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Draft Risk Evaluation for Ethylene Dibromide

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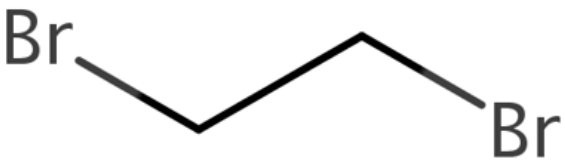

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Docket
Supporting information can be found in the public docket, Docket ID: EPA-HQ-OPPT-2018-0488.

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EXECUTIVE SUMMARY

EPA evaluated the human health and environmental risks of ethylene dibromide across its conditions of use (COUs) under section 6 of the Toxic Substances Control Act (TSCA), ranging from manufacture to disposal. In this draft risk evaluation, the Agency has preliminarily determined that of the 12 COUs assessed for ethylene dibromide, 10 significantly contribute to unreasonable risk of injury to human health. As shown in Table ES-1, the 10 COUs that significantly contribute to unreasonable risk are risks to workers due to dermal and/or inhalation exposures; of those 10, 4 COUs significantly contribute to unreasonable risk to occupational non-users (ONUs[1]) due to inhalation exposure. No COUs for ethylene dibromide significantly contribute to unreasonable risk of injury to consumers, the general population, including fenceline communities, or the environment.

Ethylene dibromide is a common name for the chemical substance 1,2-dibromoethane (CASRN 106-93-4), which is a colorless and sweet-smelling volatile organic chemical (VOC) with an annual total U.S. production volume of less than 1 million pounds (lb) as reported in the most recent Chemical Data Reporting (CDR) in 2024. Ethylene dibromide may be released during industrial activities, manufacturing (including import activities), processing, and disposal—with most environmental releases occuring to air. The main use of ethylene dibromide is in fuels and related products (*i.e.,* lead [Pb] scavenger) in commercial and consumer leaded aviation fuel ("avgas") to prevent engine fouling (U.S. EPA, 2026d). Tetraethyl lead is added to gasoline to increase the octane level and help prevent engine knock (Wells and Wells, 2014). Workers may be exposed when handling ethylene dibromide or products containing ethylene dibromide in the workplace (Section 4.1.1). Consumers such as pilots of small non-commercial airplanes may also be exposed to ethylene dibromide when refueling small aircraft that use avgas (Section 4.1.2).

As indicated in Sections 2.1 and 2.2, ethylene dibromide is volatile, highly water soluble, and unlikely to sorb to soil and sediment. If released into air, ethylene dibromide will largely remain volatile but also might undergo indirect photodegradation or wet deposition onto land or water (Section 3.3.4). Although ethylene dibromide is unlikely to bioaccumulate or bioconcentrate in exposed organisms, EPA assessed how surface water releases may result in acute and/or chronic (long-term) oral and dermal exposure to the general population. Specifically, while volatilization from surface water is expected to occur (*i.e.,* half-life ($t_{½}$) in surface water of about 2.6 hours due to volatilization (U.S. EPA, 2012d)), two other chemical properties can counteract the complete volatilization of ethylene dibromide from water. First, ethylene dibromide is highly soluble in water (4,130 mg/L) (Rumble, 2018a); second, with a density of 2.172 g/cm^3, ethylene dibromide is over twice as dense as receiving waters (O'Neil, 2013). Based on surface water releases (174–365 days per year; Section 3.1.2) and identified monitoring data (Sections 3.3.1 and 3.3.2), EPA has determined that ethylene dibromide can be present in both surface water and drinking water. While the Agency does not expect the general population to be swimming regularly in surface waters that receive direct discharges of ethylene dibromide, a screening-level analysis was conducted to evaluate potential acute exposure from incidental ingestion and dermal exposure via swimming as well as chronic exposure from drinking water and fish ingestion. These analyses were performed to determine whether expected surface water releases might result in risk from these exposure routes and found no unreasonable risk to the general population. EPA expects the ambient air pathway to be the predominant human exposure pathway to releases of ethylene dibromide.

In December 2019, EPA designated ethylene dibromide as a high-priority substance for TSCA evaluation and in August 2020 released the *Final Scope of the Risk Evaluation for Ethylene Dibromide;*

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

CASRN: 106-93-4 (U.S. EPA, 2020b). This draft risk evaluation assesses human health risk to workers (including ONUs), consumers, and the general population (including fenceline communities) exposed to environmental releases of ethylene dibromide. Although considered for the single consumer COU (Consumer use – Fuels and related products), bystanders were not assessed as part of the consumer risk assessment because stakeholder information received from the Experimental Aircraft Association (described in Section 4.3.4.1) indicated that passengers are not present during refueling events and will not be exposed to ethylene dibromide. This draft evaluation also assesses risk to the environment, including risks to aquatic and terrestrial species.

Manufacturers (including importers) reported ethylene dibromide annual production volumes between 75,000 and 20 million lb through CDR from 2012 to 2023. Import was the only activity reported as non-CBI (confidential business information) during these years—all other reported activities were claimed as CBI. No domestic manufacture was reported under CDR for this period (*i.e.,* total production reflects imports only). Annual domestic production volume (imports) was less than 1 million lb in 2012 and 2013, peaking in 2014 and 2015 between 1 and 20 million lb before dropping below 1 million lb again from 2016 to 2019. In 2020, the annual production volume was between 1 and 8.5 million lb, dropping to between 75,000 and 500,000 lb in 2021, before increasing to between 500,000 and 1 million lb in 2022 and 2023 (U.S. EPA, 2024a). Review of 2024 CDR data shows that total production volume for the years 2021 to 2023 is similar to the previously reported ranges for ethylene dibromide from the 2020 CDR. (EPA describes production volumes as a range to protect CBI.)

In this draft risk evaluation, EPA evaluated whether manufacturing, processing, distribution in commerce, use, or disposal of ethylene dibromide presents unreasonable risk of injury to human health or the environment under COUs subject to TSCA. Human or environmental exposure to ethylene dibromide 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 unreasonable risk determination. This is because these uses are excluded from TSCA's definition of a chemical substance under TSCA section 3(2)(B). Thus, conclusions in this draft evaluation cannot be extrapolated to form conclusions about uses of ethylene dibromide that are not subject to TSCA and that the Agency did not evaluate. In general, the risk estimates are based on exposure scenarios with monitoring data that reflect existing requirements, such as those established by EPA (*e.g.,* National Emission Standards for Hazardous Air Pollutants under the Clean Air Act), the Occupational Safety and Health Administration (OSHA) (*e.g.,* ethylene dibromide standard), or industry or sector best practices.

