal.), did not exceed the hazard threshold's duration. The days of exceedance did not extend beyond the 120-day aquatic vertebrate exposure used to derive the COC and therefore risk is not expected for this taxa. Additionally for the Disposal COU where RQs are greater than 1 (Manchester) the days of exceedance from modeling did not exceed the hazard threshold's duration for chronic invertebrates and amphibians. The days of exceedance did not extend beyond the 35-day aquatic invertebrate and 28-day amphibian exposure used to derive the COC and therefore risk is not expected for these taxa.

5.3.2.1 Facility-Specific Reported Releases

Facility-specific releases were available for 15 COUs. An additional 3 COUs indicated negligible water release. RQs were not calculated for these COUs (Section 5.3.1). For 12 of these COUs, facility-specific releases were zero for all sites. For these 12 COUs, RQs were not calculated and risk is not expected for aquatic species. Three of facility specific release COUs indicated water release of TBBPA greater than zero. The RQs for these three COUs are described below. For all scenarios, RQs were less than the benchmark of 1 for algae. Therefore, risk is not expected for algae.

Processing as a Reactant in Plastic Material and Resin Manufacturing

The daily release of TBBPA from Processing as a reactant in plastic material and resin manufacturing was 3.63 kg per site per day and a resulting 7Q10 surface water and sediment concentration of 3.91×10^{-2} µg/L and 19.9 µg/kg, respectively. RQs were not greater than 1 for any taxa for this COU Table 5-2).

Processing – Additive Flame Retardant in Plastic, Resin, and Paints and Coating

The daily release of TBBPA from Processing: additive flame retardant in plastic, resin, and paints and coating was 3.78×10^{-2} kg per site per day and a resulting 7Q10 surface water and sediment concentration of 2.82 µg/L and 3,730 µg/kg, respectively. RQs were greater than 1 for acute aquatic

species using the lower bound of the 95th confidence interval of the HC05 (hazardous concentration threshold for 5% of species; COC = 10 µg/L), which resulted in an RQ of 1.28. RQs were not greater than 1 for acute aquatic species using the HC05 (COC = 110 µg/L), which resulted in an RQ of 0.11. RQs were also greater than 1 for chronic aquatic vertebrates, invertebrates, sediment-dwelling invertebrates, and amphibians (Table 5-2).

Disposal

For the disposal COU, four sites indicated greater than zero TBBPA releases.

- The daily release of TBBPA from the Manchester sewage treatment plant (STP) was 0.1 kg per site per day and a resulting 7Q10 surface water and sediment concentration 7.54 µg/L and 9,960 µg/kg, respectively. For Manchester STP, RQs were greater than 1 for chronic aquatic vertebrates, invertebrates, and amphibians.
- The daily release of TBBPA from the West Unity STP was 1.83×10^{-4} kg per site per day and a resulting 7Q10 surface water and sediment concentration 8.33×10^{-2} µg/L and 336 µg/kg, respectively. All RQs were less than 1 for the West Unity STP wastewater treatment facility.
- The daily release of TBBPA from the City of Olean wastewater treatment facility was 2.99×10^{-2} kg per site per day and a resulting 7Q10 surface water and sediment concentration 2.69×10^{-2} µg/L and 42 µg/kg, respectively. All RQs were less than 1 for the City of Olean wastewater treatment facility.
- Lastly, the daily release of TBBPA from Albion WWTP was 5.48×10^{-6} kg per site per day and a resulting 7Q10 surface water and sediment concentration 3.07×10^{-5} µg/L and 0.1 µg/kg, respectively. All RQs were less than 1 for Albion WWTP.

5.3.2.2 Generic Scenario Releases

The daily release of TBBPA from Use of Laboratory Chemicals is 2.50×10^{-5} kg per site per day and a resulting P50 7Q10 surface water and sediment concentration 5.00×10^{-3} µg/L and 20 µg/kg, respectively (Table 5-2). All RQs were less than 1.

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Table 5-2. Risk Quotients per OES for TRI Releases from 2019–2023 and from OES Generic Scenario Modeling

OES (NPDES Facility)	Annual Release (kg/yr)	Days of Release	Daily Release (kg/site- day)	7Q10 Flow (m³/day) ^a	Surface Water (µg/L)	Sediment Conc. (µg/kg)	Risk Quotient ^{b c} (Days of Exceedance)				
							Acute Aquatic ^d	Chronic Vertebrates	Chronic Amphib.	Chronic Invert.	Chronic Sediment- Dwelling Invert.
Facility-specific reported releases											
Processing as a Reactant in Plastic Material and Resin Manufacturing (SABIC INNOVATIVE PLASTICS MT. VERNON LLC)	14.51	4	3.63	9.29E07	0.04	19.8	4.00E-03	0.045	2.83E-04	7.8E-06	1.60E-03
Processing: Additive Flame Retardant in Plastic, Resin, And Paints and Coating (RAVAGO MANUFACTURING AMERICAS)	0.45	12	0.038	1.30E03	12.8	1.74E04	1.28	15 (47) ^d	8.1 (161)	22 (183)	1.48 (39)
Disposal (MANCHESTER STP)	12.25	12	0.10	1.17E04	8.52	9.96E03	0.85	9.97 (12) ^c	5.39 (12) ^c	14.9 (12) ^c	0.96
Disposal (WEST UNITY STP)	0.45	300	1.84E-03	1.25E03	0.09	336	9.00E-03	0.11	0.06	0.16	0.03
Disposal (CITY OF OLEAN WASTEWATER TREATMENT FACILITY)	4.54	300	1.50E-03	1.10E06	1.52E-03	5.40	1.52E-04	1.78E-03	9.62E-04	2.67E-03	5.20E-03
Disposal (ALBION WWTP)	0.01	246	5.48E-06	1.8E05	3.07E-05	0.12	3.48E-06	4.070E-05	2.20E-05	6.12E-05	1.20E-05
Generic scenario releases											
Use of Laboratory Chemicals	6.50E-03	260	2.50E-05	3.61E-03	5.00E-03	20	0.09	5.00E-04	3.2E-03	8.7E-03	0.17
7Q10 = lowest 7-day flow in a 10-year period; NPDES = National Pollutant Discharge Elimination System; OES = occupational exposure scenario; SWC = surface water concentration; STP = sewage treatment plant; WWT = wastewater treatment ^a Concentrations were based on flows from NHDPlus EROM dataset. ^b RQs based on acute aquatic (10 µg/L), chronic vertebrate (0.854 µg/L), chronic invertebrate (0.569 µg/L), algae (120 µg/L), amphibian (1.58), and sediment-dwelling animal (11.7 µg/kg) COCs (U.S. EPA, 2026t). All RQs were calculated using surface water concentrations, except for sediment-dwelling invertebrates, which were calculated using sediment concentrations. ^c The days of exceedance from modeling did not extend beyond the aquatic exposure used to derive the COC and risk is not expected for these taxa. For chronic aquatic vertebrates, invertebrates, and amphibians, all days of exceedance were less than the hazard threshold study duration (120-, 35-, and 28-day, respectively) for the release scenarios.											

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OES (NPDES Facility)	Annual Release (kg/yr)	Days of Release	Daily Release (kg/site-day)	7Q10 Flow (m³/day) ^a	Surface Water (µg/L)	Sediment Conc. (µg/kg)	Risk Quotient ^{b c} (Days of Exceedance)				
							Acute Aquatic ^d	Chronic Vertebrates	Chronic Amphib.	Chronic Invert.	Chronic Sediment- Dwelling Invert.
^d RQs in table are calculated using the COC of 10 µg/L, which resulted from the lower bound of the 95th confidence interval of the HC05. RQs using the HC05 (110 µg/L), were all <1.											

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5.3.3 Risk Estimates for Terrestrial Receptors

EPA conducted an assessment for TBBPA release to the terrestrial environment by performing quantitative risk characterization with combined fugitive release or stack atmospheric deposition to soil (Section 3.3.2). EPA used IIOAC model to estimate total air deposition rates of TBBPA from the ambient air. EPA assumed the fugitive and stack releases occur simultaneously throughout the day and year. Therefore, the total concentration and deposition rate used is the sum of the separately modeled fugitive and stack concentrations and deposition rates at 100 m from a releasing facility. The resulting daily soil concentration is 3.01×10^{-3} mg/kg. The estimated soil concentration does not exceed hazard thresholds for terrestrial soil invertebrates (0.91 mg/kg dry soil) or for terrestrial plants (5 mg/kg dry soil) and RQs were less than 1. Therefore, risk is not expected for these taxa.

5.3.4 Overall Confidence and Remaining Uncertainties Confidence in Environmental Risk Characterization

EPA evaluated confidence in environmental exposures and environmental hazards in the environmental risk characterization. Exposure confidence is detailed in the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)), represented by modeled and monitored data.

Environmental Exposure Confidence

Modeled surface water concentrations were based on TRI reporting of releases to water, as well as high-quality physical and chemical property data derived from reasonably literature collected and evaluated through EPA's systematic review process for TSCA risk evaluations. For one COU, surface water concentrations were modeled via generic scenario.

Overall, EPA has robust confidence in the release data and the resulting modeled surface water concentrations at the point of release in the receiving water body for TRI reporting release. EPA has overall moderate confidence in the release data and the resulting modeled surface water concentrations at the point of release in the receiving water body for generic scenario release. See Section 3.3.3.1 for a description of surface water confidence.

EPA used the IIOAC model to evaluate exposures and deposition rates via the ambient air pathway. IIOAC provides reliable and reproducible results that can be used to characterize upper-bound exposures and derive screening-level risk estimates. Since IIOAC is based on the pre-run AERMOD scenarios, there are limitations regarding which inputs can be modified and which cannot. The use of annual release data and number of operating days to calculate daily average releases assumed operations are continuous and releases are the same for each day of operation. This can underestimate short-term or daily exposure and deposition rates because results may miss actual peak releases (and associated exposures and risks) if higher and lower releases occur on different days. Any limitations and uncertainties of these releases are described in the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)). Overall, EPA has moderate confidence in the modeled ambient air concentrations.

Aquatic Species Overall Confidence

Risk to aquatic organisms was characterized by comparing hazard thresholds (COCs) for aquatic organisms to TRI-derived modeled surface water exposures from three COUs and modelled generic scenarios from one COU. EPA has robust confidence in the risk characterization because of robust confidence in the hazard COCs ([U.S. EPA, 2026q](#)) and robust confidence in the exposure (Section

3.3.3.1) concentrations due to the use of TRI data. EPA has moderate confidence in modeling with generic scenarios.

Terrestrial Species Overall Confidence

EPA has robust confidence that TBBPA exposures from the highest release exposure scenarios are well below the hazard thresholds that would present risk to terrestrial invertebrate and plants ([U.S. EPA, 2026q](#)).

Trophic Transfer Overall Confidence

A hazard threshold was identified for mammals in the form of a TRV, permitting the use of a screening-level trophic transfer analysis to compare potential environmental concentrations and dietary uptake of TBBPA with a daily rate of oral uptake that produces hazard under experimental conditions. Several conservative approaches incorporated within the screening-level trophic transfer analysis likely overrepresent TBBPA ability to accumulate at higher trophic levels; however, this increases confidence that risks are not underestimated. Exposure pathways with aquatic-dependent mammals and terrestrial mammals as receptors were not examined further because, even with conservative assumptions, dietary TBBPA exposure concentrations from this analysis are well below the TRV. The utilization of both modeled and monitored data as a comparative approach with similar results increases confidence. EPA has robust confidence that dietary exposure of TBBPA does not reach concentrations that would cause hazard effects within mammals.

6 UNREASONABLE RISK DETERMINATION

TSCA section 6(b)(4) requires EPA to conduct a risk evaluation to determine whether a chemical substance presents an unreasonable risk of injury to health or the environment, without consideration of costs or other non-risk factors, including an unreasonable risk to a PESS identified by EPA as relevant to this risk evaluation, under the COUs.

EPA is preliminarily determining that TBBPA presents unreasonable risk of injury to human health. Three COUs significantly contribute to unreasonable risk based on inhalation exposures to workers. EPA is also preliminarily determining that TBBPA presents unreasonable risk of injury to the environment. One additional COU significantly contribute to unreasonable risk based on release to surface water. The Agency did not identify significant contributions to unreasonable risk to human health due to TBBPA exposures to ONUs, the general population (which includes fenceline communities), or to consumers.

This preliminary unreasonable risk determination is based on the information provided in previous sections of this draft risk evaluation, the draft TSDs, appendices, and supplemental files (see Appendix C) in accordance with TSCA section 6(b). This preliminary unreasonable risk determination and the underlying evaluations are consistent with the best available science (TSCA section 26(h)) and based on the weight of scientific evidence (TSCA section 26(i)).

EPA notes that uses of TBBPA that are not subject to TSCA (*e.g.*, cosmetics, medical devices) and resulting in human or environmental exposure to TBBPA were not evaluated as COUs by the Agency because these uses are explicitly excluded from TSCA's definition of a chemical substance. Thus, it is not appropriate to extrapolate from this risk determination to form conclusions about uses of TBBPA that are not subject to TSCA and that EPA did not evaluate as COUs.

The full list of COUs evaluated for TBBPA are listed in Table 1-1. EPA has preliminarily determined that the following three COUs significantly contribute to unreasonable risk to human health due to inhalation exposures to workers:

- Manufacture – Domestic manufacturing;
- Manufacture – Import; and
- Processing – Repackaging.

EPA has preliminarily determined that the following COU significantly contributes to unreasonable risk to the environment due to surface water releases:

- Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing

EPA has preliminarily determined that the following COUs do *not* significantly contribute to unreasonable risk of TBBPA:

- Processing – As a reactant – Flame retardant in plastic material and resin manufacturing
- Processing – As a reactant – Intermediate in all other chemical product and preparation manufacturing
- Processing – Incorporation into formulation, mixture, or reaction product – Adhesive manufacturing

- Processing – Incorporation into an article – Reactive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (*e.g.*, printed circuit boards and semiconductor packages)
- Processing – Incorporation into an article – Reactive flame retardant in: Transportation equipment manufacturing (*e.g.*, interior material for automotive and aviation articles)
- Processing – Incorporation into an article – Additive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (*e.g.*, plastic electronic enclosures)
- Processing – Recycling
- Distribution in commerce
- Industrial use – Construction, paint, electrical, and metal products – Powder coatings
- Industrial and commercial use – Construction, paint, electrical, and metal products – Reactive flame retardant in electrical and electronic articles
- Industrial and commercial use – Construction, paint, electrical, and metal products – Reactive flame retardant in automotive and aviation articles (*i.e.*, laminate and prepreg materials)
- Industrial and commercial use – Construction, paint, electrical, and metal products – Additive flame retardant in electrical and electronic articles (*i.e.*, plastic enclosures)
- Industrial and commercial use – Construction, paint, electrical, and metal products – Building/construction materials
- Industrial and commercial use – Packaging, paper, plastic, and hobby products – Plastic and rubber products
- Industrial and commercial use – Other – Laboratory chemical
- Consumer use – Construction, paint, electrical, and metal products – Reactive flame retardant in electrical and electronic articles
- Consumer use – Construction, paint, electrical, and metal products – Additive flame retardant in electrical and electronic articles (*i.e.*, plastic enclosures)
- Consumer use – Construction, paint, electrical, and metal products – Reactive flame retardant in automotive and aviation articles (*i.e.*, laminate and prepreg materials)
- Consumer use – Packaging, paper, plastic, and hobby products – Plastic and rubber products
- Disposal.

An unreasonable risk determination must be informed by best available science and, in making a finding of “presents unreasonable risk,” EPA considers risk-related factors beyond exceedance of benchmarks. Risk-related factors include the type and severity of health effects under consideration, the reversibility of the health effects being evaluated, exposure-related considerations (*e.g.*, duration, magnitude, frequency of exposure), or population exposed—particularly PESS—and the confidence in the information used to inform the hazard and exposure values. For COUs evaluated quantitatively, as described in the risk characterizations (see Sections 4 and 5), EPA based the preliminary determination of unreasonable risk of injury to human health or the environment on the risk estimate that best represents the COU. The Agency describes the strength of the scientific evidence supporting the human health and environmental assessments as robust, moderate-to-robust, moderate, slight-to-moderate, slight, or indeterminate.⁴

This draft risk evaluation discusses important assumptions and key sources of uncertainty in the risk characterization; these are described in more detail in the respective weight of scientific evidence conclusions sections for fate and transport (Section 2.2), environmental release (Section 3.3), human exposures (Section 4.1), human health hazards (Section 4.2), human health risk characterization (Section

⁴ Descriptions of the various levels of confidence used in this draft risk evaluation are provided in Section 4.1.4.

4.3), environmental exposures (Section 5.1.1), environmental hazards (Section 5.2.1), and environmental risk characterization (Section 5.3.4). Appendix E describes EPA's draft intermediate and chronic occupational exposure value (OEV) derivation; it also includes a summary of air sampling analytical methods identified.

6.1 Unreasonable Risk to Human Health

Calculated risk estimates (MOEs⁵) can provide a risk profile of TBBPA by presenting a range of estimates for different health effects for different COUs. To characterize the risk to human health from occupational exposures, EPA conducted baseline assessments of risk and made its preliminary determination of unreasonable risk in a manner that takes into consideration reasonably available information (e.g., information submitted by manufacturers and processors of TBBPA). This allows EPA to make unreasonable risk determinations based on the information regarding workers wearing PPE where the Agency has such reasonably available information. In addition, certain risk estimates are based on exposure scenarios with monitoring data that reflect existing requirements, such as those established by OSHA or industry sector best practices. EPA received some information regarding PPE use relevant to manufacturing ([Albemarle, 2025b](#)), repackaging ([Integral Consulting, 2025c](#)), and for many of the processing COUs relevant to the test order data ([Integral Consulting, 2025a](#)). The Agency found the PPE information related to the Repackaging COU to be sufficient and shows that the unreasonable risk would be addressed for certain task durations and exposure scenarios with an APF 10. For the other COUs, EPA does not have enough sufficient evidence to support confidence in the appropriate respirator selection (i.e., type of respirator); prevalence of respirator use (i.e., by all workers who may be exposed to TBBPA within a given COU); or in the duration or frequency of use for those wearing respirators (i.e., whether all SEGs wear a respirator for the full shift or only during certain tasks or operations). The Agency is requesting comments on specific PPE use for the COUs and will consider any additional information in the development of the final risk evaluation for TBBPA.

To characterize risk from non-cancer endpoints, the estimated MOEs are compared to their respective benchmark MOE. The benchmark MOE accounts for the total uncertainty in a POD. The benchmark MOE is the product of several individual uncertainty factors relevant to a given POD with values usually consisting of 1, 3, or 10. The benchmark MOE for TBBPA for inhalation, oral, and dermal exposures is 30. Additional information regarding the non-cancer hazard identification and the benchmark MOE is provided in Section 4.2, including explanation of the determination of risk from dermal exposure using the oral POD and route-to-route extrapolation from the oral POD to an inhalation HEC for determination of risk from inhalation of TBBPA. No cancer risk estimates were derived for TBBPA because EPA's approach to dose-response of uterine tumor cancer effects in chronic POD selection through a non-genotoxic, non-linear cancer threshold of effects is protective of cancer (and non-cancer) health outcomes associated with chronic TBBPA exposure.

It is important to emphasize that these calculated risk estimates alone are not "bright-line" indicators of unreasonable risk. In the preliminary risk determination, EPA considered risk-related factors beyond exceedance of benchmarks—including the Agency's confidence in the data, an evaluation of the strengths, limitations, uncertainties, and confidences associated with the information used to inform the risk estimate and risk characterization. Descriptions of risk estimates that are based on highly refined hazard and exposure information would be considered differently than risk estimates based on conservative assumptions on both hazard and exposure. The process of determining unreasonable risk is made on a case-by-case basis, given the inherently unique nature of chemical-specific risk evaluations.

⁵ EPA derives non-cancer MOEs by dividing the non-cancer POD (HEC [mg/m³] or HED [mg/kg-day]) by the exposure estimate (mg/m³ or mg/kg-day). Section 0 has additional information on the risk assessment approach for human health.

6.1.1 Populations and Exposures EPA Assessed for Human Health

EPA evaluated risk to workers (aged 16+ years), including ONUs, consumers and bystanders (adults and children), as well as the general population (including fenceline communities), using reasonably available monitoring and modeling data for inhalation, dermal, and ingestion exposures, as applicable. More specifically, the Agency has evaluated risk from inhalation and dermal exposure of TBBPA to workers, including ONUs, and ingestion, dermal, and mouthing exposures of TBBPA to consumers. Finally, the Agency evaluated risk from exposures from surface water, drinking water, soil from air to soil deposition, and land pathways (*i.e.*, landfills and application of biosolids) to the general population. EPA's evaluation of the general population also included ingestion of human milk and evaluation of populations living near facilities releasing TBBPA to the ambient air, which includes fenceline communities, as part of the ambient air exposure assessment.

In developing the exposure and hazard assessments for TBBPA, EPA has analyzed reasonably available information to ascertain whether some human populations may have greater exposure and/or susceptibility than the general population to the hazard posed by TBBPA. For the risk evaluation, EPA accounted for the following PESS: females of reproductive age; pregnant women; infants; children and adolescents; people who frequently use consumer products and/or articles containing high concentrations of TBBPA; people exposed to TBBPA in the workplace; people in close proximity to releasing facilities, including fenceline communities; and tribes and subsistence fishers whose diets include large amounts of fish. Section 4.3.5 summarizes how PESS were incorporated into the risk evaluation through consideration of potentially increased exposures and/or potentially increased biological susceptibility and summarizes additional sources of uncertainty related to consideration of PESS.