EPA's unreasonable risk determination for ethylene dibromide must be consistent with the best available science. The Agency, in determining whether ethylene dibromide *presents unreasonable risk to human health*, considers risk-related factors as described in its risk evaluation framework rule (40 CFR part 702). 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 subpopulations [PESS]); and EPA's confidence in the information used to inform the hazard and exposure values. These considerations are included as part of a pragmatic and holistic evaluation of hazard and exposure to ethylene dibromide. If an estimate of risk for a specific scenario exceeds standard risk benchmarks, the determination of whether those risks significantly contribute to the unreasonable risk of ethylene dibromide under TSCA is both case-by-case and context-driven. EPA considers all the aforementioned risk-related factors when making a determination of whether a COU significantly contributes to unreasonable risk of injury to human health.

Determining Unreasonable Risk to Human Health

EPA identified epidemiological, animal, and mechanistic studies that have been conducted to determine (1) whether exposure to ethylene dibromide would be expected to cause a range of non-cancer and cancer health effects, and (2) whether ethylene dibromide would be expected to be harmful to people if they are exposed at sufficient levels. Oral and inhalation studies provide a consistent pattern of toxicities. Although there is insufficient dermal evidence to directly calculate dermal absorption or dermal points of departure (PODs), the strong evidence of systemic toxicity provides confidence in conducting route-to-route extrapolation from inhalation and/or oral endpoints to calculate dermal PODs. The acute and intermediate inhalation non-cancer PODs are based on reproductive/developmental effects (*i.e.,* skeletal malformations and increased resorptions) observed in mice exposed to ethylene dibromide; acute and intermediate dermal non-cancer PODs were also estimated using this endpoint. The chronic inhalation non-cancer POD was based on liver effects (*i.e.,* centrilobular necrosis) observed in rats exposed to ethylene dibromide. The acute and intermediate oral non-cancer PODs were based on gastrointestinal effects (*i.e.,* hyperkeratosis of the epithelium of the stomach) observed in rats exposed to ethylene dibromide via gavage. This latter endpoint was inappropriate for dermal route-to-route extrapolation because it is not a systemic effect but rather a portal of entry effect. Similar to the chronic inhalation non-cancer POD, the chronic oral non-cancer POD was also based on liver effects (*i.e.,* focal necrosis and peliosis hepatis) observed in rats exposed to ethylene dibromide via gavage, with co-critical effects of adrenal cortex degenerative lesions and testicular atrophy. While both chronic oral and inhalation exposure resulted in histopathological changes of the liver and were used to estimate chronic dermal non-cancer PODs, the inhalation chronic non-cancer POD was ultimately used to characterize chronic dermal non-cancer risk.

EPA identified multi-site carcinogenic effects associated with chronic oral, inhalation, and dermal exposure to ethylene dibromide—primarily based on evidence from experimental animal studies. The inhalation cancer POD was based on carcinomas, adenocarcinomas, and adenomas of the nasal cavity in mice exposed to ethylene dibromide. The oral cancer POD was based on primary tumor incidence at many sites in male rats exposed to ethylene dibromide. Although both the oral and inhalation cancer PODs were considered for route-to-route extrapolation for deriving a dermal cancer POD, since ethylene dibromide exposure via inhalation and dermal both result in immediate systemic distribution and lack a first-pass effect, the inhalation cancer POD was selected as the basis for the characterization of dermal cancer risk. See Section 2 of the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t) for additional details on the characterization of human health hazard resulting from ethylene dibromide exposure.

To preliminarily determine whether ethylene dibromide presents an unreasonable risk to human health, EPA considered the following PESS in its assessment: infants exposed to drinking water during formula bottle feeding; subsistence and tribal fishers; people of reproductive age; individuals with pre-existing conditions, lifestyle factors, or other sources of variability; and fenceline communities. These subpopulations are PESS because some have greater exposure to ethylene dibromide per body weight (*e.g.,* infants, children, adolescents) whereas others may experience exposure from multiple sources, have higher exposures than others, or exhibit greater biological susceptibility than the general population. Although variability in susceptibility across the human population is likely, the Agency did not identify specific human groups expected to be more susceptible to non-cancer or cancer effects following ethylene dibromide exposure.

EPA evaluated risks to people exposed to ethylene dibromide at work, indoors, and outdoors using a combination of screening-level and more refined approaches. The Agency evaluated reasonably

available information for human health hazards resulting from ethylene dibromide exposure, including the following:

- non-cancer reproductive/developmental effects resulting from intermediate inhalation exposure;
- non-cancer gastrointestinal effects resulting from intermediate oral exposure;
- non-cancer liver effects resulting from chronic inhalation and oral exposure;
- non-cancer reproductive/developmental effects resulting from intermediate inhalation exposure as well as liver effects resulting from chronic inhalation exposure used for route-to-route extrapolation in characterizing dermal exposure; and
- cancer effects resulting from both oral and inhalation exposure, with effects associated with inhalation exposure used for route-to-route extrapolation in characterizing dermal exposure.

Acute exposures were also evaluated; however, due to the lack of suitable dose-response studies for acute exposure durations, the intermediate duration endpoints were applied to acute exposures, as described in the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t). EPA weighed the scientific evidence to determine confidence levels in underlying datasets and risk estimates for human health (Section 4.3). For workers and ONUs, the Agency has moderate confidence in the inhalation and dermal risk estimates (Section 4.3.7.1). For consumers, the Agency has moderate confidence in the inhalation and dermal risk estimates (Section 4.3.7.2). For the general population, the Agency has robust confidence in the inhalation, dermal, and oral risk estimates (Section 4.3.7.3).

Determining Unreasonable Risk to the Environment

In determining whether ethylene dibromide presents an unreasonable risk of injury to the environment, EPA considered the following groups of organisms in its assessment: aquatic vertebrates and invertebrates (Section 5.3.2) as well as terrestrial vertebrates (*i.e.,* mammals, birds) and invertebrates (Section 5.3.3).

The Agency weighed the scientific evidence to determine confidence levels in underlying datasets and risk estimates for the environment (Section 5.3.5). EPA has slight-to-moderate confidence that its aquatic risk estimates represent levels of exposure at which ecologically relevant effects will occur based on surface water release information for each COU. EPA has moderate-to-robust confidence that its terrestrial risk estimates represent levels of exposures at which ecologically relevant effects will occur based on air release information for each COU. Based on the pathways evaluated in this draft risk evaluation, the Agency has preliminarily determined that risk to the environment does not significantly contribute to the preliminary unreasonable risk determination for ethylene dibromide.

Summary and Conclusions

EPA evaluated 12 COUs for ethylene dibromide under TSCA and has preliminarily determined that 10 COUs significantly contribute to unreasonable risk of injury to human health driven by inhalation and/or dermal exposures for workers (Table ES-1). Of those 10 COUs, 4 also indicate inhalation risk to ONUs.

The Agency has preliminarily determined that ethylene dibromide presents an unreasonable risk of injury to human health due to non-cancer and cancer risk driven by exposure to workers and ONUs. Specifically, EPA has preliminarily determined that ethylene dibromide presents unreasonable risk of injury to human health in the following populations:

- non-cancer risk to workers from inhalation and/or dermal exposures;
- non-cancer risk to ONUs from inhalation exposures;
- cancer risk to workers from inhalation and/or dermal exposures; and
- cancer risk to ONUs from inhalation exposures.

EPA has preliminarily determined that two COUs do *not* significantly contribute to unreasonable risk of injury of ethylene dibromide to human health:

- Distribution in commerce; and
- Consumer use – Fuels and related products.

Furthermore, no ethylene dibromide COU significantly contributes to unreasonable risk to consumers or for the general population, including fenceline communities, or the environment.

Next Steps and Public Input

This draft risk evaluation, including EPA's preliminary determination that 10 of the 12 assessed COUs for ethylene dibromide contribute to unreasonable risk of injury to human health, as well as the accompanying technical support documents (TSDs) and supplemental files (see Appendix C), have been released for public comment. The two TSDs for ethylene dibromide, *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t) and *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d) will undergo independent, expert scientific peer review by the Science Advisory Committee on Chemicals (SACC).

Recommendations from the SACC as well as public comments on the draft risk evaluation package will inform the final risk evaluation of ethylene dibromide—including the Agency's determination of whether ethylene dibromide presents unreasonable risk of injury to human health or the environment under the COUs. If in the final risk evaluation, the Agency determines that ethylene dibromide presents unreasonable risk of injury to human health or the environment, EPA will initiate regulatory action under TSCA section 6(a) to the extent necessary so that ethylene dibromide no longer presents such risk.

Opportunities for the Public to Provide Information: The Agency seeks public comments on all aspects of this draft risk evaluation package. In particular, the Agency seeks comments and additional information on the following topics:

- Information to inform whether the data used (*e.g.,* worker activities, process descriptions, exposure monitoring data) for the Incorporation into Formulation, Mixture or Reaction Product occupational exposure scenario (OES) is representative and reliable for current exposure scenarios
- Facility-specific information on days of operation and/or release to more accurately characterize environmental releases
- Facility-specific information on days of operation and hours of operation per day for batch processes to accurately characterize occupational exposure
- Any exposure monitoring data gathered from facilities relevant to current COUs for ethylene dibromide
- Information to inform whether the data used for the Laboratory Use OES is representative and reliable for ongoing practices, including use-related information (*e.g.,* volume of ethylene dibromide), worker activity-specific details (*e.g.,* typical working hours/day and days/year, frequency and duration of ethylene dibromide use on a typical workday, personal protective equipment [PPE] use), and site-specific information (*e.g.,* location of the site, engineering controls, size of laboratory site); EPA also seeks further information on exposures in federal and non-federal laboratories
- Information from ethylene dibromide processing facilities on the current presence of laboratory sites within the same facilities
- Information on the introduction of any exposure reduction related technologies or engineering controls since the 1980s

- Information on PPE enforced by employers (*e.g.,* assigned protection factor [APF] of respirators, materials of gloves, duration of respirator or gloves used) and used by workers in various activities under each OES
- Average working hours per day and number of working days for a worker who refuels single engine small aircraft that utilize 100LL avgas containing ethylene dibromide as a fuel agent or additive
- Number of aircraft a worker (avgas refueler) refuels during a typical 8-hour workday
- Avgas use patterns (*e.g.,* frequency of refueling an aircraft per day, number of days flying an aircraft per year, average number of years that a consumer may fly and refuel their aircraft) for consumers (*i.e.,* pilots of small non-commercial airplanes)
- Racing fuel availability and use patterns (*e.g.,* number or types of vehicles using racing fuel containing ethylene dibromide, volume of use, frequency of refueling)
- Average duration of refueling an aircraft (*i.e.,* the duration of actively transferring avgas from nozzle into an aircraft fuel tank) and average volume of avgas refueled into an aircraft
- Worker activities, industrial and commercial practices for the disposal of ethylene dibromide, and any exposure monitoring data gathered at landfills or wastewater treatment plants
- EPA's draft occupational exposure value (OEV) and short-term exposure value (STEV) (see Appendix E)
- Number of operating days per year and shift lengths at bulk terminals under the Fuels and Related Products OES
- Information regarding engineering controls, administrative controls, and/or PPE use by workers engaged in refueling activities that reduce inhalation and dermal exposure to ethylene dibromide
- The representativeness of high-end exposure estimates for intermediate inhalation and dermal occupational exposures (*e.g.,* current practices involving the processing of ethylene dibromide at neat concentrations).

Table ES-1. Conditions of Use of Ethylene Dibromide Including Those That Significantly Contribute to a Preliminary Determination of Unreasonable Risk to Human Health

Condition of Use	Workers				ONUs	
	Non-Cancer		Cancer		Non-Cancer	Cancer
	Inhalation	Dermal	Inhalation	Dermal	Inhalation	
Manufacture – Import	×		×	×	×	×
Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in all other petroleum and coal products manufacturing			×	×		
Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in petroleum refineries			×	×		
Processing – As a reactant – *E.g.,* in Pigment and dye manufacturing; Plastic material and resin manufacturing		×	×	×		
Processing – Repackaging	×	×	×	×	×	×
Distribution in commerce						
Industrial use – Other use – Processing aid not otherwise specified; Pigment and dye manufacturing		×	×	×		
Industrial use – Fuel agents in petroleum refineries			×			×
Commercial use – Fuels and related products			×			
Commercial use – Other use – Laboratory chemical			×	×		×
Disposal	×			×		
Consumer use – Fuels and related products						

COU = condition of use; ONU = occupational non-user
Shaded cells with × are COUs that contribute to a preliminary determination of unreasonable risk of injury based on non-cancer and/or cancer risk for workers or ONUs resulting from acute, intermediate, or chronic exposure to ethylene dibromide.