6.1.2 Summary of Human Health Effects

EPA has preliminarily determined that the unreasonable risk presented by TBBPA is due to non-cancer effects in the following populations via the following listed exposures:

- Workers from intermediate and chronic inhalation exposures.

Human health risks were evaluated for intermediate and chronic exposure scenarios, as applicable based on reasonably available exposure and hazard data for TBBPA as well as the relevant populations for each. Because TBBPA is not expected to be acutely toxic (Section 4.2.1), acute exposure scenarios were not developed.

EPA identified the effect of polycystic kidney lesions in neonatal male rats and atypical endometrial hyperplasia uterine lesions as the most robustly supported hazards associated with oral exposure to TBBPA in experimental animal models for intermediate and chronic exposure duration scenarios, respectively. The Agency considers the intermediate duration POD to be protective of all relevant intermediate duration, non-cancer health effects across sex and life stage and considers the chronic duration POD to be protective of all relevant chronic (non-cancer and cancer) health outcomes associated with chronic TBBPA exposure. Specifically, rodents exposed *in utero* or during neonatal periods appear more sensitive to TBBPA-induced toxicity than adult rodents, and LOAELs for additional identified non-cancer health effects (*i.e.*, liver, neurological, and thyroid) were determined to consistently occur at levels above the intermediate exposure duration POD. Thus, EPA was able to incorporate potential life stage susceptibility into hazard values for intermediate exposure duration scenarios through selection of an endpoint measured in rodents exposed during the neonatal period.

The Agency identified no reasonably available studies conducted via the dermal route for extrapolating human health risk; thus, the oral HED was used in dermal human health risk estimates. Additionally, in

the absence of inhalation studies, EPA performed route-to-route extrapolation to convert the oral HEDs to an inhalation HEC of 1.66 ppm (37.0 mg/m³) for the intermediate exposure duration and HEC of 1.08 ppm (24.0 mg/m³) for the chronic exposure duration. EPA assumed similar absorption of TBBPA via the oral and inhalation routes (*i.e.*, 100%) and acknowledges uncertainty regarding the lack of route-specific ADME data. It is important to note that any decrease in inhalation absorption may be compensated for by shifting to absorption via ingestion that would likely occur for particles cleared from the respiratory tract. However, as particle size distribution of TBBPA as particles or TBBPA adhered to dust as particle aggregates is unknown, there is uncertainty in site-specific deposition or the ability of mucociliary clearance to occur for larger dust particle fractions that would contribute to total dose. Overall, no toxicokinetic data or PBPK/PD model are reasonably available to support refining absorbed dose via inhalation. Finally, as discussed in Section 4.2, the non-cancer chronic POD is protective of expected non-cancer and cancer chronic health effects—including TBBPA-related cancers that arise from a non-linear threshold (uterine tumors). Thus, separate cancer risk estimates were not derived for TBBPA.

EPA has robust overall confidence in the proposed intermediate and chronic HEDs to inform quantitative human health hazard risk estimates from oral and dermal routes of exposure. EPA has moderate overall confidence in the proposed intermediate and chronic HECs to inform quantitative human health hazard risk estimates from inhalation routes of exposure. More information on the human health hazard and PODs for TBBPA can be found in Sections 4.2.1 and 4.2.2.

6.1.3 Basis for Unreasonable Risk to Workers

Based on the occupational risk estimates and related risk factors, EPA has preliminarily determined that three COUs significantly contribute to unreasonable risk to human health due to non-cancer risks from intermediate inhalation exposure to workers, with two of these COUs (Manufacture – Import; and Processing – Repackaging) also contributing to unreasonable risk to workers from chronic inhalation exposure to TBBPA:

- Manufacture – Domestic manufacturing;
- Manufacture – Import; and
- Processing – Repackaging.

All risk estimates for dermal exposures were well above the benchmark MOE— even when considering upper-bound exposures— and EPA has preliminarily determined that dermal exposures do not significantly contribute to the unreasonable risk. Additionally, EPA preliminarily determined that no COU significantly contributes to unreasonable risk to ONUs from inhalation or dermal exposure to TBBPA.

Risk estimates were well above the benchmark MOE for the 9 COUs represented by the inhalation monitoring data collected and reported by the 21 companies of the ACC TBBPA Consortium in response to the test order. These companies processed or industrially used TBBPA at a total of 26 sites in the United States ([Integral Consulting, 2025a](#)). EPA has preliminarily determined that none of these COUs significantly contribute to the unreasonable risk to workers. See Table 6-1 for the COUs associated with the OES represented by the test order data.

Seven COUs indicated potential inhalation risk (*i.e.*, were associated with risk estimates below the benchmark MOE). Because these COUs were not aligned with OESs relevant to inhalation monitoring data submitted in response to the test order, EPA assessed occupational inhalation exposure for the three COUs for which EPA is preliminarily determining contribute to unreasonable risk (listed above) using

worker inhalation exposure monitoring data from similar exposure scenarios or surrogate worker inhalation exposure monitoring data.

For four of these COUs, such exposure monitoring data were not available; therefore, the Agency assessed occupational inhalation exposure in accordance with EPA's PNOR Model ([U.S. EPA, 2021b](#)), including the following:

- Industrial and commercial use – Construction, paint, electrical, and metal products – Building/construction materials;
- Industrial and commercial use – Construction, paint, electrical, and metal products – Powder coatings;
- Industrial and commercial use – Construction, paint, electrical, and metal products – Additive flame retardant in electrical and electronic articles (*i.e.*, plastic enclosures); and
- Disposal.

Contributions to Unreasonable Risk to Workers from the Manufacture – Domestic Manufacture COU

For EPA's analysis of the Manufacture – Domestic manufacture COU, EPA utilized historic monitoring data of total dust, which was collected as surrogate TBBPA inhalation exposure data because a TBBPA sampling and analysis method information was lacking. These data, determined to be of high quality, were submitted by a member of the ACC TBBPA Consortium in response to EPA's test order, and comprised total dust full-shift PBZ worker monitoring data from various workers (*e.g.*, a maintenance worker, an electrical and instrumentation technician, a backend operator, a loader operator, and general operators) during the manufacture of TBBPA between July 2003 to November 2021.

As noted in Section 4.3.2, one of the major limitations associated with this analysis is that the data are total dust data and not TBBPA data; therefore, the exposure concentrations that inform these risk estimates possibly exceed TBBPA exposure concentrations to which workers were exposed. However, EPA has confidence that the assessed exposure concentrations, including the assessed high-end values, are representative of this COU and are based on the following rationale: (1) TBBPA is present in the ambient environment of workplaces in the particle associated phase, as is represented by total dust; (2) using total dust as a proxy for exposure to chemicals present as solid particles is reported to be standard industrial hygiene practice for a particulate chemical with no NIOSH sampling and analytical method ([Albemarle, 2025b](#)) and is the basis of the PNOR Model used by EPA ([U.S. EPA, 2021b](#)); (3) the TBBPA production area in the manufacturing facility was separated from other areas producing other powders, and thus total dust is considered a suitable surrogate for characterizing exposure to TBBPA at this manufacturing facility; (4) the presence of detectable levels of dust was associated with locations of TBBPA manufacture, and absent in the two PBZ samples for workers not working in areas of TBBPA manufacture, providing evidence that the dust was comprised predominantly of TBBPA; and (5) the inhalation data are representative of TBBPA manufacturing, in that they were collected during the manufacture of TBBPA from 2003 to 2021 at the single TBBPA manufacturing facility in the United States according to the 2023 TRI. Therefore, EPA accepted the inhalation monitoring data of total dust as a surrogate for TBBPA submitted by the ACC TBBPA Consortium in fulfillment of the test order.

Based on the high-end risk estimate ($MOE = 25$) and EPA's consideration of risk-related factors (*e.g.*, the confidence in the underlying inhalation data, the plausibility of the exposure scenario), the Agency has preliminarily determined that the Manufacture – Domestic Manufacture COU significantly contributes to the unreasonable risk of TBBPA due to intermediate inhalation exposures to workers. Note, information submitted to EPA indicates that domestic manufacture of TBBPA in the United States ceased in 2023 ([ACC, 2025b](#); [Integral Consulting, 2025c](#)). However, EPA has determined that the

domestic manufacture of TBBPA in the United States is reasonably foreseen. If this use were to restart in the United States, a properly managed respiratory protection program (*i.e.*, one that includes medical evaluation for respirator users, annual fit-testing for each type of respirator worn, annual respirator training) would reduce the inhalation exposures to TBBPA such that the risks would no longer be unreasonable. EPA is requesting comment on this use including any information supporting this use as reasonably foreseen use and any information regarding the use being reestablished in the United States.

EPA received information regarding worker protection practices during the manufacturing of TBBPA in a memorandum from the manufacturer, Albemarle Corporation ([Albemarle, 2025b](#)). The memorandum reported the use of engineering controls to reduce air concentrations of TBBPA, specifically that “workers in the TBBPA area handled the powdered products under ventilation hoods”; however, no specific details were provided regarding whether the use of this engineering control applied to all workers and tasks associated with manufacture of TBBPA. The memorandum also notes PPE use broadly for workers to address dermal and ocular exposure (*i.e.*, workers handling TBBPA and other powdered products wore gloves, safety glasses, and disposable coveralls”). Regarding respiratory PPE, the memorandum states that packagers/loaders were wearing “dust respirators” prior to 2000, and in a 2000 report, recommendations were made and implemented to upgrade that protection to a half face respirator with particulate cartridge. However, no further details were provided in the memorandum confirming current respirator use and type, and it is unclear whether respirators are worn by all workers who may be exposed to TBBPA during manufacturing. Therefore, EPA does not have enough confidence in the prevalence of respirator use (*i.e.*, by all workers who may be exposed to TBBPA during manufacturing) or in the duration or frequency of use for those wearing respirators (*i.e.*, whether packagers and loaders wear a respirator for the full shift or only during certain tasks or operations) to consider respiratory PPE use to be sufficient to quantitatively consider in preliminarily determining unreasonable risk. Therefore, EPA’s preliminary determination that the Manufacture – Domestic manufacture COU significantly contributes to the unreasonable risk to workers is not based on APF-adjusted risk estimates. EPA requests comments on PPE use and will consider any additional information in the development of the final risk evaluation for TBBPA. Useful information regarding PPE may include documentation of a respiratory protection program, including training and fit testing, respirator type and protection factor, which workers wear respirators, and whether respirator use is only during certain tasks or in certain areas of the facility.

Contributions to Unreasonable Risk to Workers from the Repackaging and Import COUs

To determine whether the Repackaging and Import COUs significantly contribute to the unreasonable risk to workers, EPA used surrogate PBZ data that the ACC TBBPA Consortium collected at two TBBPA processing sites in response to a test order issued by EPA ([Integral Consulting, 2025c](#)). The Agency assessed two different exposure scenarios described in detail in Sections 4.1.1.1 and 4.1.1.2, respectively, but that are summarized below. |

For Scenario 1, workers repackaged 100% TBBPA powder from super sacks into smaller bags using a self-contained machine with dust collection, representing more robust engineering controls. Three full-shift TWA PBZ samples and two task-based samples were collected. The task-based samples were collected while the workers repackaged the “super sacks.” EPA assessed central tendency and high-end full-shift TWA concentrations of Scenario 1 as the 50th and 95th percentile of the three full-shift TWA PBZ samples; the resulting risk estimates for intermediate and chronic duration were well above the benchmark at both central tendency and high-end.

Scenario 2, involves fewer engineering controls compared to Scenario 1, based on the process description and level of automation between the two sites. For Scenario 2, workers transferred 100%

TBBPA powder in 2,000-pound super sacks into a reactor using a mechanism that automatically empties the super sacks after the worker unties the sack. Six task-based samples (each from a different worker) were collected while the workers transferred the contents of the super sacks into the reactor. The sample durations are mostly 15 or 17 minutes, and the exception is one sample with a duration of 25 minutes ([Integral Consulting, 2025c](#)). To assess the exposure of Scenario 2 for repackaging, EPA assumed a worker unloads super sacks during a 12-hour shift and conducts this task for 10 hours (see Table 4-5). The Agency converted each of the six task-based samples to 12-hour full-shift TWA samples and then assessed central tendency and high-end full-shift TWA concentrations of Scenario 2 as the 50th and 95th percentile of the resulting full-shift TWA concentrations, respectively. Risk estimates for intermediate and chronic duration were below the benchmark at both central tendency (MOE = 3–4) and high-end (MOE = 1).

It is important to note that risk estimates associated with these two COUs (Manufacture – Import; and Processing – Repackaging) assume that workers are exposed to the same levels as taken during these task-based samples for 10 hours out of the 12-hour work day. EPA acknowledges that the assumption that the worker performed unloading/loading tasks for the majority of their work shift has the potential to overestimate exposure. Therefore, the Agency conducted a sensitivity analysis varying the time a worker would spend during these tasks, including a 5-hour duration, which aligns with the duration reported for transloading TBBPA in super-sacks from one truck at the manufacturing/repackaging facility prior to cessation of repackaging at that site and moving to the toller facility. In addition, a 30-minute duration was included, which is comparable to the duration of the task-based samples (15–25 minutes) taken at the processing facility. The risk estimates for these refined analyses of different daily durations are included in Table 6-2. Importantly, even after refining EPA’s analysis, risk estimates for Processing – Repackaging Scenario 2 were still below the benchmark for workers repackaging for

- five hours per day (comparable to the time to unload one truck per day at the repackaging facility) at this exposure level during the 12-hour work day at both central tendency and high-end for intermediate duration (MOE = 2.4 – 6.8) and at central tendency (MOE = 7.5) and high-end (MOE = 2.6) for chronic duration;
- one hour per day at this exposure level during each 12-hour work day at high-end for intermediate duration (MOE = 12) and high-end (MOE = 13) for chronic duration; and
- thirty minutes (comparable to the task-based sample duration) each 12-hour work day at high-end for intermediate (MOE = 24) and chronic (MOE = 26) duration.

Therefore, based on the feasibility that workers would be performing import or repackaging in an environment represented by the surrogate inhalation monitoring data (*e.g.*, the process characterizing Scenario 2, with fewer engineering controls) for 5 hours per day or longer, EPA is preliminarily determining that inhalation exposure to workers under the Repackaging and Import COUs significantly contributes to unreasonable risk.

For the Repackaging COU, EPA considered information about PPE use at two processing facilities that repackage or unload TBBPA, which include a half-face respirator with cartridges, full-face air-purifying respirator with vapor/acid filters and HEPA filters, N95 respirators, a paper suit outer garment, fire-resistant uniforms, Tyvek suits, and chemical-protective gloves. The PPE used during transloading of TBBPA super sacks at Albemarle Corporation’s Magnolia, Arkansas, site includes Tyvek suits and half-face respirator with cartridges ([Integral Consulting, 2025c](#)). See Table 4-21 for further information regarding PPE use during repackaging. As stated in Section 4.3.2.1, based on all the respiratory protection information provided by the ACC TBBPA Consortium, EPA assumes that workers use an APF 10 respirator during the period that a worker transloads TBBPA super sacks as part of the repackaging COU.

Risk estimates were derived for different exposure scenarios, representing varying exposure frequencies (0.5–5 hours), durations (intermediate and chronic), and magnitude (central tendency and high-end). The resulting risk estimates indicate that a respirator with an APF of 10 would adequately reduce exposure for the majority of workers (all durations at central tendency) and for workers experiencing high-end exposure for shorter durations. However, a respirator with a higher APF would be needed to reduce exposure for workers experiencing high-end exposure for durations of 5 hours per day (e.g., the time associated with unloading/repackaging of 1 truck) or longer (Table 4-22 and Table 6-2). Therefore, EPA's preliminary determination that the Repackaging and Import COUs significantly contribute to unreasonable risk to workers is based on risk to workers exposed to high-end concentrations of TBBPA that would be expected during the exposure scenario indicated by Repackaging Scenario 2, with the assumption that workers are unloading super sacks from at least one truck per day for intermediate durations. EPA is requesting comments on PPE use and will consider any additional information in the development of the final risk evaluation for TBBPA. Useful information regarding PPE may include documentation of a respiratory protection program, including training and fit testing, respirator type, and protection factor, which workers wear respirators, and whether this use is only during certain tasks or in certain areas of the facility. If EPA is provided with additional information as a result of public comment on this draft risk evaluation, the Agency will appropriately refine and adjust the scenarios and assumptions used before finalizing the risk evaluation.

COUs Without Significant Contributions to Unreasonable Risk

There were four other COUs for which inhalation and/or aggregate risk was indicated (*i.e.*, risk estimates were below the benchmark MOE). However, EPA is preliminarily determining that these COUs do *not* significantly contribute to the unreasonable risk to workers from TBBPA:

- Industrial and commercial use – Construction, paint, electrical, and metal products – Building/construction materials;
- Industrial and commercial use – Construction, paint, electrical, and metal products – Powder coatings [MOEs only below benchmark for aggregate exposure];
- Industrial and commercial use – Construction, paint, electrical, and metal products – Additive flame retardant in electrical and electronic articles (*i.e.*, plastic enclosures) [MOEs only below benchmark for aggregate exposure]; and
- Disposal.

For all four COUs, inhalation exposure or surrogate worker inhalation exposure data were not available, and the Agency assessed occupational inhalation exposure in accordance with EPA's PNOR Model ([U.S. EPA, 2021b](#)). Risk estimates were below the benchmark only for high-end exposure. Given that high-end exposure estimates using the PNOR Model reflect the 95th percentile of the dust concentrations specific to this industry and assume that the dust is composed of TBBPA at the highest weight fraction represented by the COU, EPA considers it unlikely that this confluence of factors that comprise high-end would occur consistently in the workplace; therefore, central tendency exposure estimates are considered to be more representative of worker exposure for these COUs. Furthermore, the fact that the weight fractions in other products relevant to the COUs are orders of magnitude lower than the weight fraction used in the PNOR model provides further support that the high-end exposure values may overestimate exposure to workers. For example, as indicated in Table 3-1, EPA's risk characterization of Industrial and commercial use of building and construction materials assumed that the dust was composed of TBBPA at the percentage represented by the article with the highest weight fraction (22%) relevant to this COU, which is representative of concentrations of TBBPA in ABS (17.6–22%) but is considerably higher than weight fractions of TBBPA in other products in this COU, such as phenolic resins (0.1–0.4%). The confluence of high-end dust concentration and high-end weight fraction likely overestimate exposure of workers to TBBPA via these COUs. Therefore, EPA has preliminarily

determined that the COUs evaluated using the PNOR Model (listed above) do not contribute to unreasonable risk because risk estimates were above the benchmark for exposures at central tendency (considered to be more representative of worker exposure) which uses the 50th percentile of the dust concentration and the highest weight fraction.

There were several additional COUs (*e.g.*, Processing as a reactant; Processing – Incorporation into formulation, mixture, or reaction product) for which risk estimates were marginally below the benchmark (MOE = 27) only when considering aggregate exposure (inhalation + dermal), but were not above the benchmark for either exposure route when examined separately. As explained in Section 4.3.2.3, the high-end dermal exposure estimate is based on maximal flux through the surface area of two hands, which is an upper bound that likely overestimates exposure. Therefore, EPA does not expect that aggregation of high-end inhalation and dermal exposure estimates correlate with risks to worker populations and has preliminarily determined that aggregate exposure to workers from these COUs does not contribute to unreasonable risk.

For the Distribution in commerce, EPA defined this COU as the transportation of TBBPA and TBBPA-containing products between sites at which TBBPA manufacturing, processing, and use occurs or the transportation of TBBPA-containing wastes for recycling or disposal. The Agency expects all of the above-mentioned materials (TBBPA for manufacturing, processing, and use; and TBBPA-containing wastes for recycling or disposal) to be transported within closed containers where no exposure can be expected or otherwise to be transported in a form (*e.g.*, articles containing TBBPA) such that there is negligible potential for occupational exposure except during an incident. Other exposure opportunities during this life cycle are captured under other relevant COUs (*e.g.*, once distributed in commerce, TBBPA in a truck or container may be transferred and repackaged, so this exposure point in the life cycle would fall under Repackaging). Therefore, EPA has preliminarily determined that the Distribution in commerce COU does not contribute to unreasonable risk.

6.1.4 Basis for No Unreasonable Risk to Consumers

Based on the consumer risk estimates and related risk factors, EPA is preliminarily determining that consumer uses do not significantly contribute to the unreasonable risk of TBBPA. The Agency has confidence that (1) the high-intensity use scenarios represent an upper-bound exposure, and (2) that the screening analysis described above estimated exposures and risks that are health protective for consumers. Additional information on the consumer analysis can be found in Section 4.3.3 of this draft risk evaluation.

Under the COUs, EPA assessed consumer risk from inhalation, ingestion, mouthing and dermal exposures, as well as aggregated exposure from these routes for various scenarios involving TBBPA-containing products and articles. Consumer and bystander populations assessed were infants (<1 year), toddlers (1–2 years), preschoolers (3–5 years), middle childhood (6–10 years), young teens (11–15 years), teenagers (16–20 years), and adults (21+ years). EPA conducted a screening-level analysis for TBBPA for the Construction, paint, electrical, and metal products – Additive flame retardant use in electronics and electrical articles (*i.e.*, plastic enclosure) COU. For this COU, EPA relied on conservative and potentially unrealistically high assumptions to characterize what would be outside the high-end of the expected exposures. Because no risk was indicated (*i.e.*, all MOEs were well above the benchmark of 30)—even at potentially overly protective and unrealistic assumptions—no further refinements were made. For the assessment of Packaging, paper, plastic, hobby products – Plastic and rubber products (*i.e.*, 3D printing filament) and the Construction, paint, electrical, and metal products – Reactive flame retardant in automotive and aviation articles (*i.e.*, laminate and prepreg material) COUs, EPA relied on conservative assumptions to characterize what would be expected to be at the upper

bound of the expected exposure distribution. Similarly, because no risk was indicated (*i.e.*, all MOEs were well above the benchmark of 30), even for upper-bound and conservative assumptions above expected uses, no further refinements were made.