1 INTRODUCTION

EPA has evaluated ethylene dibromide (CASRN 106-93-4) under Toxic Substances Control Act (TSCA) section 6(b). Although ethylene dibromide may be released during industrial activities, manufacturing (including import activities), processing, and disposal, most environmental releases occur into air. The main use of ethylene dibromide is in fuels and related products (*i.e.,* lead [Pb] scavenger) in commercial and consumer leaded aviation fuel ("avgas") to prevent engine fouling (U.S. EPA, 2026d).

Figure 1-1 provides an overview of the major inputs, phases/components, and outputs of the TSCA risk evaluation process, from chemical prioritization to scoping to releasing the finalized risk evaluation.

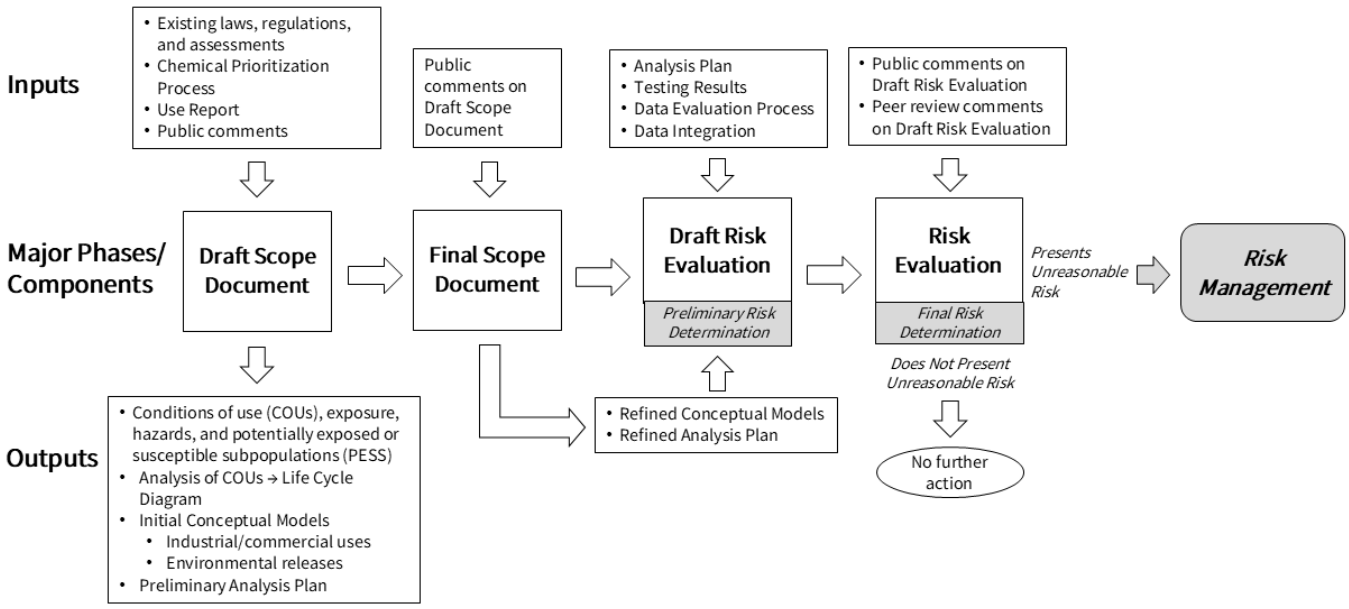


Figure 1-1. Overview of TSCA Existing Chemical Risk Evaluation Process

1.1 Scope of the Risk Evaluation

EPA evaluated risk to human and environmental populations for ethylene dibromide. This draft risk evaluation for ethylene dibromide comprises a package of technical support documents (TSDs) and supplemental files. A basic diagram showing the layout and relationship of these assessments is provided below in Figure 1-2. See Appendix C for the list of all TSDs and supplemental files comprising this draft risk evaluation for ethylene dibromide.

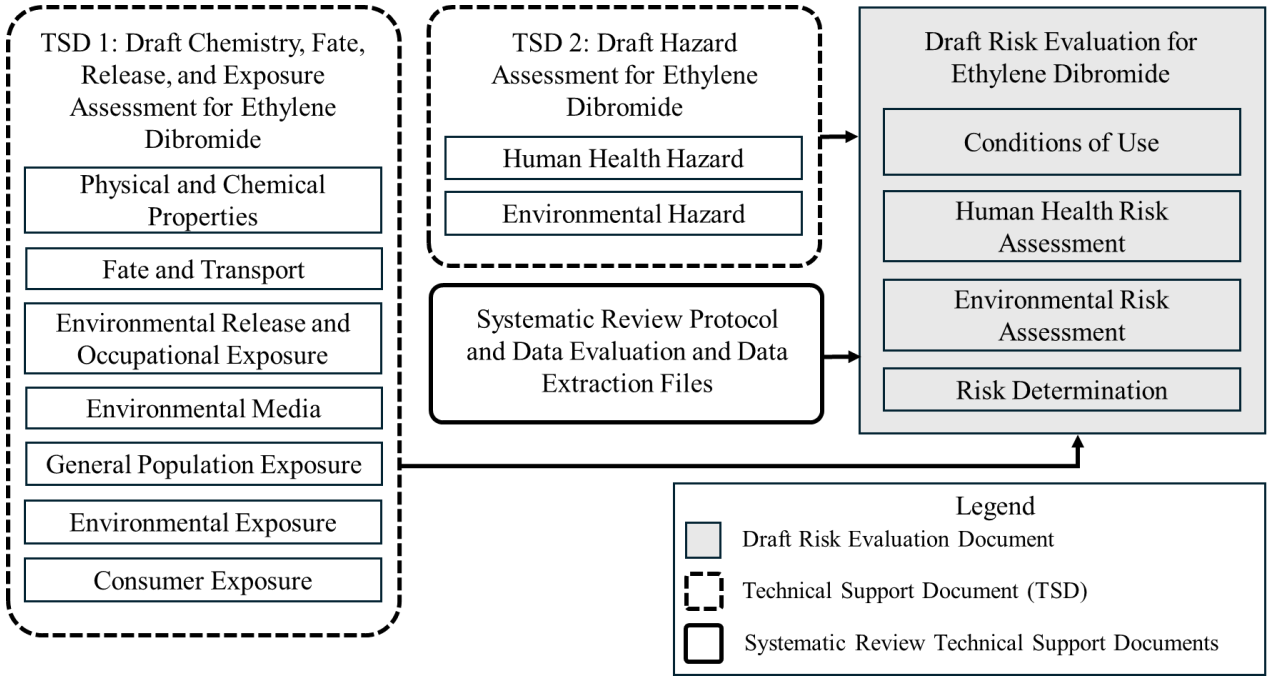


Figure 1-2. Draft Risk Evaluation Document Summary Map
Both TSDs are outlined in dashed lines; the draft risk evaluation and systematic review protocol (see also Section 1.3) and related files are outlined in solid lines.