EPA has robust confidence in the health hazard values used to estimate risks for these COUs (see Section 4.2). The health hazard values are based on the most robustly supported non-cancer endpoint for all relevant exposure durations; that is, polycystic kidney lesions for intermediate exposure duration and atypical endometrial hyperplasia uterine lesions for chronic exposure. The confidence in the precision of the exposure and risk estimates for Construction, paint, electrical, and metal products – Additive flame retardant in electrical and electronic articles (*i.e.*, plastic enclosures) COU is slight only for the inhalation route. This is because of the high uncertainties in using an unrealistic surface area of electrical and electronic articles in the household. However, EPA has robust confidence that the risk estimates are protective despite slight confidence in the precision of the exposure estimates because the risk estimates were above the benchmark—even though an unrealistically high surface area of electrical and electronic articles was used to determine the exposure estimates. Ingestion of dust or through mouthing and dermal contact risk estimates have a robust or moderate confidence because they do not require the surface area of the articles to obtain exposure estimates. EPA has moderate confidence in the risk estimates for all other assessed consumer COUs and scenarios.

6.1.5 Basis for No Unreasonable Risk to General Population

EPA has preliminarily determined that TBBPA does not present unreasonable risk to the general population from any exposure route or pathway. Based on the risk estimates, the Agency did not identify risk to the general population from the following exposure routes and pathways for TBBPA for all COUs:

- exposure via the land pathway (*i.e.*, application of biosolids and landfills);
- incidental ingestion and dermal contact from swimming;
- intermediate and chronic ingestion of drinking water;
- intermediate and chronic ingestion exposure from fish consumption;
- intermediate and chronic inhalation exposure to ambient air in proximity to releasing facilities, including fenceline communities;
- soil ingestion exposure from air deposition to soil; and
- ingestion of human milk.

EPA qualitatively evaluated exposure and risk resulting from biosolid application, landfills, and swimming in surface waters affected by TBBPA releases. Down-the-drain releases of consumer products and landfill disposal of consumer articles are also discussed qualitatively in Sections 3.1.2 and 4.1.6.2, respectively. It is difficult for EPA to quantify exposures from end-of-life consumer articles (*e.g.*, to landfill leachate) due to limited information on source attribution of the consumer COUs. For down-the-drain releases, no liquid products containing TBBPA were identified. The Agency preliminarily concluded that, based on TBBPA's physical and chemical characteristics, exposure and resulting risk to the general population through the land pathway (*i.e.*, application of biosolids and landfills) and down-the-drain releases are unlikely. For the incidental ingestion and dermal contact from swimming discussed qualitatively in Section 4.1.6.3, EPA concluded that the drinking water assessment was more protective and therefore inclusive of the swimming scenario.

As stated in Section 4.3.4, EPA quantitatively evaluated exposure via drinking water, fish ingestion, ambient air, soil via deposition from ambient air, and human milk pathways (see *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)) and Section 4.1.6 for additional

details about the assessment and assessment process). For pathways assessed quantitatively, EPA used upper-bound inputs to provide conservative estimates of TBBPA concentration in the various environmental media for screening-level purposes. EPA also used an MOE approach using upper-bound exposure estimates with the human health POD to determine whether an exposure pathway had non-cancer risk estimates below the benchmark. Upper-bound exposure estimates were defined as those associated with the manufacturing, industrial, and commercial TBBPA releases from a COU and OES that resulted in the highest environmental media concentrations. If a pathway could not be directly associated to a COU or OES, such as for the human milk pathway (Sections 4.1.6.6 and 4.3.4.4), upper-bound exposure estimates were determined through other data sources like biomonitoring.

If there is no risk for the general population based on the highly conservative screening approach and upper-bound exposure estimates, then EPA does not expect any exposure estimates based on lower releases and exposure factors will result in risk either. If MOEs below a benchmark of 30 were estimated using these conservative approaches, then the Agency would refine exposure estimates for the respective pathway using higher tiers of modeling and additional data, when available, and considering exposure to additional subpopulations and from additional COUs/OES. Risk estimates for the screening analysis for the various pathways assessed quantitatively are described in Section 4.1.6. MOEs for upper-bound exposure scenarios were all above the benchmark of 30. Therefore, using a screening-level approach described in Section 4.1.6, exposure to TBBPA through drinking water, ambient air, soil via deposition from ambient air, and human milk do not indicate risk to the general population for any COU or OES.

As described in Sections 3.3.3 and 4.1.6.7, and in more technical detail in the *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)), EPA has robust confidence in the qualitative assessment of the land pathway and robust confidence that modeled exposures used for assessing drinking water, fish ingestion, ambient air, soil via deposition from ambient air, and human milk pathways are appropriately conservative for the quantitative screening-level assessment. Therefore, EPA has robust confidence that no general population exposure scenarios via the air, land, or surface water pathways will lead to greater exposure than presented in this evaluation. Along with the Agency's robust confidence in the PODs selected to characterize risk from intermediate and chronic duration exposures to TBBPA (see Section 4.2 and [U.S. EPA \(2026t\)](#)), EPA has robust confidence that the risk estimates calculated for the general population were conservative and appropriate for a screening-level analysis and apply across all COUs.

6.2 Unreasonable Risk to the Environment

Based on the risk evaluation for TBBPA—including the risk estimates, the environmental effects, the estimated exposures, physical and chemical properties, and consideration of uncertainties—EPA has preliminarily determined that TBBPA presents unreasonable risk of injury to the environment driven by chronic exposures to aquatic vertebrates, invertebrates, sediment-dwelling invertebrates, and amphibians in surface water as described in Section 5.3.2. The one COU with significant contributions is listed below:

- Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing

For the aquatic pathways for which EPA derived risk estimates, the Agency evaluated whether the potential water releases and resultant exposures of TBBPA in water and sediment will exceed the concentrations that result in hazardous effects for aquatic vertebrates, aquatic invertebrates, sediment-dwelling invertebrates, amphibians, and algae. Of the 24 total COUs associated with TBBPA,

- 16 COUs had reported facility-specific releases, 12 of which reported no releases to water;
- 1 COU was assessed via generic scenario modeling (Industrial and commercial use – Other – Laboratory chemical);
- 3 COUs were not assessed quantitatively because EPA does not expect releases to water during activities under these COUs (Recycling; Distribution in commerce; and Industrial and commercial use – Packaging, paper, plastic, and hobby products – Plastic and rubber products); and
- 4 COUs were only relevant to consumer uses for which TRI release data would not be applicable;

EPA did not calculate RQs for the 12 COUs with zero reported releases to water or the 3 COUs not assessed quantitatively because the Agency expects water and sediment exposure for organisms for those COUs to be negligible. Furthermore, the Agency is preliminarily determining that they do not significantly contribute to the unreasonable risk to the environment; see Table 3-2 for further details on the TRI reporting of releases to water for each COU.

Four COUs with facility-specific releases indicated water release of TBBPA greater than zero, so EPA characterized the environmental risk of TBBPA to aquatic invertebrates, aquatic vertebrates, amphibians, and algae using RQs that compare the predicted surface water concentration with hazard threshold values for those four COUs. EPA also assessed one additional COU assessed using generic scenario modeling (*i.e.*, Industrial and commercial use – other – laboratory chemicals) because the Agency did not have release data specific to this COU. Of the five COUs quantitatively assessed, two COUs (Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing; and Disposal) had RQs greater than 1 (Section 5.3.2). The other three COUs that were quantitatively assessed (*i.e.*, Industrial and commercial use – Other – Laboratory chemicals; Processing – As a reactant – Flame retardant in plastic material and resin manufacturing; and Processing – As a reactant – Intermediate in all other chemical product and preparation manufacturing) resulted in RQs less than 1.

For sediment-dwelling invertebrates, EPA calculated RQs comparing the predicted sediment concentration with hazard threshold values for the same five COUs with reported releases and modeled surface water releases and risk was indicated (*i.e.*, RQs >1) for chronic exposure to sediment-dwelling invertebrates from one COU (Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing). No risk to these organisms exists under any other COU under TSCA (Section 5.3.2).

The Agency qualitatively evaluated exposures via biosolids and landfills due to high-quality physical and chemical property data suggesting that TBBPA is immobile in soils (Section 4.1.6.2). However, for soil concentrations resulting from ambient air to soil deposition, EPA quantified exposure to terrestrial invertebrates and plants. EPA modeled maximum fugitive and stack releases to air and subsequent deposition to soil. Soil concentrations of TBBPA did not exceed hazard thresholds for terrestrial soil invertebrates or for terrestrial plants, with RQs less than 1 (Section 5.3.3). Therefore, risk is not expected for these taxa.

For terrestrial mammals, the Agency conducted a screening-level, trophic transfer assessment of dietary intakes, as detailed in *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)), and

found that exposure would not exceed the hazard thresholds that would present risk. The Agency does not expect exposure to TBBPA via air, land, or dietary pathways for any COUs assessed to contribute to unreasonable risk to the environment.

Discussion of the environmental risk assessment approach and risk estimates is in Section 5.3. Briefly, an RQ less than 1 generally indicates that there is no risk of injury to the environment that would support a determination of unreasonable risk, whereas an RQ greater than 1 generally indicates that there is risk of injury to the environment that would support a determination of unreasonable risk. Additionally, if a chronic RQ is 1 or greater, the Agency evaluates whether the chronic RQ is 1 or greater for a given number of days equivalent to or exceeding the exposure period of the hazard toxicity tests before making a determination of unreasonable risk. Risk was also characterized qualitatively for specific receptor groups to support conclusions. Again, consistent with EPA's determination of unreasonable risk to human health, the RQ is not treated as a bright-line and other risk-based factors may be considered (e.g., confidence in the hazard and exposure characterization, duration, magnitude, uncertainty) for purposes of making an unreasonable risk determination.

6.2.1 Populations and Exposures EPA Assessed for the Environment

EPA estimated environmental exposures to both aquatic and terrestrial species based on releases of TBBPA and concentrations of TBBPA in the environment as part of its environmental risk assessment.

For aquatic organisms inhabiting the water column and benthic zone, including aquatic invertebrates, vertebrates, amphibians, and algae, EPA estimated exposures from surface water and sediment. For the surface water pathway, TBBPA from water releases is expected to predominantly partition into sediment. The surface water and sediment exposure assessment was performed by comparing the calculated hazard threshold to the highest environmental media concentrations modeled from the highest releasing facilities identified for each COUs (Section 5.3.2). Because these are actual releases reported to TRI and DMR, averaged over the actual reported number of release days, EPA is confident in the exposure and risk estimates.

For terrestrial invertebrates and plants, EPA estimated exposure from TBBPA in soil resulting from air-to-soil deposition from releasing facilities (Section 5.3.3). The Agency also qualitatively considered exposure via biosolids and landfills based on high-quality physical and chemical property data (Section 4.1.6.2). For terrestrial mammals, the Agency conducted a screening-level trophic transfer assessment looking at dietary intakes detailed in *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026q](#)).

EPA has robust confidence in its risk assessment for aquatic organisms, based on moderate confidence in the environmental hazard data and robust confidence in the surface water and sediment concentrations, due to the use of TRI data. EPA also has robust confidence in its risk assessment of terrestrial organisms based on robust confidence in the environmental hazard data; the use of reported releases to air from TRI, AERMOD, and IIOAC modeling to estimate soil concentrations from air-to-soil deposition; and robust confidence in the trophic transfer assessment. Additional information about EPA's confidence in the aquatic, terrestrial, and trophic transfer exposure assessments are found in Section 5.3.4 of this draft risk evaluation.

6.2.2 Summary of Environmental Effects

EPA preliminarily determined that TBBPA poses hazards from chronic exposures to aquatic vertebrates, chronic exposures to aquatic invertebrates, chronic exposure to sediment-dwelling invertebrates,

exposure to algae, dietary exposure to terrestrial mammals, soil exposure to terrestrial invertebrates, embryonic toxicity to avian species, and soil exposure to terrestrial plants. A summary of environmental hazards is provided in Section 5.2. EPA has moderate confidence in the weight of evidence in these findings as described in Section 5.2.1.

Environmental effects associated with exposures that EPA preliminarily determined contribute to unreasonable risk (described in Section 6.2.3) include reproductive effects on amphibians and chronic developmental effects on aquatic invertebrates, and are supported by the following hazard endpoints in the following studies (additional discussion of other related studies can be found in the *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)*) ([U.S. EPA, 2026t](#)):

- chronic effects on aquatic invertebrates based on impaired development of copepod (*Pseudodiaptomus inopinus*) larvae (nauplii) to adult in both generations in a multigenerational study ([Gong et al., 2017](#));
- adverse effects on amphibians based on a decrease in metamorphosis in a 21-day study on the African Clawed Frog (*Xenopus laevis*) ([Zhang et al., 2014](#)); and
- chronic effects on sediment-dwelling based on blackworm mortality ([Wildlife International Ltd, 2002](#)).

6.2.3 Basis for Unreasonable Risk to the Environment

EPA is preliminarily determining that TBBPA presents unreasonable risk of injury to the environment driven by exposures to amphibians and chronic exposure to aquatic invertebrates in surface water under the following COU:

- Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing

Basis for the Unreasonable Risk to Aquatic Organisms

As discussed in Section 5.3.2, EPA evaluated the effect of TBBPA exposure through surface water to aquatic vertebrates, invertebrates, amphibians, and algae; however, the unreasonable risk of TBBPA is based on chronic risk to aquatic invertebrates because this population is more sensitive to TBBPA exposure in surface water than amphibians, algae, and chronic exposure to aquatic invertebrates. Risk to aquatic organisms was characterized by comparing hazard thresholds (COCs) for aquatic organisms to modeled surface water exposures from TRI release data associated with four COUs and with releases modeled from generic scenarios for one COU. The Agency evaluated the calculated RQs, the modeled surface water concentrations, as well as the confidence in the exposure and hazard assessments to determine unreasonable risk to the environment. For the COU with releases modeled using generic scenarios (Use of laboratory chemicals), all RQs were less than 1 for all aquatic organisms. Of the four COUs with TRI data reflecting actual releases, two COUs had RQs greater than 1 for aquatic vertebrates, aquatic invertebrates, aquatic sediment-dwelling invertebrates and amphibians, with RQs ranging from 1.48 to 22 (see Section 5.3.2 and Table 6-3). The preliminary determination that this COU (Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing) significantly contributes to the unreasonable risk to the environment was based on these considerations and is further outlined in the subsequent section.

Surface Water Exposure Risk from TRI Data

Risk for the following COUs was characterized by comparing hazard thresholds (COCs) to surface water concentrations modeled from facility-specific releases reported to TRI (see Table 6-3):

- Processing – As a reactant – Flame retardant in plastic material and resin manufacturing;
- Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing; and
- Disposal

The Processing – As a reactant – Flame retardant in plastic material and resin manufacturing COU did not have any RQs greater than 1, so EPA has preliminarily determined that the COU does not significantly contribute to unreasonable risk. The Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing COU as well as the Disposal COU had RQs greater than 1 and are described below.

For the Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing COU, EPA assessed exposure from a single facility releasing TBBPA to a POTW. Surface water and sediment concentrations were estimated using the maximum annual discharge reported to TRI averaged over the reported number of release days. RQ values were 1.28 for acute exposure to aquatic species, 14.9 for chronic exposure to aquatic vertebrates, 22 for chronic exposure to aquatic invertebrates, 1.48 for sediment-dwelling invertebrates, and 8.1 for amphibians. For this COU, the RQ was marginally greater than 1 (*i.e.*, RQ = 1.28) for acute aquatic species using the lower bound of the 95th confidence interval of the HC05 (hazardous concentration threshold for 5% of species; COC = 10 µg/L). However, as explained in Section 5.3.2) the RQ for acute aquatic species using the HC05 (COC = 110 µg/L) was well below 1 (RQ = 0.11). The SSD curve depicted a steep response, indicating similar sensitivity across the species. Given that relationship, along with the fact that the lower bound of the 95th confidence interval of the HC05 is an order of magnitude lower than the HC05, and because the RQ is only marginally above 1 when considering the lower bound (RQ = 1.28), EPA has preliminarily determined that acute exposure to aquatic species does not significantly contribute to unreasonable risk.

However, RQs were greater than 1 for chronic exposure to aquatic vertebrates, invertebrates, sediment-dwelling invertebrates, and amphibians for a sufficient duration to result in the chronic hazard.

Therefore, EPA has preliminarily determined that this COU significantly contributes to unreasonable risk to the environment based on chronic exposure to these taxa. Days of exceedance of the COC were 183 days for the chronic exposure to aquatic invertebrates, 161 days for amphibians, and 39 days for sediment-dwelling invertebrates compared to the exposure study durations of 35, 14, and 28 days, respectively (Table 6-3). For chronic exposure to aquatic vertebrates, the days of exceedance from modeling, where RQs were greater than 1, did not exceed the 120-day duration associated with the hazard used to derive the COC and therefore risk is not expected to these taxa. EPA has robust confidence in the calculated RQ values because they are based on facility-specific release data reported to TRI. EPA also applied a wastewater treatment removal rate of 88.8% based on the facility's reporting that it discharges to a POTW. Even with treatment, RQs were greater than 1, and days of exceedance were greater than the exposure study durations for chronic exposure to aquatic invertebrates and amphibians (see Section 5.3.2.1 and Table 5-2 for additional information).

For the Disposal COU, EPA assessed exposure from multiple facilities. Surface water and sediment concentrations were estimated using the maximum annual discharge reported to TRI averaged over the reported number of release days. For the facility with the highest water release, the RQ was 9.97 for chronic exposure to aquatic vertebrates, 14.9 for chronic exposure to aquatic invertebrates, and 5.39 for amphibians. Although the RQ value was greater than 1 for these taxa, the days of exceedance were not greater than the exposure duration in the hazard studies. Days of exceedance were 12 for all chronic exposures to aquatic species compared to the exposure study durations of 120, 35, and 28 days for vertebrates, invertebrates, and amphibians, respectively (Table 5-2)—indicating that the water concentrations did not exceed the COC for a sufficient duration to result in the adverse effect. Therefore, EPA has preliminarily determined that the Disposal COU does not significantly contribute to unreasonable risk to the environment due to chronic effects to aquatic invertebrates and amphibians (see Section 5.3.2.1 and Table 5-2 for additional information).

Surface Water Exposure Risk from Generic Scenario Data

For the Industrial and commercial use – Other – Laboratory chemical COU, releases were modeled using generic scenarios. EPA conservatively estimated surface water concentrations associated with this COU by assuming a modeled 95th percentile release would be discharged directly to a receiving water body with an assumed low flow volume (P50). Even using multiple conservative assumptions, all RQs were less than 1 for all aquatic organisms. Therefore, EPA is preliminarily determining that the Industrial and Commercial use – Other – Laboratory chemical COU does not significantly contribute to unreasonable risk to the environment.

Unreasonable Risk from COUs with Negligible Water Release

EPA did not calculate RQs for 15 COUs but expects exposure to TBBPA via water to be negligible for those COUs. The Agency has preliminarily determined that they do not significantly contribute to the unreasonable risk to the environment. Specifically, 12 of the COUs reported zero releases to water (Table 3-2) and EPA does not expect releases to water during activities under the following three COUs:

- Processing – Recycling;
- Industrial and commercial use – Packaging, paper, plastic, hobby products – Plastic and rubber products.; and
- Distribution in commerce.

For Processing – Recycling, particulate emissions are expected to be captured by various types of particulate filters and not wet scrubbing that may result in water releases. Similarly, for the Industrial and commercial use – Packaging, paper, plastic, hobby products – Plastic and rubber products COU, though the release media for the dust generation is uncertain (fugitive or stack air, water, incineration, or landfill), dust releases are not likely captured by wet scrubbing or other removal method that could result in water releases.

The Agency did not develop risk estimates for the Distribution in commerce COU. EPA expects TBBPA to be transported in sealed containers from import sites to downstream processing and use sites or for final disposal. EPA further expects that under standard operating procedures, along with the expectation that TBBPA would be transported in a closed system, that there is negligible potential for releases except during a release incident. Therefore, EPA expects that environmental releases from distribution in commerce are unlikely to occur and that exposures to ecological receptors are not expected to exceed hazard thresholds.

Sediment Exposure Risk

EPA modeled maximum TBBPA exposure to sediment for four COUs with facility-specific release and one COU with generic scenario modeled release. EPA compared the highest environmental media concentration based on releases to an estimated hazard threshold value (COC) and determined chronic risk to sediment-dwelling invertebrates from one COU (Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing). No risk to these organisms exists under any other COU. See Section 5.3.2 of this draft risk evaluation for more details. EPA has moderate-to-robust confidence in this risk assessment as shown in Section 5.3.4.

Basis for No Unreasonable Risk to Terrestrial Organisms

EPA conducted an assessment for TBBPA release to the terrestrial environment by performing quantitative risk characterization with combined fugitive release or stack atmospheric deposition to soil for the highest reported releases across multiple facilities. The Agency compared the highest environmental media concentration based on releases to an estimated hazard threshold value, which resulted in RQs less than 1. As this was based on maximum releases from reporting facilities, no further refinement was performed.