1.1.1 Life Cycle and Production Volume

The life cycle diagram (LCD) shown in Figure 1-3 depicts the COUs assessed in this draft risk evaluation during various life cycle stages, including import, processing, distribution use (industrial, commercial, consumer), and disposal. The LCD has been updated since its original inclusion in the *Final Scope of the Risk Evaluation for Ethylene Dibromide; CASRN: 106-93-4* (also called the "final scope [document]"(U.S. EPA, 2020b). A complete list of updates and explanations made to COUs for ethylene dibromide from the final scope document to this draft risk evaluation is provided in Appendix D. The information in the LCD is grouped according to Chemical Data Reporting (CDR) processing codes and use categories (including functional use codes for industrial uses and product categories for consumer and commercial uses). The CDR rule under TSCA section 8(a) (see 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. The Agency collects CDR data approximately every 4 years with the latest collections occurring in 2006, 2012, 2016, 2020, and 2024.

EPA included descriptions of the industrial, commercial, and consumer use categories identified from the 2024 CDR in the LCD (Figure 1-3) (U.S. EPA, 2024a). The descriptions provide a brief overview of the use category. The *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d) contains more detailed descriptions (*e.g.,* process descriptions, worker activities, process flow diagrams, equipment illustrations) for each import, processing, use, and disposal category.

The production volumes for ethylene dibromide reported to CDR for years 2012 to 2023 were all from two companies, Innospec Inc. and NewMarket Corporation. The only non-CBI (confidential business information) reported activity within these years was from imports. From 2012 to 2013, the production volume reported to CDR was less than 1 million pounds (lb). In 2014 and 2015, the production volume was between 1 million and 20 million lb. From 2016 to 2019, the production volume was less than 1 million lb. In 2020, the production volume was between 1 and 8.5 million lb. In 2021, the production

volume was between 75,000 and 500,000 lb, and from 2022 to 2023, the production volume was between 500,000 and 1 million lb. Production volume is described herein as a range to protect production information claimed as confidential CBI.

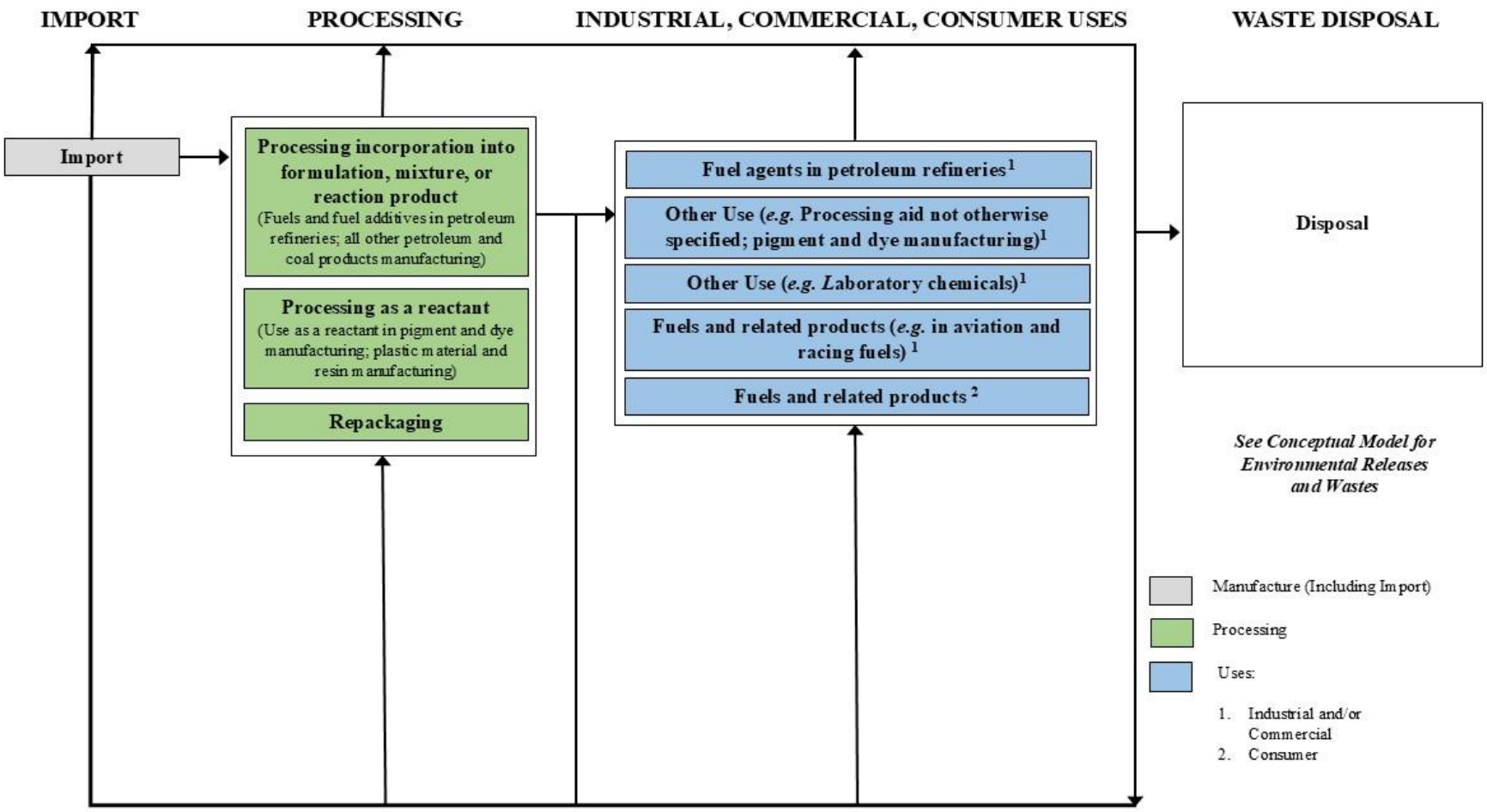


Figure 1-3. Ethylene Dibromide Life Cycle Diagram

See Table 1-1 for categories and subcategories of conditions of use.

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 EPA planned to consider in the risk evaluation. The COUs included in this draft risk evaluation are reflected in the LCD (Figure 1-2) and conceptual models (Section 1.2.1). These COUs are evaluated for acute, intermediate, chronic, and lifetime exposures, as applicable, based on reasonably available exposure and hazard data as well as the relevant study populations for each. Table 1-1 below presents all COUs under TSCA for ethylene dibromide.