Additionally, a screening-level trophic transfer analysis was conducted for terrestrial dietary exposure, including terrestrial invertebrates, terrestrial mammals (e.g., short-tailed shrew consuming earthworms), and aquatic-dependent mammals (e.g., American mink consuming fish that prey on chironomids). Results for calculated dietary exposures of TBBPA to mammals from modeled concentrations within relevant pathways such as water, sediment, and soil indicated exposure concentrations were below the TRV. These results align with previous studies indicating that TBBPA is not bioaccumulative through dietary exposure and will not biomagnify. Based on the screening-level trophic transfer assessments, EPA has robust confidence that TBBPA exposures from the highest release exposure scenarios are below the levels that would present risk. For more information on the screening-level trophic transfer analysis, see Section 5.1.

Therefore, EPA has preliminarily determined that there is no significant contribution to unreasonable risk for terrestrial organisms for any COU. For more information on the risk assessment for terrestrial organisms, see Section 5.3.3. EPA has moderate confidence in this risk assessment as provided in Section 5.3.4.

Additional Assessment Without Risk Estimates

EPA did not quantitatively assess down-the-drain releases from consumer uses because no liquid products containing TBBPA were identified. Although the Agency acknowledges that there may be environmental releases of TBBPA via their end-of-life disposal, it is difficult for EPA to quantify these exposures due to limited reasonably available information on source attribution of the consumer COUs. However, high-quality physical and chemical property data suggest that TBBPA is expected to be immobile in landfills (see Section 3.1.2).

6.3 Supporting Basis for the Preliminary Risk Determination

Table 6-1 summarizes the basis for this preliminary unreasonable risk determination of injury to human health presented in the TBBPA risk evaluation for occupational uses; Table 6-3 summarizes the basis for this preliminary unreasonable risk determination of injury to the environment. In both tables, the **bolded and shaded text** indicate significant contributions to unreasonable risk. Both tables identify the duration of exposure (e.g., intermediate or chronic duration) and the exposure route to the population.

4458 Parentheticals with “APF” in Table 6-1 give the minimum level of PPE that would be necessary to raise
4459 the calculated MOE above the benchmark. Table 6-2 provides additional risk estimates, using various
4460 exposure durations, to support the preliminary unreasonable risk determination to workers from the
4461 Repackaging COU Risk estimates across the full range of variables for the COUs with modeled
4462 multimedia scenarios are available in the *Draft Risk Calculator for Occupational Exposures for 4,4'-(1-*
4463 *Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026y](#)). For this preliminary
4464 unreasonable risk determination, EPA considered the effects of TBBPA to human health, including
4465 PESS, as well as a range of risk estimates as appropriate, risk related factors, and the confidence in the
4466 analysis. Section 4.3 provides a summary of human health risk estimates.

4467 Table 6-1. Supporting Basis for the Preliminary Unreasonable Risk Determination for Human Health (Non-Cancer, Workers)

COU		OES	Population	Exposure Level	Inhalation Risk Estimates (Benchmark MOE = 30)		Dermal Risk Estimates (Benchmark MOE = 30)		Aggregate Risk Estimates (Benchmark = 30)	
Life Cycle Stage – Category	Subcategory				Int.	Chronic	Int.	Chronic	Int.	Chronic
Manufacture	Domestic manufacture	Manufacturing	Average adult worker	CT	88	65	187	137	60	44
				HE	25 (APF 10)	18	93	69	20	15
			ONU	CT	88	65	187	137	60	44
	Import	Repackaging of TBBPA Powder	Scenario 1	CT	187	137	187	137	93	69
				HE	104	76	93	69	49	36
			Scenario 2	CT	3.3 (APF 10)	3.7 (APF 25)	187	137	3.3	3.6
				HE	1.2 (APF 50)	1.3 (APF 50)	93	69	1.2	1.3
			ONU	CT	187	137	187	137	93	69
Processing – As a reactant	Flame retardant in plastic material and resin manufacturing	ACC TBBPA Consortium’s Group 2: Production of Intermediate Products (Liquid, Semi-Solid, And Powder) from TBBPA Powder	Processing operator	CT	1.1E04	7.9E03	187	137	184	135
				HE	60	44	93	69	37	27
			Laboratory technician	CT	3.3E05	2.5E05	187	137	187	137
				HE	1.7E05	1.2E05	93	69	93	69
			ONU	CT	5.0E04	3.7E04	187	137	186	137
				HE	3.4E03	2.5E03			177	130
	Intermediate in all other chemical product and preparation manufacturing	ACC TBBPA Consortium’s Group 2: Production of Intermediate Products (Liquid, Semi-Solid, And Powder) from TBBPA Powder	Processing operator	CT	1.1E04	7.9E03	187	137	184	135
				HE	60	44	93	69	37	27
			Laboratory technician	CT	3.3E05	2.5E05	187	137	187	137
				HE	1.7E05	1.2E05	93	69	93	69
			ONU	CT	5.0E04	3.7E04	187	137	186	137
				HE	3.4E03	2.5E03			177	130

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COU		OES	Population	Exposure Level	Inhalation Risk Estimates (Benchmark MOE = 30)		Dermal Risk Estimates (Benchmark MOE = 30)		Aggregate Risk Estimates (Benchmark = 30)	
Life Cycle Stage – Category	Subcategory				Int.	Chronic	Int.	Chronic	Int.	Chronic
Processing – Incorporation into formulation, mixture, or reaction product	Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing	ACC TBBPA Consortium’s Group 1: Production of Formulations (Particulate Solids) from TBBPA Powder	Processing operator	CT	427	314	187	137	130	96
				HE	223	164	93	69	66	48
			User operator	CT	3.6E03	2.7E03	187	137	178	131
				HE	2.1E03	1.6E03	93	69	90	66
			ONU	CT	1.3E05	9.4E04	187	137	187	137
				HE	1.0E05	7.5E04				
		ACC TBBPA Consortium’s Group 2: Production of Intermediate Products (Liquid, Semi-Solid, And Powder) from TBBPA Powder	Processing operator	CT	1.1E04	7.9E03	187	137	184	135
				HE	60	44	93	69	37	27
			Laboratory technician	CT	3.3E05	2.5E05	187	137	187	137
				HE	1.7E05	1.2E05	93	69	93	69
			ONU	CT	5.0E04	3.7E04	187	137	186	137
				HE	3.4E03	2.5E03			177	130
		ACC TBBPA Consortium’s Group 3: Production of Intermediate Solid Products (Sheet, Film, and Pellet) from the Products of Group 2	Processing operator	CT	2.5E05	1.8E05	187	137	187	137
				HE	1.7E05	1.3E05	93	69	93	69
			User operator	CT	1.0E05	7.5E04	187	137	187	137
				HE	6.6E03	4.9E03	93	69	92	68
			Laboratory technician	CT	7.6E05	5.6E05	187	137	187	137
				HE	3.3E04	2.5E04	93	69	93	68
			Logistics technician	CT	3.2E05	2.3E05	187	137	187	137
				HE	1.6E05	1.2E05	93	69	93	69
			Maintenance technician	CT	1.2E05	9.0E04	187	137	187	137
				HE	8.7E04	6.4E04	93	69	93	69
			ONU	CT	7.0E05	5.2E05	187	137	187	137
				HE	7.4E04	5.4E04			186	
	Adhesive manufacturing	ACC TBBPA Consortium’s Group 2: Production of Intermediate Products (Liquid, Semi-Solid, And Powder) from TBBPA Powder	Processing operator	CT	1.1E04	7.9E03	187	137	184	135
				HE	60	44	93	69	37	27
			Laboratory technician	CT	3.3E05	2.5E05	187	137	187	137
				HE	1.7E05	1.2E05	93	69	93	69
			ONU	CT	5.0E04	3.7E04	187	137	186	137
				HE	3.4E03	2.5E03			177	130

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COU		OES	Population	Exposure Level	Inhalation Risk Estimates (Benchmark MOE = 30)		Dermal Risk Estimates (Benchmark MOE = 30)		Aggregate Risk Estimates (Benchmark = 30)	
Life Cycle Stage – Category	Subcategory				Int.	Chronic	Int.	Chronic	Int.	Chronic
Processing – Incorporation into articles	Reactive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., printed circuit boards and semiconductor packages)	ACC TBBPA Consortium’s Group 3: Production of Intermediate Solid Products (Sheet, Film, and Pellet) from the Products of Group 2	Processing operator	CT	2.5E05	1.8E05	187	137	187	137
				HE	1.7E05	1.3E05	93	69	93	69
			User operator	CT	1.0E05	7.5E04	187	137	187	137
				HE	6.6E03	4.9E03	93	69	92	68
			Laboratory technician	CT	7.6E05	5.6E05	187	137	187	137
				HE	3.3E04	2.5E04	93	69	93	68
			Logistics technician	CT	3.2E05	2.3E05	187	137	187	137
				HE	1.6E05	1.2E05	93	69	93	69
			Maintenance technician	CT	1.2E05	9.0E04	187	137	187	137
				HE	8.7E04	6.4E04	93	69	93	69
			ONU	CT	7.0E05	5.2E05	187	137	187	137
				HE	7.4E04	5.4E04			186	
	Reactive flame retardant in transportation equipment manufacturing (e.g., interior material for automotive and aviation articles)	ACC TBBPA Consortium’s Group 3: Production of Intermediate Solid Products (Sheet, Film, and Pellet) from the Products of Group 2	Processing operator	CT	2.5E05	1.8E05	187	137	187	137
				HE	1.7E05	1.3E05	93	69	93	69
			User operator	CT	1.0E05	7.5E04	187	137	187	137
				HE	6.6E03	4.9E03	93	69	92	68
			Laboratory technician	CT	7.6E05	5.6E05	187	137	187	137
				HE	3.3E04	2.5E04	93	69	93	68
			Logistics technician	CT	3.2E05	2.3E05	187	137	187	137
				HE	1.6E05	1.2E05	93	69	93	69
			Maintenance technician	CT	1.2E05	9.0E04	187	137	187	137
				HE	8.7E04	6.4E04	93	69	93	69
			ONU	CT	7.0E05	5.2E05	187	137	187	137
				HE	7.4E04	5.4E04			186	

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COU		OES	Population	Exposure Level	Inhalation Risk Estimates (Benchmark MOE = 30)		Dermal Risk Estimates (Benchmark MOE = 30)		Aggregate Risk Estimates (Benchmark = 30)	
Life Cycle Stage – Category	Subcategory				Int.	Chronic	Int.	Chronic	Int.	Chronic
Processing – Incorporation into articles	Additive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., plastic electronic enclosures)	ACC TBBPA Consortium’s Group 3: Production of Intermediate Solid Products (Sheet, Film, and Pellet) from the Products of Group 2	Processing operator	CT	2.5E05	1.8E05	187	137	187	137
				HE	1.7E05	1.3E05	93	69	93	69
			User operator	CT	1.0E05	7.5E04	187	137	187	137
				HE	6.6E03	4.9E03	93	69	92	68
			Laboratory technician	CT	7.6E05	5.6E05	187	137	187	137
				HE	3.3E04	2.5E04	93	69	93	68
			Logistics technician	CT	3.2E05	2.3E05	187	137	187	137
				HE	1.6E05	1.2E05	93	69	93	69
			Maintenance technician	CT	1.2E05	9.0E04	187	137	187	137
				HE	8.7E04	6.4E04	93	69	93	69
ONU	CT	7.0E05	5.2E05	187	137	187	137			
	HE	7.4E04	5.4E04			186				
Processing – Repackaging	Repackaging	Repackaging of TBBPA Powder	Scenario 1	CT	187	137	187	137	93	69
				HE	104	76	93	69	49	36
			Scenario 2	CT	3.3 (APF 10)	3.7 (APF 25)	187	137	3.3	3.6
				HE	1.2 (APF 50)	1.3 (APF 50)	93	69	1.2	1.3
			ONU	CT	187	137	187	137	93	69
Processing – Recycling	Recycling	Recycling	Average adult worker	CT	5.0E07	3.7E07	187	137	187	137
				HE	2.4E05	1.8E05	93	69	93	69
			ONU	CT	5.0E07	3.7E07	187	137	187	137
Distribution in commerce	Distribution in commerce	N/A	N/A	–	–	–	–	–	–	–

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COU		OES	Population	Exposure Level	Inhalation Risk Estimates (Benchmark MOE = 30)		Dermal Risk Estimates (Benchmark MOE = 30)		Aggregate Risk Estimates (Benchmark = 30)	
Life Cycle Stage – Category	Subcategory				Int.	Chronic	Int.	Chronic	Int.	Chronic
Industrial and commercial use – Construction, paint, electrical, and metal products	Powder coatings	Use of Powder Coatings in Electronics	Average adult worker	CT	350	258	187	137	122	90
				HE	47	34	93	69	31	23
				ONU	CT	350	258	187	137	122
	Reactive flame retardant in electrical and electronic articles	ACC TBBPA Consortium’s Group 4: Production of Composite Parts from Prepreg and Adhesive Film	User operator	CT	8.2E05	6.1E05	187	137	187	137
				HE	2.7E05	2.0E05	93	69	93	69
			Logistics technician	CT	1.1E06	7.9E05	187	137	187	137
				HE	5.4E05	4.0E05	93	69	93	69
			Maintenance technician	CT	1.1E06	7.9E05	187	137	187	137
				HE	5.4E05	4.0E05	93	69	93	69
			ONU	CT	7.6E05	5.6E05	187	137	187	137
				HE	7.3E05	5.4E05				
	Reactive flame retardant in automotive and aviation articles (i.e., laminate and prepreg material)	ACC TBBPA Consortium’s Group 4: Production of Composite Parts from Prepreg and Adhesive Film	User operator	CT	8.2E05	6.1E05	187	137	187	137
				HE	2.7E05	2.0E05	93	69	93	69
			Logistics technician	CT	1.1E06	7.9E05	187	137	187	137
				HE	5.4E05	4.0E05	93	69	93	69
			Maintenance technician	CT	1.1E06	7.9E05	187	137	187	137
				HE	5.4E05	4.0E05	93	69	93	69
			ONU	CT	7.6E05	5.6E05	187	137	187	137
				HE	7.3E05	5.4E05				
	Additive flame retardant in electrical and electronic articles (i.e., plastic enclosures)	Industrial and Commercial Additive Use in Electrical and Electronic Articles	Average adult worker	CT	1.1E03	781	187	137	159	117
				HE	58	43	93	69	36	26
			ONU	CT	1.1E03	781	187	137	159	117
	Building/construction materials	Industrial and Commercial Use in Building and Construction Materials	Average adult worker	CT	132	98	187	137	78	57
				HE	21 (APF 10)	16 (APF 10)	93	69	17	13
			ONU	CT	132	98	187	137	78	57

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COU		OES	Population	Exposure Level	Inhalation Risk Estimates (Benchmark MOE = 30)		Dermal Risk Estimates (Benchmark MOE = 30)		Aggregate Risk Estimates (Benchmark = 30)	
Life Cycle Stage – Category	Subcategory				Int.	Chronic	Int.	Chronic	Int.	Chronic
Industrial use – Packaging, paper, plastic, hobby products	Plastic and rubber products	Industrial Use in Plastic and Rubber Products	Average adult worker	CT	8.2E05	6.1E05	187	137	187	137
				HE	2.9E05	2.1E05	93	69	93	69
			ONU	CT	7.6E05	5.6E05	187	137	187	137
				HE	7.3E05	5.4E05				
Industrial and commercial use – Other	Laboratory chemical	Industrial and Commercial Laboratory Chemical Use	Average adult worker	CT	1.1E06	7.9E05	187	137	187	137
				HE	2.8E04	2.1E04	93	69	93	68
			ONU	CT	1.1E06	7.9E05	187	137	187	137
				HE	1.1E06	7.9E05				
Disposal	Disposal	Disposal	Average adult worker	CT	127	94	187	137	76	56
				HE	21 (APF 10)	16 (APF 10)	93	69	17	13
			ONU	CT	127	94	187	137	76	56
APF = assigned protection factor; COU = condition of use; CT = central tendency; HE = high-end; Int. = intermediate dose; OES = occupational exposure scenario; ONU = occupational non-user; MOE = margin of exposure										

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Table 6-2. Additional Risk Estimates to Support Preliminary Unreasonable Risk Determination to Workers

Life Cycle Stage – Category	Subcategory	OES	Exposure Level	MOEs from Intermediate Duration Exposure				MOEs from Chronic Duration Exposure			
				10-Hour Task	5-Hour Task	1-Hour Task	30-Minute Task	10-Hour Task	5-Hour Task	1-Hour Task	30-Minute Task
Processing – Repackaging	Repackaging	Repackaging of TBBPA Powder (Scenario 2)	CT	3.3 (APF 10)	6.8 (APF 10)	34	68	3.7 (APF 25)	7.5 (APF 10)	37	75
			HE	1.2 (APF 25)	2.4 (APF 25)	12 (APF 10)	24 (APF 10)	1.3 (APF 50)	2.6 (APF 25)	13 (APF 10)	26 (APF 10)
Manufacture	Import	Repackaging of TBBPA Powder (Scenario 2)	CT	3.3 (APF 10)	6.8 (APF 10)	34	68	3.7 (APF 25)	7.5 (APF 10)	37	75
			HE	1.2 (APF 25)	2.4 (APF 25)	12 (APF 10)	24 (APF 10)	1.3 (APF 50)	2.6 (APF 25)	13 (APF 10)	26 (APF 10)

CT = central tendency; HE = high-end; MOE = margin of exposure; OES = occupational exposure scenario

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Table 6-3. Supporting Basis for the Preliminary Draft Unreasonable Risk Determination for the Environment

COU		OES (NPDES Facility)	Annual Release (kg/yr)	Days of Release	7Q10 Flow (m ³ /day) ^a	Risk Quotient ^b (Days of Exceedance)				
Life Cycle Stage – Category	Subcategory					Acute Aquatic ^{c e}	Chronic Vert.	Chronic Amphib.	Chronic Invert.	Chronic Sed. Dwelling Invert.
Facility-specific reported releases										
Processing – As a reactant	Flame retardant in plastic material and resin manufacturing	Processing as a Reactant in Plastic Material and Resin Manufacturing (SABIC INNOVATIVE PLASTICS MT. VERNON LLC)	14.51	4	9.29E07	4.00E-03	0.045	2.83E-04	7.8E-06	1.60E-03
Processing – Incorporation into formulation, mixture, or reaction product	Flame retardant in: Plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing	Processing: Additive Flame Retardant in Plastic, Resin, and Paints and Coating (RAVAGO MANUFACTURING AMERICAS)	0.45	12	1.30E03	1.28	15 (47) ^d	8.1 (161)	22 (183)	1.48 (39)

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COU		OES (NPDES Facility)	Annual Release (kg/yr)	Days of Release	7Q10 Flow (m ³ /day) ^a	Risk Quotient ^b (Days of Exceedance)				
Life Cycle Stage – Category	Subcategory					Acute Aquatic ^{c e}	Chronic Vert.	Chronic Amphib.	Chronic Invert.	Chronic Sed. Dwelling Invert.
Disposal	Disposal	Disposal (MANCHESTER STP)	12.25	12	1.17E04	0.85	9.97 (12) ^d	5.39 (12) ^d	14.9 (12) ^d	0.96
		Disposal (WEST UNITY STP)	0.45	300	1.25E03	9.00E-03	0.11	0.06	0.16	0.03
		Disposal (CITY OF OLEAN WASTEWATER TREATMENT FACILITY)	4.54	300	1.10E06	1.40E-04	1.78E-03	9.62E-04	2.67E-03	5.20E-03
		Disposal (ALBION WWTP)	0.01	246	1.80E05	3.48E-06	4.07E-05	2.20E-05	6.12E-05	1.20E-05
Generic scenario releases										
Industrial and commercial use – Other	Laboratory chemical	Use of laboratory chemicals	6.50E-03	260	3.61E-03	0.09	5.00E-04	3.2E-03	8.7E-03	0.17

7Q10 = lowest 7-day flow (on average) over a 10-year period; Amphib. = amphibian; NPDES = National Pollutant Discharge Elimination System; OES = occupational exposure scenario; SWC = surface water concentration; STP = sewage treatment point; Vert. = vertebrate; WWT = wastewater treatment

^a Concentrations based on flows from NHDPlus EROM dataset.

^b RQs were based on acute aquatic (10 µg/L), chronic vertebrate (0.854 µg/L), chronic invertebrate (0.569 µg/L), algae (120 µg/L), amphibian (1.58), and sediment-dwelling animal (11.7 µg/kg) COCs ([U.S. EPA, 2026t](#)). EPA has a moderate confidence in the quality, consistency, strength and precision, and relevance of the studies used in determining these COCs.

^c “Acute Aquatic” includes vertebrates, invertebrates, and amphibians.

^d The days of exceedance from modeling did not extend beyond the aquatic exposure used to derive the COC and risk is not expected for these taxa. For chronic aquatic vertebrates, invertebrates, and amphibians, all days of exceedance were less than the hazard threshold study duration (120-, 35-, and 28-day, respectively) for the release scenarios. For chronic aquatic invertebrates and amphibians, all days of exceedance were greater than the hazard threshold study duration (120- and 35-day, respectively) for the release scenarios.

^e RQs in table are calculated using the COC of 10 µg/L, which resulted from the lower bound of the 95th confidence interval of the HC05. RQs using the HC05 (110 µg/L), were all below 1.

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APPENDICES

Appendix A KEY ABBREVIATIONS AND ACRONYMS

5134	7Q10	Lowest 7-day flow (on average) in a 10-year period
5135	30Q5	Lowest 30 consecutive days of flow over a 5-year period
5136	ACC	American Chemistry Council
5137	ADD	Average daily dose
5138	ADME	Absorption, distribution, metabolism, and elimination
5139	AERMOD	American Meteorological Society (AMS)/EPA Regulatory Model
5140	AF	Assessment factor
5141	APF	Assigned protection factor
5142	ATSDR	Agency for Toxic Substances and Disease Registry
5143	BAF	Bioaccumulation factor
5144	BCF	Bioconcentration factor
5145	BLS	Bureau of Labor Statistics (U.S.)
5146	BMD	Benchmark dose
5147	BMDL ₁₀	Benchmark dose (lower confidence limit 10%)
5148	BPA	Bisphenol A
5149	CASRN	Chemical Abstracts Service Registry Number
5150	CBI	Confidential business information
5151	CDR	Chemical Data Reporting
5152	CEHD	Chemical Exposure Health Data
5153	CEM	Consumer Exposure Model version 3.2
5154	CFR	Code of Federal Regulations
5155	COC	Concentration(s) of concern
5156	COU	Condition of use
5157	DMR	Discharge Monitoring Report
5158	dw	Dry weight
5159	E-waste	Electronic waste
5160	EC ₅₀	Effect concentration at which 50% of test organisms exhibit an effect
5161	ECB	European Chemicals Bureau
5162	EC/HC	Environment and Climate Change Canada/Health Canada
5163	EFSA	European Food Safety Authority
5164	ELG	Effluent Limitation Guidelines
5165	EPA	Environmental Protection Agency (U.S.)
5166	EPI Suite™	Estimation Program Interface Suite™
5167	ESD	Emission scenario document
5168	FAA	Federal Aviation Administration
5169	FR	Federal Register
5170	GS	Generic scenario
5171	HC ₀₅	Hazard concentration that is protective of 95% of the species in the sensitivity
5172		distribution
5173	HEC	Human equivalent concentration
5174	HED	Human equivalent dose
5175	HM	Harmonic mean
5176	IARC	International Agency for Research on Cancer
5177	IIOAC	Integrated Indoor-Outdoor Air Calculator
5178	K _{oc}	Organic carbon/water partition coefficient

5179	Kow	Octanol/water partition coefficient
5180	LC ₅₀	Lethal concentration at which 50% of test organisms die
5181	LCD	Life cycle diagram
5182	LOAEL	Lowest-observed-adverse-effect level
5183	LOD	Limit of detection
5184	LOQ	Limit of quantification
5185	lw	Lipid weight
5186	MOA	Mode of action
5187	MOE	Margin of exposure
5188	NAICS	North American Industry Classification System
5189	ND	Non-detect
5190	NEI	National Emissions Inventory
5191	NHDPlus	National Hydrography Dataset Plus
5192	NIOSH	National Institute for Occupational Safety and Health
5193	NOAEL	No-observed-adverse-effect level
5194	NPDES	National Pollutant Discharge Elimination System
5195	NTP	National Toxicology Program
5196	OCSPP	Office of Chemical Safety and Pollution Prevention (EPA)
5197	OECD	Organisation for Economic Co-operation and Development
5198	OEL	Occupational exposure limit
5199	OES	Occupational exposure scenario
5200	ONU	Occupational non-user
5201	OPPT	Office of Pollution Prevention and Toxics (EPA)
5202	OSHA	Occupational Safety and Health Administration (U.S.)
5203	PBPK	Physiologically-based pharmacokinetic
5204	PBZ	Personal breathing zone
5205	PEL	Permissible exposure limit
5206	PESS	Potentially exposed or susceptible subpopulations
5207	PF	Protection factor
5208	POD	Point of departure
5209	POTW	Publicly owned treatment works
5210	PPE	Personal protective equipment
5211	PSC	Point Source Calculator
5212	RQ	Risk quotient
5213	SACC	Science Advisory Committee on Chemicals
5214	SDS	Safety data sheet
5215	SEG	Similar exposure group
5216	SSD	Species sensitivity distribution
5217	STP	Sewage treatment plant
5218	TBBPA	4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] or tetrabromobisphenol A
5219	TLV	Threshold limit value
5220	TMF	Trophic magnification factor
5221	TRI	Toxics Release Inventory
5222	TRV	Toxicity reference value
5223	TSCA	Toxic Substances Control Act
5224	TSD	Technical support document
5225	TWA	Time-weighted average
5226	UF	Uncertainty factor
5227	U.S.	United States

5228	VVWM	Variable Volume Water Model
5229	WHO	World Health Organization
5230	ww	Wet weight
5231	WWTP	Wastewater treatment plant

Appendix B REGULATORY AND ASSESSMENT HISTORY

B.1 Federal Laws and Regulations

Table Apx B-1. Federal Laws and Regulations

Statutes/Regulations	Description of Authority/Regulation	Description of Regulation
EPA statutes/regulations		
Toxic Substances Control Act (TSCA) – section 5(a)	Once EPA finalizes a Significant New Use Rule (SNUR) determining that a use of a chemical substance is a significant new use under TSCA section 5(a), persons are required to submit a significant new use notice (SNUN) to EPA at least 90 days before they manufacture (including import) or process the chemical substance for that use.	In June 2023, EPA proposed a significant new use rule (SNUR) to designate manufacture or processing of TBBPA for any use as a significant new use, with the exception that the conditions of use the Agency expects to consider within the scope of the TSCA section 6 risk evaluations are not proposed as significant new uses (88 FR 40728 , June 22, 2023).
TSCA – section 6(b)	EPA is directed to identify high-priority chemical substances for risk evaluation; and conduct risk evaluations on at least 20 high-priority substances no later than three and one-half years after the date of enactment of the Frank R. Lautenberg Chemical Safety for the 21st Century Act.	TBBPA is one of the first 20 chemical substances designated as high-priority substances for risk evaluation under TSCA (84 FR 71924 , December 30, 2019).
TSCA – section 8(a)	TSCA section 8(a) Chemical Data Reporting (CDR) Rule requires manufacturers (including importers) to give EPA basic exposure-related information on the types, quantities and uses of chemical substances produced domestically and imported into the United States.	TBBPA manufacturing (including importing), processing and use information is reported under the CDR rule (40 CFR part 711).
TSCA – section 8(b)	EPA must compile, keep current and publish a list (the TSCA Inventory) of each chemical substance manufactured (including imported) or processed in the United States.	TBBPA was on the initial TSCA Inventory and therefore was not subject to EPA's new chemicals review process under TSCA Section 5 (60 FR 16309 , March 29, 1995).
TSCA – section 8(e)	Manufacturers (including importers), processors, and distributors must immediately notify EPA if they obtain information that supports the conclusion that a chemical substance or mixture presents a substantial risk of injury to health or the environment.	11 risk reports received for TBBPA (1992-2005) (U.S. EPA, ChemView , Accessed June 25, 2019).
TSCA – section 4	Provides EPA with authority to issue rules, enforceable consent agreements and orders requiring manufacturers (including importers) and processors to test chemical substances and mixtures.	14 chemical data submissions from test rules was received for TBBPA: 8 ecotoxicity reports and 6 environmental fate reports (1986–1994) (U.S. EPA, ChemView , Accessed April 2, 2019).

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Statutes/Regulations	Description of Authority/Regulation	Description of Regulation
		The Frank R. Lautenberg Chemical Safety for the 21st Century Act revised TSCA section 4 to add authority to issue test orders. Under this authority EPA issued test orders for information on environmental hazard and inhalation and dermal exposures to workers for TBBPA on January 14, 2021, and March 24, 2022.
Emergency Planning and Community Right-to-Know Act (EPCRA) – section 313	Requires annual reporting from facilities in specific industry sectors that employ 10 or more full-time equivalent employees and that manufacture, process or otherwise use a TRI-listed chemical in quantities above threshold levels. A facility that meets reporting requirements must submit a reporting form for each chemical for which it triggered reporting, providing data across a variety of categories, including activities and uses of the chemical, releases and other waste management (<i>e.g.</i> , quantities recycled, treated, combusted) and pollution prevention activities (under Section 6607 of the Pollution Prevention Act). These data include on- and off-site data as well as multimedia data (<i>i.e.</i> , air, land and water).	TBBPA is a listed substance subject to reporting requirements (40 CFR 372.65 , effective January 1, 2000).

B.2 State Laws and Regulations

Table_Apx B-2. State Laws and Regulations

State Actions	Description of Action
State Prohibitions	California adopted a prohibition on the selling and distribution in commerce of new, not previously owned juvenile products, mattresses, or upholstered furniture that contains, or a constituent component of which contains, covered flame retardant chemicals at levels above 1,000 parts per million (A.B. 2998, Legislative Council, Sess. 2017-2018, C.A. 2018).
State Right-to-Know Acts	New Jersey lists TBBPA as a chemical of concern: persistent, bioaccumulative, toxic (PBT) substance on the Environmental Hazardous Substance List, (N.J.A.C. 7:1G-2).
Chemicals of High Concern to Children	Several states have adopted reporting laws for chemicals in children's products containing TBBPA, including Maine (38 MRSA Chapter 16-D), Minnesota (Toxic Free Kids Act Minn. Stat. 116.9401 to 116.9407), Oregon (Toxic-Free Kids Act, Senate Bill 478, 2015), Vermont (18 V.S.A § 1776) and Washington State (Wash. Admin. Code 173-334-130).
Other	California listed TBBPA on Proposition 65 in 2017 due to cancer. (Cal Code Regs. Title 27, § 27001). TBBPA is listed as a Candidate Chemical under California's Safer Consumer Products Program (Health and Safety Code § 25252 and 25253).

State Actions	Description of Action
	California issued a Health Hazard Alert for TBBPA (Hazard Evaluation System and Information Service, 2016). California lists TBBPA as a designated priority chemical for biomonitoring (California SB 1379). The Oregon Department of Environmental Quality lists TBBPA as a priority persistent pollutant (Oregon SB 737).

B.3 International Laws and Regulations

Table Apx B-3. International Laws and Regulations

Country/ Organization	Requirements and Restrictions
Canada	TBBPA is on the Domestic Substances List (Government of Canada. Managing substances in the environment. Substances search . Database accessed April 16, 2019).
European Union (EU)	TBBPA is registered for use in the EU. (European Chemicals Agency (ECHA database, accessed April 16, 2017). The Waste Electrical and Electronic Equipment (WEEE) directive 2012/19/EU requires the separation of plastics containing brominated flame retardants prior to recycling (European Commission WEEE). TBBPA was evaluated under the 2015 Community rolling action plan (CoRAP) under regulation (European Commission [EC]) No 1907/2006 – REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals). Additional information was requested and is due January 2021. (ECHA database, accessed April 16, 2019). TBBPA is recommended by the European Commission for addition to the Restriction of Hazardous Substances Directive, which currently restricts the use of ten hazardous substances at more than 0.1% by weight at the “homogeneous material” level in electrical and electronic equipment. (European Commission RoHS).
Australia	In 2001, TBBPA was assessed. (Polybrominated Flame Retardants. Priority Existing Chemical Assessment Report No. 20 (2001)).
Japan	TBBPA is regulated in Japan under the following legislation: - Act on the Evaluation of Chemical Substances and Regulation of Their Manufacture, <i>etc.</i> (Chemical Substances Control Law; CSCL) - Water Pollution Control Law (National Institute of Technology and Evaluation [NITE] Chemical Risk Information Platform [CHRIP], accessed April 9, 2019).
Basel Convention	Waste substances and articles containing or contaminated with polychlorinated biphenyls (PCBs) and/or polychlorinated terphenyls (PCTs) and/or polybrominated biphenyls (PBBs) and wastes, substances and articles containing, consisting of or contaminated with polychlorinated biphenyl (PCB), polychlorinated terphenyl (PCT), polychlorinated naphthalene (PCN) or polybrominated biphenyl (PBB), or any other polybrominated analogues of these compounds, at a concentration level of 50 mg/kg or more are listed as a category of waste under the Basel Convention. Although the United States is not currently a party to the Basel Convention, this treaty still affects U.S. importers and exporters. http://www.basel.int/Portals/4/Basel%20Convention/docs/text/BaselConventionText-e.pdf

Country/ Organization	Requirements and Restrictions
OECD Control of Transboundary Movements of Wastes Destined for Recovery Operations	Wastes, substances and articles containing, consisting of or contaminated with polychlorinated biphenyl (PCB), polychlorinated terphenyl (PCT), polychlorinated naphthalene (PCN) or polybrominated biphenyl (PBB), or any other polybrominated analogues of these compounds, at a concentration level of 50 mg/kg or more are listed as a category of waste subject to The Amber Control Procedure under Council Decision C (2001) 107/Final. https://www.oecd.org/env/waste/guidance-manual-control-transboundary-movements-recoverable-wastes.pdf

B.4 Assessment History

Table_Apx B-4. Assessment History of TBBPA

Authoring Organization	Publication
EPA publications	
U.S. EPA, Office of Chemical Safety and Pollution Prevention (OCSPP)	TSCA Work Plan Chemical Problem Formulation and Initial Assessment – Tetrabromobisphenol A and Related Chemicals Cluster Flame Retardants (2015)
U.S. EPA, Design for the Environment (DfE)	Flame Retardants in Printed Circuit Boards (2015)
Other U.S.-based organizations	
American Chemistry Council (ACC)	HPV Data Summary and Test Plan for phenol, 4,4'-isopropylidenebis[2,6-dibromo- (Tetrabromobisphenol A, TBBPA) (2005)
Agency for Toxic Substances and Disease Registry (ATSDR)	Toxicological Profile for Polybrominated Biphenyls (2004)
Consumer Product Safety Commission (CPSC): Toxicology Excellence for Risk Assessment (TERA)	Environmental Concentrations and Consumer Exposure Data for Selected Flame Retardants (TBB, TBPH, TBBPA, ATO) (2015)
CPSC: TERA	Flame Retardant Exposure Assessment (2016)
National Toxicology Program (NTP), National Institutes of Health (NIH)	Toxicological Studies of Tetrabromobisphenol A in F344/NTac Rats and B6C3F1/N Mice and Toxicology and Carcinogenesis Studies of Tetrabromobisphenol A in Wistar Han [CrI:WI(Han)] Rats and B6C3F1/N Mice (Gavage Studies) (2014)
International	
Australia: National Industrial Chemicals Notification and Assessment Scheme (NICNAS)	Polybrominated Flame Retardants (PBFRs): Priority Existing Chemical Assessment Report No. 20 (2001)
Australia: NICNAS	Tetrabromobisphenol A: Priority Existing Chemical Assessment Report Assessment No. 42 (2020)

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Authoring Organization	Publication
Canada: Environment and Climate Change Canada/Health Canada (EC/HC)	Screening assessment report phenol, 4,4'-(1-methylethylidene)bis[2,6-dibromochemical abstracts service registry number 79-94-7 ethanol, 2,2'-[(1-methylethylidene)bis[(2,6- dibromo-4,1-phenylene)oxy]]bis chemical abstracts service registry number 4162-45-2 benzene, 1,1'-(1-methylethylidene)bis[3,5-dibromo-4-(2-propenyloxy)-chemical abstracts service registry number 25327-89-3 (2013)
European Chemicals Bureau (ECB)	European Union Risk Assessment Report: 2,2',6,6'-tetrabromo-4,4'-isopropylidenediphenol (tetrabromobisphenol-A or TBBP-A): Part II – Human Health (2006)
ECB	Risk Assessment of 2,2',6,6'-tetrabromo-4,4'-isopropylidene diphenol (tetrabromobisphenol-A): Part I – Environment (2008)
European Food Safety Authority (EFSA)	Scientific opinion on tetrabromobisphenol A (TBBPA) and its derivatives in food (2011)
EFSA	Update of the scientific opinion on tetrabromobisphenol A and its derivatives in food (2024)
Germany: Oko-Institut e.V.	ROHS Annex II Dossier for TBBP-A Restriction proposal for substances in electrical and electronic equipment under RoHS, Version 3 (2019)
International Agency for Research on Cancer (IARC)	Tetrabromobisphenol A, in Some Industrial Chemicals, Volume 115 (2018)
Organisation for Economic Co-operation and Development (OECD)	SIDS Initial Assessment Profile (2005)
Switzerland: Swiss Agency for the Environment, Forests and Landscape (SAEFL)	Selected Polybrominated Flame Retardants PBDEs and TBBPA: Substance Flow Analysis, in Environmental Series No. 338 – Environmentally Hazardous Substances (2002)
World Health Organization (WHO): International Programme on Chemical Safety (IPCS)	Tetrabromobisphenol A and its Derivatives (Environmental Health Criteria [EHC] 172) (1995)
WHO: IPCS	Flame Retardants: A General Introduction (Environmental Health Criteria [EHC] 192) (1997)

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Appendix C LIST OF TECHNICAL SUPPORT AND SUPPLEMENTAL FILES

This appendix includes a list and citations for all technical support documents (TSDs) and supplemental files included in this draft risk evaluation for TBBPA. These include discipline-specific assessments, systematic review results, risk calculations, and modeling outputs. Files are numbered to correspond with the filenames uploaded to the docket: [EPA-HQ-2018-0462](#).

Associated **Technical Support Documents** – Provide additional details and information on physical chemistry, fate, exposure, hazard, and risk assessments.

02. *Draft Physical Chemistry and Fate Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol]* (TBBPA) ([U.S. EPA, 2026w](#))
03. *Draft Release Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol]* (TBBPA) ([U.S. EPA, 2026x](#))
04. *Draft Occupational Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol]* (TBBPA) ([U.S. EPA, 2026v](#))
05. *Draft Consumer and Indoor Dust Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol]* (TBBPA) ([U.S. EPA, 2026e](#))
06. *Draft Environmental Media, General Population, and Environmental Exposure Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol]* (TBBPA) ([U.S. EPA, 2026q](#))
07. *Draft Human Health and Environmental Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol]* (TBBPA) ([U.S. EPA, 2026t](#))

Associated **Systematic Review Protocol and Data Quality Evaluation and Data Extraction**

Documents – Provide additional detail and information on systematic review methodologies used as well as the data quality evaluations and extractions criteria and results.

08. *Draft Systematic Review Protocol for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol]* (TBBPA) ([U.S. EPA, 2026ab](#)) – In lieu of an update to the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances*, also referred to as the “2021 Draft Systematic Review Protocol” ([U.S. EPA, 2021a](#)), this systematic review protocol for the Risk Evaluation for TBBPA describes some clarifications and different approaches that were implemented than those described in the 2021 Draft Systematic Review Protocol in response to (1) SACC comments, (2) public comments, or (3) to reflect chemical-specific risk evaluation needs. This supplemental file may also be referred to as the “Draft Systematic Review Protocol for TBBPA.”
09. *Draft Data Quality Evaluation and Data Extraction Information for Physical and Chemical Properties for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol]* (TBBPA) ([U.S. EPA, 2026l](#)) – Provides a compilation of tables for the data extraction and data quality evaluation information for TBBPA. Each table shows the data point, set, or information element that was extracted and evaluated from a data source that has information relevant for the evaluation of physical and chemical properties. This supplemental file may also be referred to as the “TBBPA Data Quality Evaluation and Data Extraction Information for Physical and Chemical Properties.”