Table 1-1. Categories and Subcategories of Conditions of Use in the Draft Risk Evaluation for Ethylene Dibromide

Conditions of Use			Source(s)
Life Cycle Stage[a]	**Category[b]**	**Subcategory[c]**	
Manufacture	Import	N/A	U.S. EPA (2024a, 2020a, 2016a)
Processing	Incorporation into formulation, mixture, or reaction product	Fuels and fuel additives in all other petroleum and coal products manufacturing	U.S. EPA (2024a, 2020a, 2016a)
		Fuels and fuel additives in petroleum refineries	U.S. EPA (2024a, 2016a)
	As a reactant	*E.g.,* in Pigment and dye manufacturing; Plastic material and resin manufacturing	He et al. (2013); Hansch et al. (2011)
	Repackaging	N/A	
Distribution in commerce	N/A	N/A	
Industrial use	Fuel agent in petroleum refineries	N/A	U.S. EPA (2024a, 2020a)
	Other use	Processing aid not otherwise specified; Pigment and dye manufacturing	EPA-HQ-OPPT-2018-0488-0060; Moran (1962)
Commercial use	Fuels and related products	N/A	U.S. EPA (2024a, 2020a, 2016a)
	Other uses	Laboratory chemical	Sigma-Aldrich (2024); EPA-HQ-OPPT-2018-0488-0038
Consumer use	Fuels and related products	N/A	U.S. EPA (2024a, 2016a)
Disposal	N/A	N/A	

[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 conditions of use (COUs) appear in the preliminary life cycle diagram, reflect Chemical Data Reporting (CDR) codes, and broadly represent ethylene dibromide COUs in industrial and/or commercial settings.