- 5294 10. *Draft Data Quality Evaluation and Data Extraction Information for Environmental Fate and*
5295 *Transport for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026j](#)) –
5296 Provides a compilation of tables for the data extraction and data quality evaluation information
5297 for TBBPA. Each table shows the data point, set, or information element that was extracted and
5298 evaluated from a data source that has information relevant for the evaluation for Environmental
5299 Fate and Transport. This supplemental file may also be referred to as the “TBBPA Data Quality
5300 Evaluation and Data Extraction Information for Environmental Fate and Transport.”
5301
- 5302 11. *Draft Data Quality Evaluation and Data Extraction Information for Environmental Release and*
5303 *Occupational Exposure for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S.](#)
5304 [EPA, 2026k](#)) – Provides a compilation of tables for the data extraction and data quality
5305 evaluation information for TBBPA. Each table shows the data point, set, or information element
5306 that was extracted and evaluated from a data source that has information relevant for the
5307 evaluation of environmental release and occupational exposure. This supplemental file may also
5308 be referred to as the “TBBPA Data Quality Evaluation and Data Extraction Information for
5309 Environmental Release and Occupational Exposure.”
5310
- 5311 12. *Draft Data Quality Evaluation and Data Extraction Information for Dermal Absorption for 4,4'-*
5312 *(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026i](#)) – Provides a
5313 compilation of tables for the data extraction and data quality evaluation information for TBBPA.
5314 Each table shows the data point, set, or information element that was extracted and evaluated
5315 from a data source that has information relevant for the evaluation for Dermal Absorption. This
5316 supplemental file may also be referred to as the “TBBPA Data Quality Evaluation and Data
5317 Extraction Information for Dermal Absorption.”
5318
- 5319 13. *Draft Data Quality Evaluation Information for General Population, Consumer, and*
5320 *Environmental Exposure for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S.](#)
5321 [EPA, 2026n](#)) – Provides a compilation of tables for the data quality evaluation information for
5322 TBBPA. Each table shows the data point, set, or information element that was evaluated from a
5323 data source that has information relevant for the evaluation of general population, consumer, and
5324 environmental exposure. This supplemental file may also be referred to as the “TBBPA Data
5325 Quality Evaluation Information for General Population, Consumer, and Environmental
5326 Exposure.”
5327
- 5328 14. *Draft Data Extraction Information for General Population, Consumer, and Environmental*
5329 *Exposure for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026h](#)) –
5330 Provides a compilation of tables for the data extraction for TBBPA. Each table shows the data
5331 point, set, or information element that was extracted from a data source that has information
5332 relevant for the evaluation of general population, consumer, and environmental exposure. This
5333 supplemental file may also be referred to as the “TBBPA Data Extraction Information for
5334 General Population, Consumer, and Environmental Exposure.”
5335
- 5336 15. *Draft Data Quality Evaluation Information for Human Health Hazard Epidemiology for 4,4'-(1-*
5337 *Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026p](#)) – Provides a compilation
5338 of tables for the data quality evaluation information for TBBPA. Each table shows the data point,
5339 set, or information element that was evaluated from a data source that has information relevant
5340 for the evaluation of epidemiological information. This supplemental file may also be referred to
5341 as the “TBBPA Data Quality Evaluation Information for Human Health Hazard Epidemiology.”
5342

16. *Draft Data Quality Evaluation Information for Human Health Hazard Animal Toxicology for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026o](#)) – Provides a compilation of tables for the data quality evaluation information for TBBPA. Each table shows the data point, set, or information element that was evaluated from a data source that has information relevant for the evaluation of human health hazard animal toxicity information. This supplemental file may also be referred to as the “TBBPA Data Quality Evaluation Information for Human Health Hazard Animal Toxicology.”
17. *Draft Data Quality Evaluation Information for Environmental Hazard for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026m](#)) – Provides a compilation of tables for the data quality evaluation information for TBBPA. Each table shows the data point, set, or information element that was evaluated from a data source that has information relevant for the evaluation of environmental hazard toxicity information. This supplemental file may also be referred to as the “TBBPA Data Quality Evaluation Information for Environmental Hazard.”
18. *Draft Data Extraction Information for Environmental Hazard and Human Health Hazard Animal Toxicology and Epidemiology for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026g](#)) – Provides a compilation of tables for the data extraction for TBBPA. Each table shows the data point, set, or information element that was extracted from a data source that has information relevant for the evaluation of environmental hazard and human health hazard animal toxicology and epidemiology information. This supplemental file may also be referred to as the “TBBPA Data Extraction Information for Environmental Hazard and Human Health Hazard Animal Toxicology and Epidemiology.”
- Associated **Supplemental Files** – Provide additional details and information on fate, release, exposure, hazard, and risk assessments.
19. *Draft Water Releases for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026ad](#)).
20. *Draft Land Releases for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026u](#)).
21. *Draft Air Releases for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026b](#)).
22. *Draft Risk Calculator for Occupational Exposures for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026y](#))
23. *Draft Estimates of Number of Workers and ONUs Model for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026r](#))
24. *Draft Calculations of Dermal Absorption Fluxes for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026d](#))
25. *Draft Use of Laboratory Chemicals OES Environmental Release Modeling Results for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026ac](#))

- 5392 26. *Draft Consumer Exposure Analysis and Risk Calculator for 4,4'-(1-Methylethylidene)bis[2,6-*
5393 *dibromophenol]* (TBBPA) ([U.S. EPA, 2026f](#))
- 5394
- 5395 27. *Draft Surface Water Human Exposure Calculator for 4,4'-(1-Methylethylidene)bis[2,6-*
5396 *dibromophenol]* (TBBPA) ([U.S. EPA, 2026aa](#))
- 5397
- 5398 28. *Draft Fish Ingestion Risk Calculator for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol]*
5399 *(TBBPA)* ([U.S. EPA, 2026s](#))
- 5400
- 5401 29. *Draft Ambient Air HIOAC Results and Risk Calculations for 4,4'-(1-Methylethylidene)bis[2,6-*
5402 *dibromophenol]* (TBBPA) ([U.S. EPA, 2026c](#))
- 5403
- 5404 30. *Draft Supplemental Information on Benchmark Dose (BMD) Modeling Results in the Human*
5405 *Health Hazard Assessment for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol]* (TBBPA) ([U.S.](#)
5406 [EPA, 2026z](#))

Appendix D CONDITIONS OF USE

D.1 Consolidation and Other Changes to the Conditions of Use Table

After the publication of the *Final Scope of the Risk Evaluation for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)*; CASRN 79-94-7 (also called the “final scope document” or “final scope”) ([U.S. EPA, 2020b](#)), EPA amended the COUs based on CDR and other reasonably available information. The Agency received updated submissions from the 2020 CDR cycle ([U.S. EPA, 2020a](#)), which required submitters to use updated function and product category codes for the chemical substances designated by EPA as a high-priority for risk evaluation, including TBBPA ([85 FR 20122](#), April 9, 2020). Additionally, the Agency received information on the uses of TBBPA in public comment on the proposed significant new use rule for certain non-ongoing uses for three flame retardants, tris(2-chloroethyl) phosphate (TCEP), TBBPA, and triphenyl phosphate (TPP) ([88 FR 40728](#), June 22, 2023). EPA also received information from stakeholders about uses of TBBPA. Table_Apx D-1 summarizes the changes to the conditions of use based on the new codes in the 2020 CDR and any other additional information reasonably available to EPA since the publication of the final scope document.

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Table Apx D-1. Changes to Categories and Subcategories of COUs from Final Scope to Draft Risk Evaluation

Life Cycle Stage and Category in the Final Scope Document	Subcategory in the Final Scope Document	Change Occurred After Scope	Revised Condition of Use (COU) in the Draft Risk Evaluation
Manufacturing – domestic manufacturing	Domestic manufacturing	Changed the life cycle stage from “manufacturing” to “manufacture.” Changed the category from “domestic manufacturing” to “domestic manufacture.” Changed the subcategory from “domestic manufacturing” to “N/A.”	Manufacture – Domestic manufacture
Manufacturing – import	Import	Changed the life cycle stage from “manufacturing” to “manufacture.” Changed the subcategory from “import” to “N/A.”	Manufacture – Import
Processing – processing as a reactant	Flame retardant (<i>e.g.</i> , plastic material and resin manufacturing)	Changed the category from “processing as a reactant: to “as a reactant.” Changed the subcategory from “flame retardant (<i>e.g.</i>, plastic material and resin manufacturing)” to “flame retardant in plastic material and resin manufacturing.”	Processing – As a reactant – Flame retardant in plastic material and resin manufacturing
Processing – processing as a reactant	Intermediate (<i>e.g.</i> , all other chemical product and preparation manufacturing)	Changed the category from “processing as a reactant” to “as a reactant.” Changed the subcategory from “intermediate (<i>e.g.</i>, all other chemical product and preparation manufacturing)” to “intermediate in all other chemical product and preparation manufacturing.”	Processing – As a reactant – Intermediate in all other chemical product and preparation manufacturing
Processing – processing - incorporating into formulation, mixture, or reaction product	Flame retardant (<i>e.g.</i> , electrical equipment, appliance and component manufacturing)	Changed the category from “processing – incorporating into formulation, mixture or reaction product” to “incorporation into articles” because EPA determined this category better represents the incorporation of TBBPA into articles in the industrial sector “electrical equipment, appliance, and component manufacturing.” Changed the subcategory from “flame retardant (<i>e.g.</i>, electrical equipment, appliance and component manufacturing)” to “reactive flame retardant in electrical equipment, appliance, and component manufacturing” and “additive flame retardant in electrical equipment, appliance, and component manufacturing.”	Processing – Incorporation into articles – Reactive flame retardant in computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (<i>e.g.</i>, printed circuit boards and semiconductor packages) and Processing –Incorporation into articles – Additive flame retardant in computer and

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Life Cycle Stage and Category in the Final Scope Document	Subcategory in the Final Scope Document	Change Occurred After Scope	Revised Condition of Use (COU) in the Draft Risk Evaluation
			electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; plastic product manufacturing (e.g., plastic electronic enclosures)
Processing – incorporating into formulation, mixture or reaction product	Flame retardant (e.g., computer and electronic manufacturing)	Changed the category from “processing – incorporating into formulation, mixture or reaction product” to “incorporation into articles” because EPA determined this category better represents the incorporation of TBBPA into articles in the industrial sector “computer and electronic manufacturing.” Changed the subcategory from “flame retardant (e.g., computer and electronic manufacturing)” to “reactive flame retardant in computer and electronic manufacturing” and “additive flame retardant in computer and electronic manufacturing.”	Processing – Incorporation into articles – Reactive flame retardant in computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., printed circuit boards and semiconductor packages) and Processing – Incorporation into articles – Additive flame retardant in computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., plastic electronic enclosures)
Processing – incorporating into formulation, mixture or reaction product	Flame retardant (e.g., plastic material and resin manufacturing)	Changed the category from “processing – incorporating into formulation, mixture or reaction product” to “incorporation into formulation, mixture, or reaction product.” Consolidated certain industrial sectors, including “plastic material and resin manufacturing” under the “incorporation into formulation, mixture, or reaction product” category. Added the industrial sectors “custom compounding of purchased resins” and “paint and coating manufacturing” to the subcategory based on 2020 CDR submissions.	Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing
Processing – incorporating into formulation, mixture, or reaction product	Flame retardant (e.g., plastics product manufacturing)	Changed the category from “processing – incorporating into formulation, mixture or reaction product” to “incorporation into formulation, mixture, or reaction product.” Consolidated certain industrial sectors, including “plastics product manufacturing” under the “incorporation into formulation, mixture, or reaction product” category.	Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant in plastic material and resin manufacturing; Plastics product manufacturing; Custom compounding of purchased resins; Paint and coating manufacturing

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Life Cycle Stage and Category in the Final Scope Document	Subcategory in the Final Scope Document	Change Occurred After Scope	Revised Condition of Use (COU) in the Draft Risk Evaluation
		Added the industrial sectors “custom compounding of purchased resins” and “paint and coating manufacturing” to the subcategory based on 2020 CDR submissions.	
Processing – incorporating into articles	Reactive flame retardant (e.g., printed circuit boards and semiconductor packages)	Changed the category from “processing – incorporating into articles” to “incorporation into article.” Changed the subcategory from “reactive flame retardant (e.g., printed circuit boards and semiconductor packages)” to “reactive flame retardant in computer and electronic product manufacturing; electrical equipment, appliance, and component manufacturing; plastic product manufacturing (e.g., printed circuit boards and semiconductor packages).”	Processing – Incorporation into articles – Reactive flame retardant in computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., printed circuit boards and semiconductor packages)
Processing – incorporating into articles	Reactive flame retardant (e.g., interior material for transportation equipment)	Changed the category from “processing – incorporating into articles” to “incorporation into article.” Changed the subcategory from “reactive flame retardant (e.g., interior material for transportation equipment)” to “reactive flame retardant in transportation equipment manufacturing (e.g., interior material for automotive and aviation articles).”	Processing – Incorporation into articles – Reactive flame retardant in transportation equipment manufacturing (e.g., interior material for automotive and aviation articles)
Processing – incorporating into articles	Additive flame retardant (e.g., plastic electronic enclosures)	Changed the category from “processing – incorporating into articles” to “incorporation into article.” Changed the subcategory from “additive flame retardant (e.g., Plastic electronic enclosures)” to “additive flame retardant in computer and electronic product manufacturing; electrical equipment, appliance, and component manufacturing; plastic product manufacturing (e.g., plastic electronic enclosures).”	Processing – Incorporation into articles – Additive flame retardant in computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., plastic electronic enclosures)
N/A	N/A	Added “Processing – repackaging” as a use	Processing – Repackaging
Distribution in commerce – distribution in commerce	Distribution in commerce	Changed the category and subcategory from “distribution in commerce” to “N/A” to avoid repetition	Distribution in commerce
N/A	N/A	Added “industrial use - construction, paint, electrical, and metal products – powder coatings” as a use based on reasonably available information.	Industrial use – Construction, paint, electrical, and metal products – Powder coatings
Industrial and commercial use – construction, paint,	Electrical and electronic products (e.g., reactive flame retardant)	Changed the subcategory from “electrical and electronic products (e.g., reactive flame retardant)” to “reactive flame retardant in electrical and electronic articles.”	Industrial and commercial use – Construction, paint, electrical, and metal products – Reactive flame retardant in electrical and electronic articles

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Life Cycle Stage and Category in the Final Scope Document	Subcategory in the Final Scope Document	Change Occurred After Scope	Revised Condition of Use (COU) in the Draft Risk Evaluation
electrical, and metal products			
Industrial and commercial use – construction, paint, electrical, and metal products	Laminate (<i>e.g.</i> , reactive flame retardant in prepreg material for automotive and aviation interiors)	Changed the subcategory from “laminate (<i>e.g.</i> , reactive flame retardant in prepreg material for automotive and aviation interiors)” to “reactive flame retardant in automotive and aviation articles (<i>i.e.</i> , laminate and prepreg material).”	Industrial and commercial use – Construction, paint, electrical, and metal products – Reactive flame retardant in automotive and aviation articles (<i>i.e.</i> , laminate and prepreg material)
Industrial and commercial use – construction, paint, electrical, and metal products	Electrical and electronic products (<i>e.g.</i> , additive flame retardant in plastic enclosures)	Changed the subcategory from “electrical and electronic products (<i>e.g.</i> , additive flame retardant in plastic enclosures)” to “additive flame retardant in electrical and electronic articles (<i>i.e.</i> , plastic enclosures).”	Industrial and commercial use – Construction, paint, electrical, and metal products – Additive flame retardant in electrical and electronic articles (<i>i.e.</i> , plastic enclosures)
Industrial and commercial use – construction, paint, electrical, and metal products	Building/construction materials not covered elsewhere	Changed the subcategory from “building/construction materials not covered elsewhere” to “building/construction materials.”	Industrial and commercial use – Construction, Paint, electrical, and metal products – Building/construction materials
Industrial and commercial use – construction, paint, electrical, and metal products	Batteries (<i>e.g.</i> , adhesive in lead-acid battery casings)	Removed “industrial and commercial use – construction, paint, electrical, and metal products – batteries (<i>e.g.</i> , adhesive in lead-acid battery casings)” based on reasonably available information that indicates this use is no longer known, intended, or reasonably foreseen.	N/A
Industrial and commercial use – furnishing, cleaning and treatment/care products	Fabric, textile and leather products not covered elsewhere	Removed “industrial and commercial use – furnishing, cleaning and treatment/care products – fabric, textile and leather products not covered elsewhere” based on reasonably available information that indicates this use is no longer known, intended, or reasonably foreseen.	N/A
N/A	N/A	Added “industrial and commercial use – packaging, paper, plastic, hobby products – plastic and rubber products” based on reasonably available information.	Industrial and commercial use – Packaging, paper, plastic, hobby products – Plastic and rubber products
Industrial and commercial use – other	<i>E.g.</i> , Laboratory chemical	Changed the subcategory “ <i>e.g.</i> , Laboratory chemical” to “laboratory chemical.”	Industrial and commercial use – Other – Laboratory chemical
Consumer use – construction, paint, electrical, and metal products	Electrical and electronic products (<i>e.g.</i> , reactive flame retardant)	Changed the subcategory from “electrical and electronic products (<i>e.g.</i> , reactive flame retardant)” to “reactive flame retardant in electrical and electronic articles.”	Consumer use – Construction, paint, electrical, and metal products – Reactive flame retardant in electrical and electronic articles

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Life Cycle Stage and Category in the Final Scope Document	Subcategory in the Final Scope Document	Change Occurred After Scope	Revised Condition of Use (COU) in the Draft Risk Evaluation
Consumer use – construction, paint, electrical, and metal products	Electrical and electronic products (<i>e.g.</i> , additive flame retardant in plastic enclosures)	Changed the subcategory from “electrical and electronic products (<i>e.g.</i> , additive flame retardant in plastic enclosures)” to “additive flame retardant in electrical and electronic articles (<i>i.e.</i> , plastic enclosures).”	Consumer use – Construction, paint, electrical, and metal products – Additive flame retardant in electrical and electronic articles (<i>i.e.</i> , plastic enclosures)
Consumer use – construction, paint, electrical, and metal products	Batteries (<i>e.g.</i> , adhesive in lead-acid battery casings)	Removed “consumer use – construction, paint, electrical, and metal products – batteries (<i>e.g.</i> , adhesive in lead-acid battery casings)” based on reasonably available information that indicates this use is no longer known, intended, or reasonably foreseen.	N/A
N/A	N/A	Added “consumer use – construction, paint, electrical, and metal products – reactive flame retardant in automotive and aviation articles (<i>i.e.</i> , laminate and prepreg material)” based on reasonably available information.	Consumer use – Construction, paint, electrical, and metal products – Reactive flame retardant in automotive and aviation articles (<i>i.e.</i> , laminate and prepreg material)
N/A	N/A	Added “consumer use – packaging, paper, plastic, hobby products – plastic and rubber products” based on reasonably available information.	Consumer use – Packaging, paper, plastic, hobby products – Plastic and rubber products
Consumer use – furnishing, cleaning and treatment/care products	Fabric, textile and leather products not covered elsewhere	Removed “consumer use – furnishing, cleaning and treatment/care products – fabric, textile and leather products not covered elsewhere” based on reasonably available information that indicates this use is no longer known, intended, or reasonably foreseen.	N/A
Disposal – disposal	Disposal	Changed the category from “disposal” to “N/A” and the subcategory from “disposal” to “N/A” to avoid repetition.	Disposal
Note: “N/A” means not applicable where the category name, subcategory name, or both are duplicative and therefore unnecessary for identifying the COU.			

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In addition, EPA is including further detail about changes to the following COUs, which resulted in changes presented in Table_Apx D-1 and warrant further explanation because these COUs were changed significantly between the final scope and this draft risk evaluation:

- ***Processing – Repackaging***
 - This COU was added to the draft risk evaluation because EPA determined this use is intended, known, or reasonably foreseen to be manufactured, processed, distributed in commerce, used, or disposed of based on reasonably available information that indicates TBBPA is repackaged ([Integral Consulting, 2025a](#)).
- ***Industrial use – Construction, paint, electrical, and metal products – Powder coatings***
 - This COU was added to the draft risk evaluation because EPA determined this use is intended, known, or reasonably foreseen to be manufactured, processed, distributed in commerce, used, or disposed of based on reasonably available information that indicates TBBPA is used at industrial sites in powder coatings for the electronics industry ([EPA-HQ-OPPT-2018-0462-0016](#); ([SolEpoxy, 2010](#)).
- ***Industrial and commercial use – Packaging, paper, plastic, hobby products – Plastic and rubber products***
 - This COU was added to the draft risk evaluation because EPA determined this use is intended, known, or reasonably foreseen to be manufacture, processed, distributed in commerce, used, or disposed of based on reasonably available information that indicates TBBPA is used in rubber and plastic products and articles ([U.S. EPA, 2020c](#); [3DXTECH, 2017](#)).
- ***Industrial and commercial use – Construction, paint, electrical, and metal products – Batteries (e.g., adhesive in lead-acid battery casings)***
 - This COU was removed from the draft risk evaluation because this use is no longer intended, known, or reasonably foreseen to be manufactured, processed, distributed in commerce, used, or disposed of. EPA did not find evidence that TBBPA is found in any lead-acid battery that is currently available on the market and reasonably anticipates that TBBPA is no longer manufactured or processed for use in batteries. A recent safety data sheet of a battery product that previously indicated TBBPA was a component in the product ([Yuasa, 2016](#)) no longer contains TBBPA ([Yuasa, 2022](#)). Given the expected useful life of a lead-acid battery of five years or less, EPA determined exposure to TBBPA in batteries that were previously available on that market is unlikely.
- ***Industrial and commercial use – Furnishing, cleaning and treatment/care products – Fabric, textile and leather products not covered elsewhere***
 - This COU was removed from the draft risk evaluation because this use is no longer intended, known, or reasonably foreseen to be manufactured, processed, distributed in commerce, used, or disposed of. After additional analysis, EPA found that, while TBBPA had been found in a small number of textile products at contaminant levels in the past, recent studies involving product testing did not find TBBPA in clothing samples, furniture samples, camping products, and other textiles ([EPA-HQ-OPPT-2018-0462-0038](#)) ([WSDE, 2024](#)). EPA could not find recent evidence that TBBPA is currently being used in textiles. Therefore, EPA determined TBBPA is unlikely to be used in fabrics and textiles.
- ***Consumer use – Construction, paint, electrical, and metal products – Reactive flame retardant in automotive and aviation articles (i.e., laminate and prepreg material)***

- This COU was added to the draft risk evaluation because EPA determined this use is intended, known, or reasonably foreseen to be manufacture, processed, distributed in commerce, used, or disposed of based on reasonably available information that indicates TBBPA is used in automotive and aviation articles ([EPA-HQ-OPPT-2018-0462-0041](#); ([MAT-CS, 2023](#); [NORDAM, 2023](#); [RJLG, 2023a, b](#))).
- ***Consumer use – Construction, paint, electrical, and metal products – Batteries (e.g., adhesive in lead-acid battery casings)***
 - This COU was removed from the draft risk evaluation because this use is no longer intended, known, or reasonable foreseen to be manufactured, processed, distributed in commerce, used, or disposed of. EPA did not find evidence that TBBPA is found in any lead-acid battery that is currently available on the market and reasonably anticipates that TBBPA is no longer manufactured or processed for use in batteries. A recent safety data sheet of a battery product that previously indicated TBBPA was a component in the product ([Yuasa, 2016](#)) no longer contains TBBPA ([Yuasa, 2022](#)). Given the expected useful life of a lead-acid battery of five years or less, EPA determined exposure to TBBPA in batteries that were previously available on that market is unlikely.
- ***Consumer use – Packaging, paper, plastic, hobby products – Plastic and rubber products***
 - This COU was added to the draft risk evaluation because EPA determined this use is intended, known, or reasonably foreseen to be manufactured, processed, distributed in commerce, used, or disposed of based on reasonably available information that indicates TBBPA is used in rubber and plastic products and articles ([3DXTECH, 2017](#)).
- ***Consumer use – Furnishing, cleaning and treatment/care products – Fabric, textile and leather products not covered elsewhere***
 - This COU was removed from the draft risk evaluation because this use is no longer intended, known, or reasonable foreseen to be manufactured, processed, distributed in commerce, used, or disposed of. After additional analysis, EPA found that, while TBBPA had been found in a small number of textile products at contaminant levels in the past, recent studies involving product testing did not find TBBPA in clothing samples, furniture samples, camping products, and other textiles ([EPA-HQ-OPPT-2018-0462-0038](#); ([WSDE, 2024](#))). EPA could not find recent evidence that TBBPA is currently being used in textiles. Therefore, the Agency determined TBBPA is unlikely to be used in fabrics and textiles.

D.2 Conditions of Use Descriptions

The following COU descriptions are based on CDR use codes and reflect the reasonably available information regarding COUs that the Agency has identified during the draft risk evaluation. The descriptions are intended to include examples of uses, so as not to exclude other activities that may also be included, in the COUs of TBBPA. To better describe the COUs, EPA considered CDR submissions for TBBPA from the last two CDR cycles and other reasonably available information, including stakeholder engagements, published literature, company websites, government and commercial trade databases and publications, and TSCA section 4(a)(2) test order data. The COU descriptions reflect what EPA identified as the best fit for that submission. Examples of articles, products, or activities are included in the following descriptions to help describe the COU but are not exhaustive. EPA uses the terms “articles” and “products” or “product mixtures” in the following descriptions and is generally referring to articles and products as defined by 40 CFR part 751. There may be instances where the terms are used interchangeably by a company or commenters, or by EPA in reference to a code from the CDR reports that are referenced; for example, “plastic products manufacturing,” or “fabric, textile, and

leather products.” EPA will clarify as needed when these references are included throughout the COU descriptions below.

TBBPA is one of the most widely used brominated flame retardants and is used as both an additive and reactive flame retardant. Flame retardants are used to alter the normal degradation or combustion processes of plastics, rubbers, textiles, papers and woods, etc., used on the surface of or incorporated into combustible materials to reduce or eliminate their tendency to ignite when exposed to heat or a flame for a short period of time, and used to raise the ignition point and/or to slow down or prevent combustion. Flame retardants are generally incorporated throughout the polymeric material, although they can also be coated on the external surface of the polymer to form a suitable protective barrier. Flame retardants can be classified, broadly speaking, into two types according to the method of incorporation:

1. Reactive flame retardants are incorporated into polymers via chemical reactions. The production of existing polymers is modified so that one or more unsubstituted reactant monomers is replaced with a substituted monomer containing flame-retardant heteroelements. The substituted monomers and their heteroelement components become an integral part of the resulting polymer structure. Reactive flame retardants must be incorporated at an early stage of manufacturing, but once introduced, they become a permanent part of the polymer structure. Once they are chemically bound, reactive flame-retardant chemicals cease to exist as separate chemical entities. Reactive flame retardants have a greater effect than additive flame retardants on the chemical and physical properties of the polymer into which they are incorporated.
2. Additive flame retardants are incorporated into the compounds via physical mixing. Compounds containing flame-retardant elements are mixed with existing polymers without undergoing any chemical reactions. As a result, the polymer/additive mixture is less susceptible to combustion than the polymer alone. Since additive flame retardants can be incorporated into the product up until the final stages of manufacturing, it is typically simpler for manufacturers to use additive flame retardants than reactive flame retardants.

Although TBBPA is primarily used as a flame retardant, TBBPA may have other functions such as an intermediate.

D.2.1 Manufacture – Domestic Manufacture

Domestic manufacture means to manufacture or produce TBBPA within the United States (including manufacturing for export). For purposes of this draft risk evaluation, this includes the extraction of TBBPA from a previously existing chemical substance or complex combination of chemical substances and loading and repackaging (but not transport) associated with the manufacturing or production of TBBPA.

Information submitted to EPA indicates that domestic manufacture of TBBPA in the United States ceased in 2023 ([ACC, 2025b](#); [Integral Consulting, 2025c](#)). However, EPA has determined that the domestic manufacture of TBBPA in the United States is reasonably foreseen.

Examples of CDR Submissions

In the 2016 CDR cycle, two companies (at one site [as defined at 40 CFR 711.3]) reported domestic manufacture of TBBPA. In the 2016 and 2020 CDR cycles, several sites claimed the manufacturing activity (domestically manufactured, imported, or both domestically manufactured and imported) as confidential business information (CBI).

D.2.2 Manufacture – Import

This COU refers to the import of TBBPA, including TBBPA-containing products and articles, into the customs territory of the United States. This COU includes loading/unloading and repackaging (but not transport) associated with the import of TBBPA. In general, chemicals may be imported into the United States in bulk via water, air, land, and intermodal shipments.

Examples of CDR Submissions

In the 2016 and 2020 CDR cycles, several sites reported import of TBBPA, and several sites claimed the manufacturing activity (domestically manufactured, imported, or both domestically manufactured and imported) as CBI.

D.2.3 Processing – As a Reactant – Flame Retardant in Plastic Material and Resin Manufacturing

This COU refers to the use of TBBPA as a reactant flame retardant in chemical reactions for the manufacturing of another chemical substance or product. Flame retardants are used to alter the normal degradation or combustion processes of plastics, rubbers, textiles, papers and woods (etc.) used on the surface of or incorporated into combustible materials to reduce or eliminate their tendency to ignite when exposed to heat or a flame for a short period of time, and used to raise the ignition point and/or to slow down or prevent combustion. This COU includes use of TBBPA as a flame retardant in plastic material and resin manufacturing where TBBPA is consumed (converted) in the reaction. This COU includes use of TBBPA as a reactive flame retardant that is fully reacted (*i.e.*, TBBPA is wholly consumed and further processing and use does not exist) as well as use of TBBPA as a reactive flame retardant that is partially consumed in a reaction ([Integral Consulting, 2025a](#)). For example, TBBPA is used as a flame retardant in chemical reactions for the manufacture of liquid resin and polymer.

Examples of CDR Submissions

In the 2020 CDR cycle, two sites reported use in Processing as a reactant – flame retardant in plastic material and resin manufacturing.

D.2.4 Processing – As a Reactant – Intermediate in All Other Chemical Product and Preparation Manufacturing

This COU refers to the use of TBBPA as an intermediate in chemical reactions for the manufacturing of another chemical substance or product. Intermediates (as defined at 40 CFR 704.3) are partially or fully consumed in a reaction in order to manufacture other chemical substances at an industrial processing facility and formed (directly or indirectly) from reactants and reacted further to create (either directly or indirectly) the products of a chemical reaction. This COU includes the use of TBBPA as an intermediate in all other chemical products and preparation manufacturing, such as intermediate in the synthesis of other brominated flame retardants.

Examples of CDR Submissions

In the 2016 CDR cycle, two sites reported use in Processing as a reactant – intermediate in all other chemical product and preparation manufacturing.

In the 2020 CDR cycle, one site reported use in Processing – incorporation into formulation, mixture, or reaction product – intermediate in all other chemical product and preparation manufacturing; for purposes of this risk evaluation, EPA concluded that the correct category classification of this reported use is Processing – As a reactant – Intermediate in all other chemical product and preparation manufacturing.

D.2.5 Processing – Incorporation into a Formulation, Mixture, or Reaction Product – Flame Retardant in: Plastic Material and Resin Manufacturing; Plastics Product Manufacturing; Custom Compounding of Purchased Resins; Paint and Coating Manufacturing

This COU refers to the preparation of a product; that is, the incorporation of TBBPA into formulation, mixture, or a reaction product which occurs when a chemical substance is added to a product (or product mixture), after its manufacture, for distribution in commerce. In this case, TBBPA is added to a formulation, mixture, or reaction product (e.g., TBBPA-containing liquid, semi-solid, powder, or solid material) as a flame retardant for use in multiple sectors, including plastic material and resin manufacturing; plastics product manufacturing; custom compounding of purchased resins; and paint and coating manufacturing. This COU includes use of TBBPA as an additive flame retardant and as a reactive flame retardant that is not completely reacted (i.e., TBBPA is not fully reacted and the product intentionally contains TBBPA). Flame retardants are used to alter the normal degradation or combustion processes of plastics, rubbers, textiles, papers and woods, etc., used on the surface of or incorporated into combustible materials to reduce or eliminate their tendency to ignite when exposed to heat or a flame for a short period of time, and used to raise the ignition point and/or to slow down or prevent combustion. For example, TBBPA is incorporated as a flame retardant in the preparation of formulation, mixture, or reaction products such as liquid and solid resin, flame retardant powder, polymer pellet, polymer granule, and acrylonitrile-butadiene-styrene (ABS) compound.

Examples of CDR Submissions

In the 2016 CDR cycle, one site reported use in Processing – incorporation into formulation, mixture, or reaction product – processing aid in plastic material and resin manufacturing to make building/construction materials. Based on communication with the reporter, EPA has interpreted this reported use as “Processing – Incorporation into formulation, mixture, or reaction product – Flame retardant.”

In the 2020 CDR cycle, for use in Processing – incorporation into formulation, mixture, or reaction product – flame retardant, three sites reported use in plastics material and resin manufacturing, three sites reported use in plastics product manufacturing, one site reported use is custom compounding of purchased resins, and one site reported use in paint and coating manufacturing.

D.2.6 Processing – Incorporation into a Formulation, Mixture, or Reaction Product – Adhesive Manufacturing

This COU refers to the preparation of a product; that is, the incorporation of TBBPA into formulation, mixture, or a reaction product which occurs when a chemical substance is added to a product (or product mixture), after its manufacture, for distribution in commerce. This COU includes use of TBBPA in adhesive manufacturing, such as semi-solid adhesive film.

Examples of CDR Submissions

In the 2020 CDR cycle, one site reported use in Processing – incorporation into formulation, mixture, or reaction product – intermediate in adhesive manufacturing.

D.2.7 Processing – Incorporation into Article – Reactive Flame Retardant in: Computer and Electronic Product Manufacturing; Electrical Equipment, Appliance, and Component Manufacturing; Plastic Product Manufacturing (e.g., Printed Circuit Boards and Semiconductor Packages)

This COU refers to the preparation of an article; that is, the incorporation of TBBPA or a TBBPA-containing product (e.g., TBBPA-containing liquid, semi-solid, powder, or solid material) into articles,

meaning TBBPA becomes an integral component of the article, after its manufacture, for distribution in commerce. In this case, TBBPA is used as a reactive flame retardant incorporated into polymers via chemical reactions. Flame retardants are used to alter the normal degradation or combustion processes of plastics, rubbers, textiles, papers and woods, etc., used on the surface of or incorporated into combustible materials to reduce or eliminate their tendency to ignite when exposed to heat or a flame for a short period of time, and used to raise the ignition point and/or to slow down or prevent combustion. This COU includes use of TBBPA as a reactive flame retardant in computer and electronic product manufacturing; electrical equipment, appliance and component manufacturing; and plastic product manufacturing. For example, TBBPA is used reactively in the manufacture of laminate (e.g., copper-clad laminate sheets), prepreg (i.e., composite material pre-impregnated with partially cured resin), and TBBPA-coated straps used for electromagnetic and thermal shielding for electronic components that is incorporated into electrical products and articles such as printed circuit boards and semiconductor packages ([Integral Consulting, 2025a](#)). This COU also includes use of TBBPA-containing adhesives for surface mount component attach applications.

Examples of CDR Submissions

In the 2016 CDR cycle, for use in Processing – incorporation into article – flame retardant, one site reported use in plastics product manufacturing, and two sites reported use in electrical equipment, appliance, and component manufacturing.

In the 2016 CDR cycle, one site reported Processing – incorporation into formulation, mixture, or reaction product – miscellaneous manufacturing; after further communication with the reporter, EPA concluded that the correct classification for this use is Processing – Incorporation into article – Reactive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., printed circuit boards and semiconductor packages). This site also reported use for Processing – Incorporation into formulation, mixture, or reaction product – Intermediate in transportation equipment manufacturing. In the Scope of the Risk Evaluation for TBBPA, EPA concluded that the correct classification of this use of TBBPA is as a reactive flame retardant (e.g., interior material for transportation equipment) and as industrial and commercial use in laminate (e.g., reactive flame retardant in prepreg material for automotive and aviation interiors). For purposes of this draft risk evaluation, as described in this appendix, based on communication with the reporter and other reasonably available information, EPA determined that the correct classification for this reported use is Processing – Incorporation into article – Reactive flame retardant in: Computer and electronic product manufacturing; Electrical equipment, appliance, and component manufacturing; Plastic product manufacturing (e.g., printed circuit boards and semiconductor packages) ([EPA-HQ-OPPT-2018-0462-0040](#); [EPA-HQ-OPPT-2018-0462-0041](#)).

In the 2016 and 2020 CDR cycles, some sites reported use of TBBPA in Processing – incorporation into formulation, mixture, or reaction product in two industrial sectors: computer and electronic product manufacturing and electrical equipment, appliance, and component manufacturing; for purposes of this draft risk evaluation, EPA concluded that these reported uses are better represented in the Processing – Incorporation into article category and therefore are included in this COU.

In the 2020 CDR cycle, one site reported use in Processing – incorporation into article – flame retardant in plastics product manufacturing.

D.2.8 Processing – Incorporation into Article – Reactive Flame Retardant in Transportation Equipment Manufacturing (e.g., Interior Material for Automotive and Aviation Articles)

This COU refers to the preparation of an article; that is, the incorporation of TBBPA or a TBBPA-containing product (e.g., TBBPA-containing liquid, semi-solid, powder, or solid material) into articles, meaning TBBPA becomes an integral component of the article, after its manufacture, for distribution in commerce. In this case, TBBPA is used as a reactive flame retardant incorporated into polymers via chemical reactions. Flame retardants are used to alter the normal degradation or combustion processes of plastics, rubbers, textiles, papers and woods, etc., used on the surface of or incorporated into combustible materials to reduce or eliminate their tendency to ignite when exposed to heat or a flame for a short period of time, and used to raise the ignition point and/or to slow down or prevent combustion. This COU includes use of TBBPA as a reactive flame retardant in transportation equipment manufacturing. For example, TBBPA is used reactively in the manufacture of laminate, prepreg composite, and solid adhesive film for use in interior material for transportation equipment, including for automotive interiors, aviation aircraft interiors, and for the aerospace industry.

Examples of CDR Submissions

In the 2016 CDR cycle, one site reported Commercial use in industrial manufacturing. In the final scope document for TBBPA, EPA concluded that the correct classification of the use of TBBPA is as a reactive flame retardant (e.g., interior material for transportation equipment) and as industrial and commercial use in laminate (e.g., reactive flame retardant in prepreg material for automotive and aviation interiors). For purposes of this draft risk evaluation, as described in Appendix D, based on communication with the reporter and other reasonably available information, EPA determined that the correct classification for this reported use is Processing – Incorporation into article – Reactive flame retardant in transportation equipment manufacturing (e.g., interior material for automotive and aviation articles) and Industrial and commercial use – construction, paint, electrical and metal products – reactive flame retardant in automotive and aviation articles (i.e., laminate and prepreg material) ([EPA-HQ-OPPT-2018-0462-0040](#); [EPA-HQ-OPPT-2018-0462-0041](#)).

D.2.9 Processing – Incorporation into Article – Additive Flame Retardant in: Computer and Electronic Product Manufacturing; Electrical Equipment, Appliance, and Component Manufacturing; Plastic Product Manufacturing (e.g., Plastic Electronic Enclosures)

This COU refers to the preparation of an article; that is, the incorporation of TBBPA or a TBBPA-containing product (e.g., TBBPA-containing liquid, semi-solid, powder, or solid material) into articles, meaning TBBPA becomes an integral component of the article, after its manufacture, for distribution in commerce. In this case, TBBPA is used as an additive flame retardant that is incorporated into polymers via physical mixing and are not chemically bound to the polymer. Flame retardants are used to alter the normal degradation or combustion processes of plastics, rubbers, textiles, papers and woods, etc., used on the surface of or incorporated into combustible materials to reduce or eliminate their tendency to ignite when exposed to heat or a flame for a short period of time, and used to raise the ignition point and/or to slow down or prevent combustion. This COU includes use of TBBPA as an additive flame retardant in computer and electronic product manufacturing; electrical equipment, appliance, and component manufacturing; and plastic product manufacturing. For example, TBBPA or TBBPA-containing material such as solid pellets or ABS compound is additively processed in the manufacture of plastic and polymer products for electronic housing in electrical equipment and molded electronic parts.

Examples of CDR Submissions

In the 2016 CDR cycle, one company reported use in Processing – incorporation into article – flame retardant in plastics product manufacturing and two companies reported use in processing – incorporation into article – flame retardant in electrical equipment, appliance, and component manufacturing. In the 2020 CDR cycle, one company reported use in Processing – incorporation into article – flame retardant in plastics product manufacturing.

D.2.10 Processing – Repackaging

This COU refers to preparation of TBBPA for distribution into commerce in a different form, state, or quantity than originally received or stored by various industrial sectors, including chemical product and preparation manufacturing, wholesale and retail trade, and laboratory chemicals manufacturing. This COU includes transferring TBBPA from a bulk storage container into smaller containers. This COU would not apply to the relabeling or redistribution of a chemical substance without removing the chemical substance from the original container it was supplied in.

Examples of CDR Submissions

This use was not reported during the 2016 or 2020 CDR cycles.

D.2.11 Processing – Recycling

This COU refers to the process of treating generated waste streams (*i.e.*, which would otherwise be disposed of as waste), containing TBBPA, that are collected, either on-site or at a third-party site, for commercial purposes. For example, TBBPA may be present during the process of recycling waste plastics and electronic waste (e-waste).

Examples of CDR Submissions

This use was not reported during the 2016 or 2020 CDR cycles.

D.2.12 Distribution in Commerce

For purposes of assessment in this draft risk evaluation, distribution in commerce consisting of the transportation associated with the moving of TBBPA or TBBPA-containing products and/or articles between sites manufacturing, processing or recycling TBBPA or TBBPA-containing products and/or articles, or to final use sites, or for final disposal of TBBPA or TBBPA-containing products and/or articles. More broadly under TSCA, “distribution in commerce” and “distribute in commerce” are defined under TSCA section 3(5). Cleanup of accidents/spills that may occur during transport are not within the scope of this risk evaluation.

D.2.13 Industrial Use – Construction, Paint, Electrical and Metal Products – Powder Coatings

This COU refers to the industrial use of TBBPA in dry powder coating that does not contain solvents and is cured under heat to create a coating film. This COU refers to the use of TBBPA after it has already been incorporated into a powder coating product, as opposed to when it is processed upstream (*e.g.*, when TBBPA is processed into the paint and coating formulation). For example, TBBPA may be found in flame retardant powder that is used for coating electronics.

Examples of CDR Submissions

This use was not reported during the 2016 or 2020 CDR cycles.

D.2.14 Industrial and Commercial Use – Construction, Paint, Electrical, and Metal Products – Reactive Flame Retardant in Electrical and Electronic Articles

This COU refers to the industrial and commercial use of TBBPA as a reactive flame retardant in electrical and electronic products and articles, including printed circuit boards and laminates. Electrical and electronic products and articles include machinery, mechanical appliances, and electrical/electronic articles (e.g., refrigerators, washing machines, vacuum cleaners, computers, telephones, drills, saws, smoke detectors, thermostats, radiators) and other machinery, mechanical appliances, and electrical/electronic articles (e.g., large-scale stationary industrial tools). Specifically, this COU includes use of TBBPA-containing articles (e.g., TBBPA-containing materials such as prepreg composite, sheet, or cloth) and the use of TBBPA-containing articles in the assembling of other articles. For example, this COU includes use of TBBPA-containing prepreg composite in the manufacture and assembly of final products for electrical utilities. Additionally, this COU includes industrial and commercial use of TBBPA in electrical and electronic products that are used to control moving parts of furniture and furnishings, including soft plastic articles and leather articles; replacement parts; and electrical and electronic products containing TBBPA that are distributed in commerce, including through third-party merchant listings, e-commerce marketplaces, and other secondary markets. This COU also includes repair and refurbishment of TBBPA-containing electrical and electronic articles.

Examples of CDR Submissions

In the 2016 CDR cycle, three sites reported commercial use in electrical and electronic products.

In the 2020 CDR cycle, one site reported Commercial use as a flame retardant in electrical and electronic products; one site reported Commercial use as a flame retardant in machinery, mechanical appliances, electrical/electronic articles; and two sites reported Commercial use as a flame retardant in other machinery, mechanical appliances, electronic/electronic articles. One site reported Commercial use as a flame retardant in furniture and furnishings including plastic articles (soft) and leather articles; for purposes of this draft risk evaluation, EPA determined that this use is classified under Industrial and commercial use – Construction, paint, electrical, and metal products – Reactive flame retardant in electrical and electronic articles and Industrial and commercial use – Construction, paint, electrical, and metal products – Additive flame retardant in electrical and electronic articles (i.e., plastic enclosures).