Conditions of Use			Source(s)
Life Cycle Stage[a]	**Category[b]**	**Subcategory[c]**	
- "N/A" means not applicable where the category name, subcategory name, or both are duplicative and therefore unnecessary for identifying the COU. [c] These subcategories represent more specific activities within the life cycle stage and category of the potential COUs of ethylene dibromide.			

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 ethylene dibromide. There is potential for exposure to workers via inhalation and dermal contact and/or to ONUs via inhalation. Inhalation exposure to ethylene dibromide vapor and dermal exposure to ethylene dibromide in liquid form are expected. EPA evaluated activities resulting in exposures associated with distribution in commerce (*e.g.,* loading, unloading) throughout the various life cycle stages and COUs (*e.g.,* Import, Processing, Repackaging, Industrial use, Commercial use, Disposal)—rather than a single distribution scenario.

Figure 1-4 presents the conceptual model for industrial and commercial activities and uses. 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.

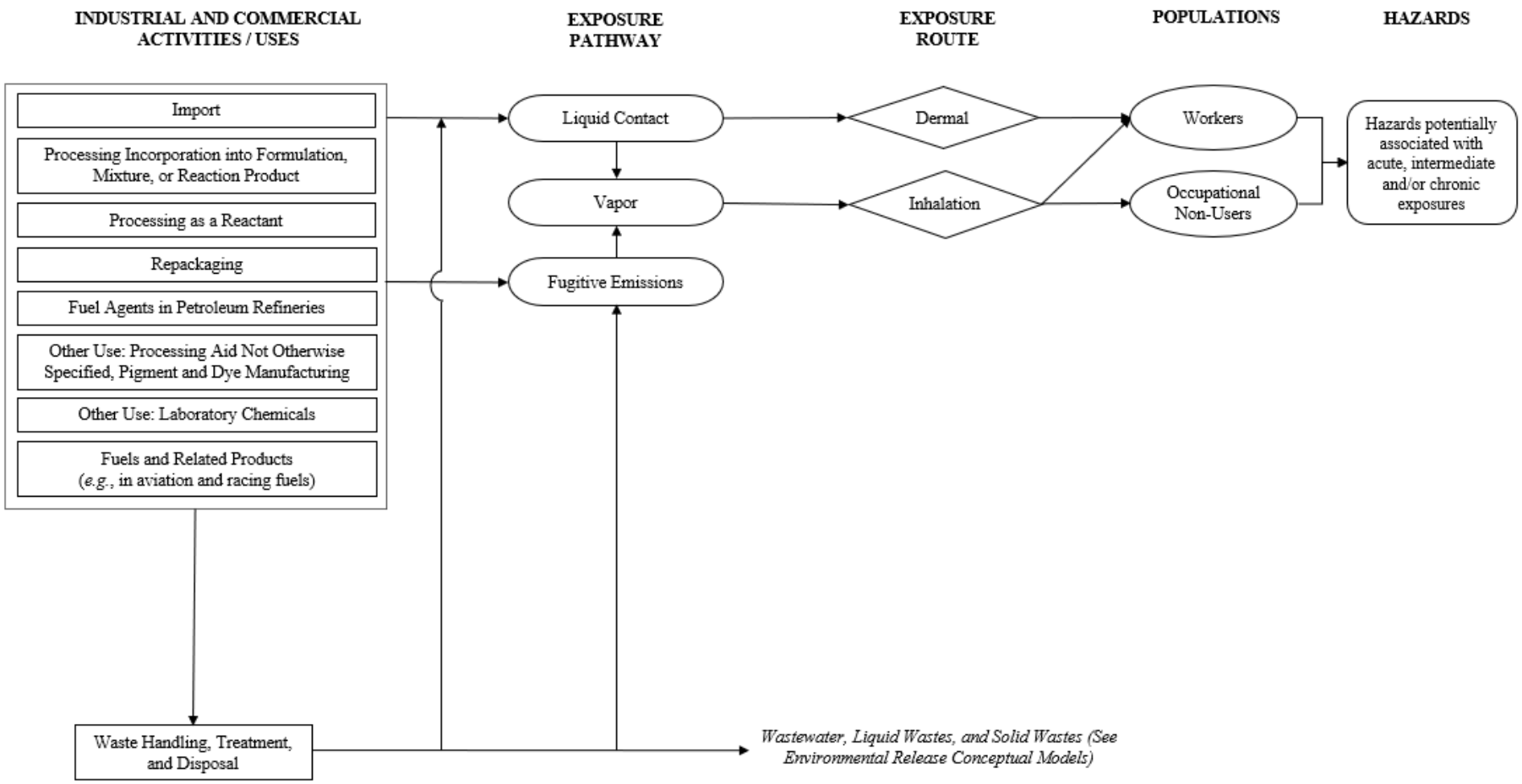
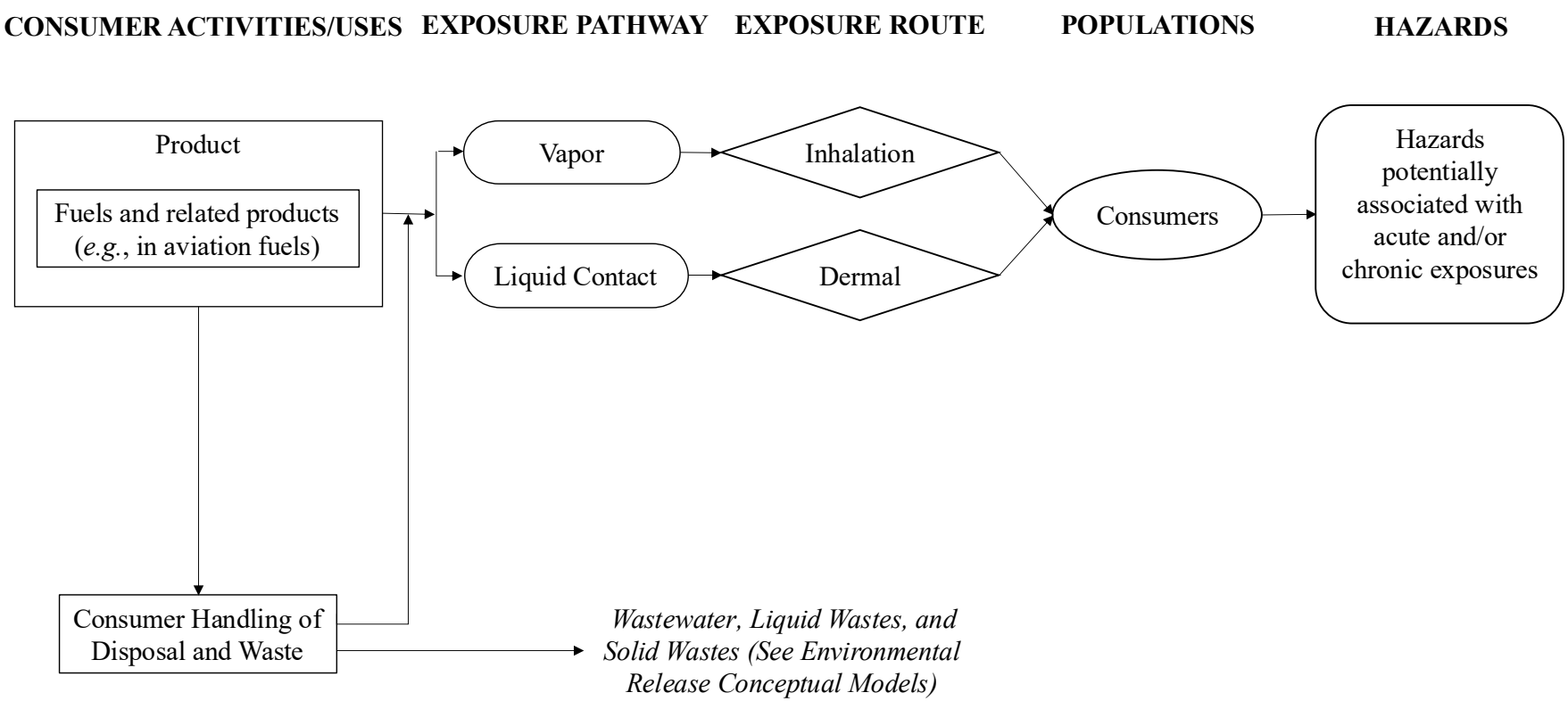