D.2.15 Industrial and Commercial Use – Construction, Paint, Electrical and Metal Products – Reactive Flame Retardant in Automotive and Aviation Articles (i.e., Laminate and Prepreg Material)

This COU refers to the industrial and commercial use of TBBPA as a reactive flame retardant in automotive and aviation articles. Specifically, this COU includes use of TBBPA-containing articles (e.g., TBBPA-containing materials such as prepreg composite, sheet, or cloth), as well as the incorporation of a TBBPA-containing article into another article or final product or in the assembling of other articles. For example, this COU includes use of TBBPA-containing prepreg composite in the manufacture and assembly of laminate for automotive and aviation interiors. This COU includes replacement parts that have TBBPA-containing materials such as prepreg composite, sheet, or cloth.

Examples of CDR Submissions

In the 2016 CDR cycle, one site reported Commercial use in industrial manufacturing. In the Scope of the Risk Evaluation for TBBPA, EPA concluded that the correct classification of this reported use of TBBPA is as a reactive flame retardant (e.g., interior material for transportation equipment) and as industrial and commercial use in laminate (e.g., reactive flame retardant in prepreg material for automotive and aviation interiors). For purposes of this draft risk evaluation, as described in this appendix, based on communication with the reporter and other reasonably available information, EPA

determined that the correct classification for this reported use is Processing – Incorporation into article – Reactive flame retardant in transportation equipment manufacturing (e.g., interior material for automotive and aviation articles) and Industrial and commercial use – Construction, paint, electrical and metal products – Reactive flame retardant in automotive and aviation articles (i.e., laminate and prepreg material) ([EPA-HQ-OPPT-2018-0462-0040](#); [EPA-HQ-OPPT-2018-0462-0041](#)).

D.2.16 Industrial and Commercial Use – Construction, Paint, Electrical and Metal Products – Additive Flame Retardant in Electrical and Electronic Articles (i.e., Plastic Enclosures)

This COU refers to the industrial and commercial use of TBBPA as an additive flame retardant that is incorporated into plastic enclosures for electrical and electronic products. Electrical and electronic products and articles include machinery, mechanical appliances, and electrical/electronic articles (e.g., refrigerators, washing machines, vacuum cleaners, computers, telephones, drills, saws, smoke detectors, thermostats, radiators) and other machinery, mechanical appliances, and electrical/electronic articles (e.g., large-scale stationary industrial tools). Specifically, this COU includes use of TBBPA-containing articles (e.g., TBBPA-containing plastic enclosures that are external to an electronic device), as well as the incorporation of a TBBPA-containing article into another article or final product. For example, this COU includes use of TBBPA-containing molded electronic parts in the manufacture and assembly of plastic enclosures for electrical utilities. Additionally, this COU includes industrial and commercial use of: TBBPA in plastic enclosures of electrical and electronic products that are part of furniture and furnishings including soft plastic articles and leather articles; replacement parts that have TBBPA-containing plastic enclosures; and electrical and electronic products that incorporated TBBPA as an additive flame retardant into plastic enclosures that are distributed in commerce, including through third-party merchant listings, e-commerce marketplaces, and other secondary markets. This COU also includes repair and refurbishment of TBBPA-containing plastic enclosures for electrical and electronic articles.

Examples of CDR Submissions

In the 2016 CDR cycle, three sites reported Commercial use in electrical and electronic products.

In the 2020 CDR cycle, one site reported Commercial use as a flame retardant in electrical and electronic products; one site reported Commercial use as a flame retardant in machinery, mechanical appliances, electrical/electronic articles; and two sites reported Commercial use as a flame retardant in other machinery, mechanical appliances, electronic/electronic articles. One site reported Commercial use as a flame retardant in furniture and furnishings including plastic articles (soft) and leather articles; for purposes of this draft risk evaluation, EPA determined that this use is classified under Industrial and commercial use – Construction, paint, electrical, and metal products – Reactive flame retardant in electrical and electronic articles; and Industrial and commercial use – Construction, paint, electrical, and metal products – Additive flame retardant in electrical and electronic articles (i.e., plastic enclosures).

D.2.17 Industrial and Commercial Use – Construction, Paint, Electrical and Metal Products – Building/Construction Materials

This COU refers to the Industrial and Commercial Use in Building and Construction Materials. Examples included in the CDR description for “building and construction materials” include insulation panels, wall papers, roof sheets, drinking water pipes, sewer pipes, cement flooring, and mirrors. For example, TBBPA may be found in finished composites that are used commercially in U.S. building and construction applications, including architectural fascia, building panels, bridges, and pilings ([ACC, 2025b](#)).

Examples of CDR Submissions

In the 2016 CDR cycle, one site reported Commercial use in building/construction materials not covered elsewhere.

D.2.18 Industrial and Commercial Use – Packaging, Paper, Plastic, Hobby Products – Plastic and Rubber Products

This COU refers to the industrial and commercial use of TBBPA in rubber and plastic products and articles. Examples included in the CDR description for “plastic and rubber products not covered elsewhere,” which means that the chemical substance is not associated with any other plastic or rubber product category within CDR, are articles such as packaging (excluding food packaging), including rubber articles, plastic articles (hard), and plastic articles (soft) (e.g., phone covers, personal tablet covers, styrofoam packaging, bubble wrap) and other articles with routine direct contact during normal use including rubber articles and plastic articles (hard) (e.g., gloves, boots, clothing, rubber handles, gear lever, steering wheels, handles, pencils, handheld device casing). This COU refers to the use of TBBPA after it has already been incorporated into plastic and rubber products or articles, as opposed to when it is processed upstream (e.g., when TBBPA is processed into the formulation or article). Additionally, TBBPA may be found in 3D printing filament ([3DXTECH, 2017](#)).

Examples of CDR Submissions

In the 2020 CDR cycle, one site reported Commercial Use in Plastic and Rubber Products not covered elsewhere.

D.2.19 Industrial and Commercial Use – Other – Laboratory Chemical

This COU refers to the industrial and commercial use of TBBPA as a laboratory chemical, such as a chemical standard, research, equipment calibration and sample preparation, including as a reference material during analysis. This COU refers to the use of TBBPA in industrial and commercial settings, as opposed to when it is processed upstream (e.g., when TBBPA is repackaged for laboratory use).

Examples of CDR Submissions

This use was not reported during the 2016 or 2020 CDR cycles.

D.2.20 Consumer Use – Construction, Paint, Electrical, and Metal Products – Reactive Flame Retardant in Electrical and Electronic Articles

This COU refers to the consumer use of electrical and electronic products that incorporated TBBPA as a reactive flame retardant, for example printed circuit boards and semiconductor packages. Electrical and electronic products and articles include machinery, mechanical appliances, and electrical/electronic articles (e.g., refrigerators, washing machines, vacuum cleaners, computers, telephones, drills, saws, smoke detectors, thermostats, radiators) and other machinery, mechanical appliances, and electrical/electronic articles (e.g., large-scale stationary industrial tools). This COU includes consumer use of: TBBPA in electrical and electronic products that are used to control moving parts of furniture and furnishings, including soft plastic articles and leather articles; replacement parts that have TBBPA-containing materials such as prepreg composite, sheet, or cloth; and electrical and electronic products containing TBBPA that are distributed in commerce, including through third-party merchant listings, e-commerce marketplaces, and other secondary markets. This COU does not include consumer use of electrical and electronic products that incorporated TBBPA as an additive flame retardant into plastic enclosures, which is covered under a different COU.

Examples of CDR Submissions

In the 2016 CDR cycle, three sites reported Consumer use in electrical and electronic products.

In the 2020 CDR cycle, one site reported Consumer use as a flame retardant in electrical and electronic products; one site reported Consumer use as a flame retardant in machinery, mechanical appliances, electrical/electronic articles; and two sites reported Consumer use as a flame retardant in other machinery, mechanical appliances, electronic/electronic articles.

D.2.21 Consumer Use – Construction, Paint, Electrical, and Metal Products – Additive Flame Retardant in Electrical and Electronic Articles (*i.e.*, Plastic Enclosures)

This COU refers to the consumer use of electrical and electronic products that incorporated TBBPA as an additive flame retardant into plastic enclosures. Electrical and electronic products and articles include machinery, mechanical appliances, and electrical/electronic articles (*e.g.*, refrigerators, washing machines, vacuum cleaners, computers, telephones, drills, saws, smoke detectors, thermostats, radiators) and other machinery, mechanical appliances, and electrical/electronic articles (*e.g.*, large-scale stationary industrial tools). This COU includes consumer use of: TBBPA in electrical and electronic products that are used to control moving parts of furniture and furnishings, including soft plastic articles and leather articles; electrical and electronic product replacement parts that have TBBPA-containing plastic enclosures; and electrical and electronic products that incorporated TBBPA as an additive flame retardant into plastic enclosures that are distributed in commerce, including through third-party merchant listings, e-commerce marketplaces, and other secondary markets.

Examples of CDR Submissions

In the 2020 CDR cycle, one site reported Consumer use as a flame retardant in electrical and electronic products; one site reported Consumer use as a flame retardant in machinery, mechanical appliances, electrical/electronic articles; and two sites reported Consumer use as a flame retardant in other machinery, mechanical appliances, electronic/electronic articles.

D.2.22 Consumer Use – Construction, Paint, Electrical, and Metal Products – Reactive Flame Retardant in Automotive and Aviation Articles (*i.e.*, Laminate and Prepreg Material)

This COU refers to the consumer use of automotive and aviation articles that incorporated TBBPA as a reactive flame retardant. This COU includes aircraft interiors, cabinetry, and frames.

Examples of CDR Submissions

This use was not reported during the 2016 or 2020 CDR cycles.

D.2.23 Consumer Use – Packaging, Paper, Plastic, Hobby Products – Plastic and Rubber Products

This COU refers to the consumer use of TBBPA in rubber and plastic products and articles. Examples included in the CDR description for “plastic and rubber products not covered elsewhere,” which means that the chemical substance is not associated with any other plastic or rubber product category within CDR, are articles such as packaging (excluding food packaging), including rubber articles, plastic articles (hard), and plastic articles (soft) (*e.g.*, phone covers, personal tablet covers, styrofoam packaging, bubble wrap) and other articles with routine direct contact during normal use including rubber articles and plastic articles (hard) (*e.g.*, gloves, boots, clothing, rubber handles, gear lever, steering wheels, handles, pencils, handheld device casing). This COU refers to the use of TBBPA after it has already been incorporated into plastic and rubber products or articles, as opposed to when it is processed upstream (*e.g.*, when TBBPA is processed into the formulation or article). Additionally, TBBPA may be found in 3D printing filament used by consumers ([3DXTECH, 2017](#)).

Examples of CDR Submissions

This use was not reported during the 2016 or 2020 CDR cycles, though in the 2020 CDR cycle, one site reported Commercial Use in Plastic and Rubber Products not covered elsewhere.

D.2.24 Disposal

Each of the COUs of TBBPA may generate waste streams of the chemical that are collected and transported to third-party sites for disposal, treatment, or recycling. For purposes of the TBBPA draft risk evaluation, this COU refers to the TBBPA in a waste stream that is collected from facilities, commercial sites, or households and unloaded at and treated or disposed at waste disposal sites. Recycling of TBBPA and TBBPA-containing products and articles is considered a different COU. Environmental releases from industrial sites are assessed in each COU and are not included as part of the disposal COU.

Appendix E DRAFT OCCUPATIONAL EXPOSURE VALUE DERIVATION AND ANALYTICAL METHODS USED TO DETECT TBBPA

Based on the available hazard and exposure profile for TBBPA, EPA has calculated a draft 8-hour time-weighted average (TWA) existing chemical occupational exposure value. This calculated value may be used to support risk management efforts for TBBPA under TSCA section 6(a) (see 15 U.S.C. § 2605). EPA calculated the value rounded to 0.077 ppm (1.72 mg/m³) for inhalation exposures to TBBPA as an 8-hour TWA and for consideration in workplace settings (see Appendix E.1 below) based on the chronic exposure duration human equivalent concentration (HEC) of 1.08 ppm for uterine toxicity effects (*i.e.*, atypical endometrial hyperplasia in female Wistar Han rats from a chronic oral study). The Agency did not calculate a short-term occupational exposure value (STEV) separately for TBBPA because EPA determined that TBBPA is not acutely hazardous; thus, there is no concern for effects following short-term exposure at 15-minute concentrations.

TSCA requires risk evaluations to be conducted without consideration of cost and other non-risk factors, and thus this occupational exposure value represents a risk-only number. EPA may consider cost and other non-risk factors, such as analytical and technological feasibility, the availability of alternatives, and the potential for critical or essential uses during risk management. Any existing chemical exposure limit (ECEL) established for occupational safety risk management purposes could differ from the occupational exposure value presented in this appendix based on additional consideration of exposures and non-risk factors consistent with TSCA section 6(c).

The draft calculated value for TBBPA represents the exposure concentration below which exposed workers and occupational non-users (ONUs) are not expected to exhibit any appreciable risk of adverse toxicological outcomes. This draft value accounts for the corresponding risk estimates (margin of exposure [MOEs]) will fall below the benchmark MOE for exposed workers and ONUs, accounting for potentially exposed and susceptible subpopulations (PESS). The draft value is derived based on the HECs described in Section 4.2, reflecting the best available science on sensitive human health effects. This preliminary value is expressed relative to benchmarks and standard occupational scenario assumptions of 8 hours per day, 5 days per week exposures, for a total of 250 days exposure per year across a 40-year working life.

All draft hazard values used in these calculations are based on an HEC of 1.66 ppm for intermediate exposure duration scenarios and an HEC of 1.08 ppm for chronic exposure duration scenarios from the *Draft Human Health and Environmental Hazard for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026t](#)).

Of the identified occupational monitoring data for TBBPA, there have been measured workplace air concentrations below the calculated exposure value. No available monitoring methods were identified from the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), or EPA, but a validated monitoring method is included in Appendix E.2 below. The calculated draft exposure value is above the limit of detection (LOD) and limit of quantification/quantitation (LOQ) using the monitoring method identified. OSHA has not set a permissible exposure limit (PEL) as an 8-hour TWA for TBBPA (<https://www.osha.gov/annotated-pels>; accessed May 22, 2026). EPA did not identify other occupational exposure limit values for the United States or other countries.

E.1 Occupational Exposure Value Calculations

This section presents the calculations used to estimate the draft occupational exposure value using inputs derived in this risk evaluation. Multiple values are presented below for hazard endpoints based on different exposure durations. For TBBPA, the occupational exposure value is based on atypical endometrial hyperplasia in female rats following chronic exposure and the resulting 8-hour TWA is rounded to 0.077 ppm (1.72 mg/m³). The HECs used in the equations are derived in this draft risk evaluation and the *Draft Human Health and Environmental Hazard for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026t](#)).

Draft Chronic Occupational Exposure Value

The draft chronic occupational exposure value ($EV_{chronic}$) was calculated as the concentration for at which the chronic MOE would equal the benchmark MOE for 8-hour chronic occupational exposures using the following equation:

Equation_Apx E-1.

$$EV_{chronic} = \frac{HEC_{chronic}}{Benchmark\ MOE_{chronic}} \times \frac{AT_{HEC_{chronic}}}{(ED \times EF \times WY)} \times \frac{IR_{resting}}{IR_{workers}}$$

$$= \frac{1.08\ ppm}{30} \times \frac{([24\ hrs/day] \times [365\ days/yr] \times 40\ yrs \times [0.6125\ m^3/hr])}{([8\ hrs/day] \times [250\ days/yr] \times 40\ yrs \times [1.25\ m^3/hr])} = 0.077\ ppm = 1.72\ mg/m^3$$

Draft Intermediate Occupational Exposure Value

The draft intermediate occupational exposure value ($EV_{intermediate}$) was calculated as the concentration at which the intermediate MOE would equal the benchmark MOE for intermediate occupational exposure using the following equation:

Equation_Apx E-2.

$$EV_{intermediate} = \frac{HEC_{intermediate}}{Benchmark\ MOE_{intermediate}} \times \frac{AT_{HEC_{intermediate}}}{(ED \times EF)} \times \frac{IR_{resting}}{IR_{workers}}$$

$$= \frac{1.6\ ppm}{30} \times \frac{([24\ hrs/day] \times 30\ days)}{([8\ hrs/day] \times 22\ days)} \times \frac{0.6125\ m^3/hr}{1.25\ m^3/hr} = 0.17\ ppm$$

$$EV_{intermediate} = \frac{(EV\ [ppm] \times MW)}{Molar\ Volume} = \frac{(0.17\ ppm \times [543.88\ g/mol])}{24.45\ L/mol} = 3.7\ mg/m^3$$

The parameters used in the above equations are summarized below. Numerical values chosen for the parameters are described in relevant sections of this draft risk evaluation and the *Draft Human Health and Environmental Hazard for 4,4'-(1-Methylethylidene)bis[2,6-dibromophenol] (TBBPA)* ([U.S. EPA, 2026t](#)).

June 2026

Where:

$AT_{HEC_chronic}$	=	Averaging time for the POD/HEC used for evaluating non-cancer, chronic occupational risk, based on study conditions and/or HEC adjustments (24 h/day for 365 days/yr) and assuming the number of years matches the high-end working years (WY = 40 yrs) for a worker
$AT_{HEC_intermediate}$	=	Averaging time for the POD/HEC used for evaluating non-cancer, intermediate occupational risk, based on study conditions and/or any HEC adjustments (24 h/day for 30 days)
$Benchmark\ MOE_{chronic}$	=	Chronic non-cancer benchmark margin of exposure, based on the total uncertainty factor of 30
$Benchmark\ MOE_{intermediate}$	=	Intermediate non-cancer benchmark margin of exposure, based on the total uncertainty factor of 30
$EV_{intermediate}$	=	Draft intermediate occupational exposure value (mg/m ³)
$EV_{chronic}$	=	Draft chronic occupational exposure value (mg/m ³)
ED	=	Exposure duration (8 h/day)
EF	=	Exposure frequency (22 days/yr for intermediate, 250 days/yr for chronic)
$HEC_{intermediate\ or\ chronic}$	=	Human equivalent concentration (ppm) for intermediate or chronic OESs
IR	=	Inhalation rate (default is 1.25 m ³ /hr for workers and 0.6125 m ³ /hr for the general population at rest) ⁶
WY	=	Working years per lifetime at the 95th percentile (40 yrs)
$Molar\ Volume$	=	Volume of a mole of gas at 1 atm and 25 °C (24.45 L/mol)
MW	=	Molecular weight of TBBPA (543.88 g/mol)

Unit conversion: 1 ppm = 22.24 mg/m³ (based on the molecular weight of 543.88 g/mol for TBBPA)

E.2 Summary of Air Sampling Analytical Methods Identified

EPA conducted a search to identify relevant NIOSH, OSHA, and EPA analytical methods used to monitor for the presence of TBBPA in air (see Table_Apx E-1). This table presents validated methods from governmental agencies and is not intended to be a comprehensive list of available air monitoring methods for TBBPA. The sources used for the search included the following (all hyperlinks accessed May 22, 2026):

1. [NIOSH Manual of Analytical Methods \(NMAM\); 5th Edition](#)
2. [NIOSH NMAM 4th Edition](#)
3. [OSHA Index of Sampling and Analytical Methods](#)
4. [EPA Environmental Test Method and Monitoring Information](#)

⁶ 0.6125 m³/h is also assumed for animals in toxicity studies if they are “at rest” vs. exercising.

Table_Apx E-1. Limit of Detection (LOD) and Limit of Quantification (LOQ) Summary for Air Sampling Analytical Methods Identified for TBBPA

Air Sampling Analytical Methods	Year Published	LOD and LOQ	Notes	Source
Method developed by ALS Global as part of the ACC TBBPA Consortium's response to EPA's test order	2025	The LOD is 0.01 for the calibration range between 0.01–1.0 µg per sample and 0.2 for the calibration range between 1.0–20 µg per sample. The reporting limit is 0.03 and 0.3 for the same calibration ranges, respectively. The LOQ is approximately 3 times the LOD.	This method uses GC-MS to determine TBBPA in air samples collected using the OSHA Versatile sampler: Tenax with Quartz Fiber Filter, SKC 226-66.	Integral Consulting (2025a)
ALS = Australian Laboratory Services; ACC = American Chemistry Council; GC-MS = gas chromatography-mass spectrometry; OSHA = (U.S.) Occupational Safety and Health Administration				

Appendix F INFORMATION ON PERSONAL PROTECTIVE EQUIPMENT FROM OTHER SOURCES

The European Centre for Ecotoxicology and Toxicology of Chemicals' Targeted Risk Assessment (ECETOC TRA) tool version 3 represents the protection factor (PF) of gloves as a fixed, assigned protection factor equal to 5, 10, or 20 ([Marquart et al., 2017](#)). It should be noted that the described PFs are not based on experimental values or field investigations of personal protective equipment (PPE) effectiveness, but rather professional judgments used in the development of the ECETOC TRA v3. These PFs are summarized below in Table_Apx F-1.

Table_Apx F-1. Glove PFs for Different Dermal Protection Strategies from ECETOC TRA v3

Dermal Protection Characteristics	Setting(s)	PF
a. No gloves used, or any glove/gauntlet without permeation data and without employee training	Industrial and commercial uses	1
b. Gloves with available permeation data indicating that the material of construction offers good protection for the substance		5
c. Chemically resistant gloves (<i>i.e.</i> , as b. above) with "basic" employee training		10
d. Chemically resistant gloves in combination with specific activity training (<i>e.g.</i> , procedure for glove removal and disposal) for tasks where dermal exposure can be expected to occur	Industrial uses only	20

PF = protective factor

Source: [Marquart et al. \(2017\)](#)