Figure 1-4. Ethylene Dibromide Conceptual Model for Industrial and Commercial Activities and Uses: Potential Exposures and Hazards

The conceptual model presents the exposure pathways, exposure routes, populations exposed, and hazards/effects associated with industrial and commercial activities and uses of ethylene dibromide, including liquid contact, vapor p

[a] Some products are used in both commercial and consumer applications (*i.e.,* fuels and related products). See Table 1-1 for categories and subcategories of conditions of use (COUs).

[b] Fugitive air emissions are those that are not stack emissions and include fugitive equipment leaks from valves, pump seals, flanges, compressors, sampling connections and open-ended lines; evaporative losses from surface impoundment and spills; and releases from building ventilation systems.



744

745 **Figure 1-5. Ethylene Dibromide Conceptual Model for Consumer Activities and Uses: Potential Exposures and Hazards**
746 The conceptual model presents the exposure pathways, exposure routes, populations exposed, and hazards/effects associated with consumer activities and
747 uses of ethylene dibromide—including vapor and liquid contact pathways, inhalation and dermal routes, and exposures among consumer populations

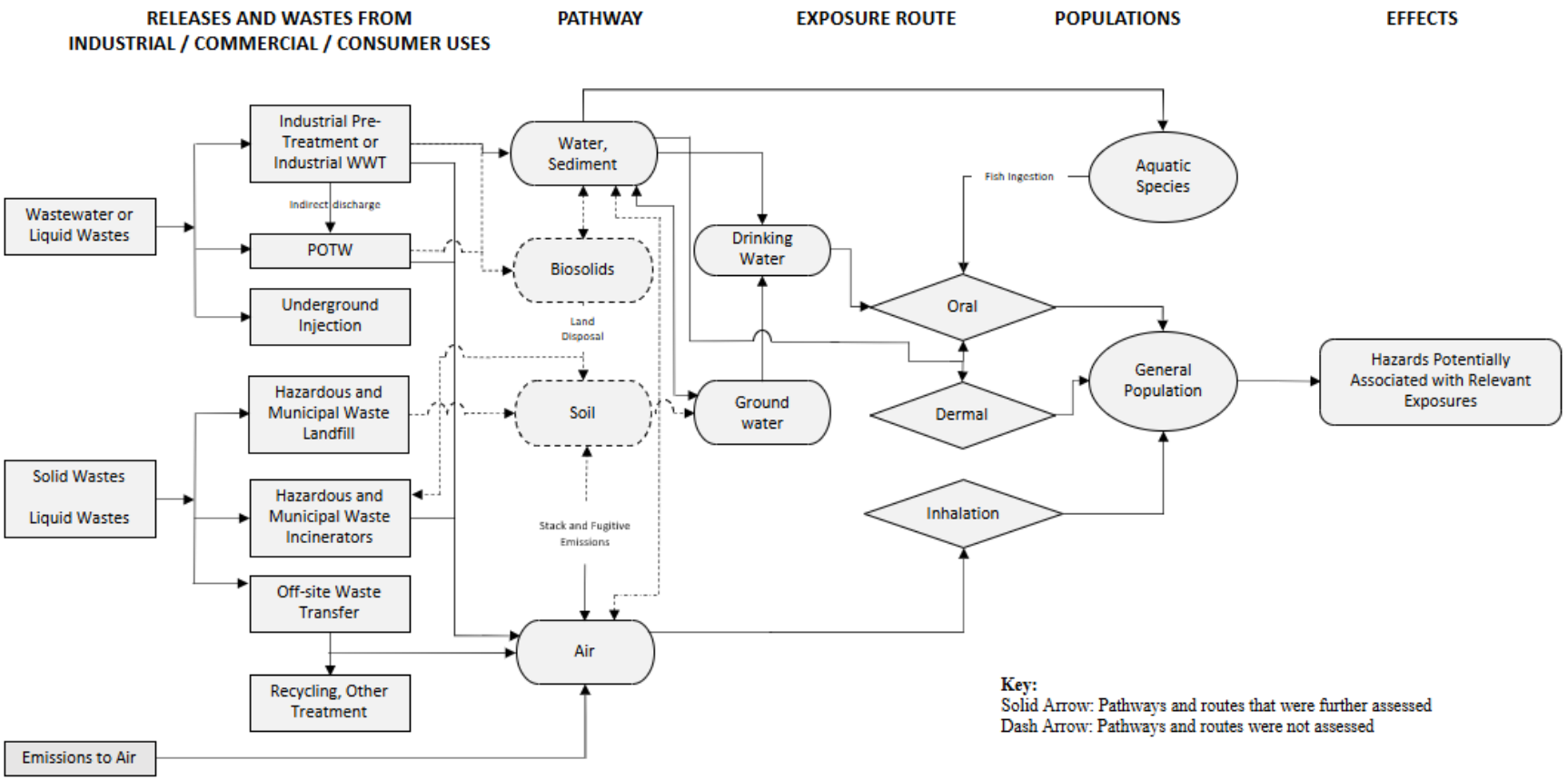


Figure 1-6. Ethylene Dibromide Conceptual Model for Environmental Releases and Wastes: General Population Hazards

The conceptual model presents the exposure pathways, exposure routes, populations exposed, and hazards/effects associated with releases and wastes from industrial, commercial, and consumer uses of ethylene dibromide—including pathways through water, sediment, biosolids, soil, and air, and corresponding oral, dermal, and inhalation exposure routes affecting the general population.

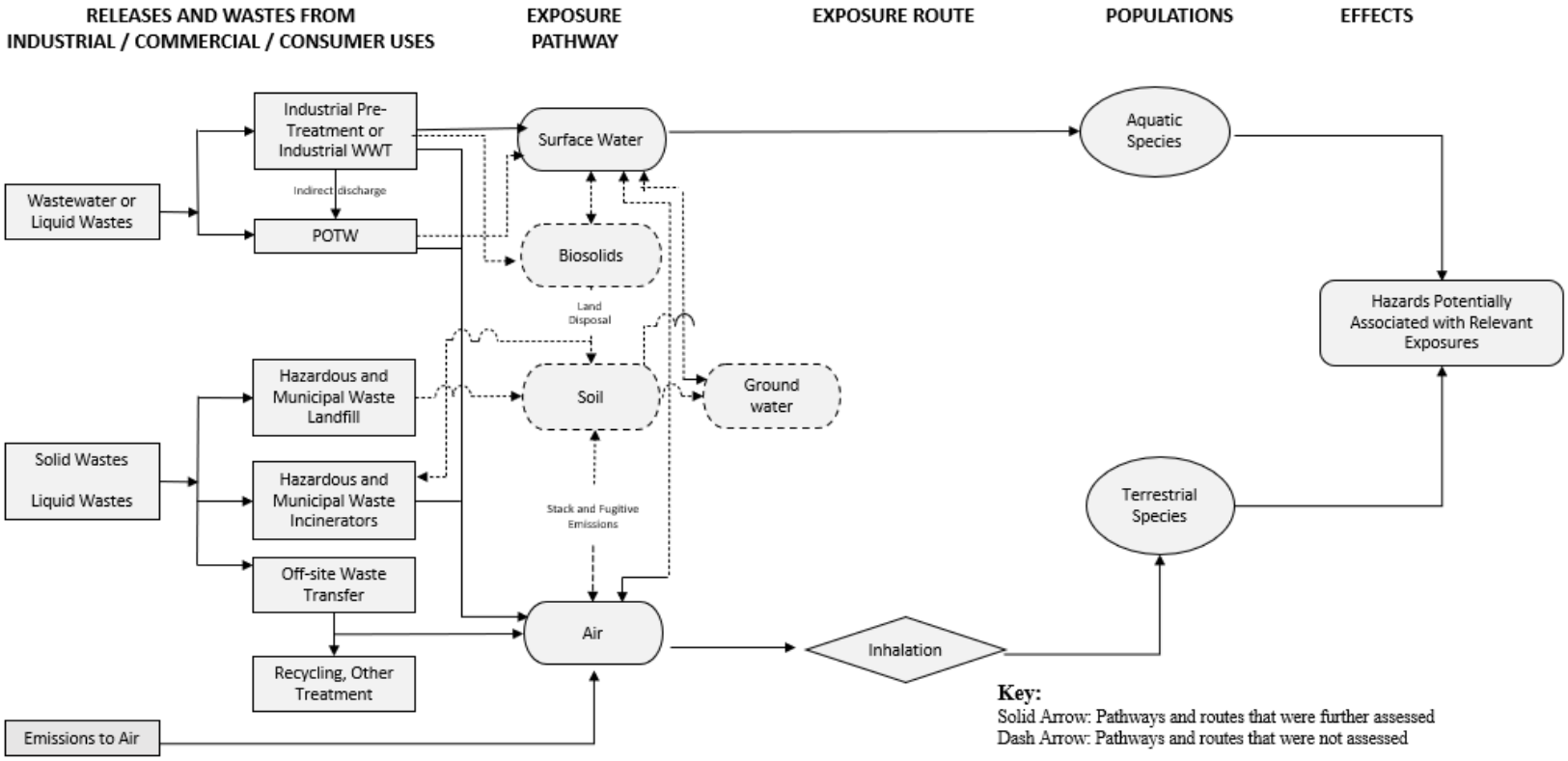


Figure 1-7. Ethylene Dibromide Conceptual Model for Environmental Releases and Wastes: Ecological Exposures and Hazards

The conceptual model presents the exposure pathways, exposure routes, populations exposed, and hazards/effects associated with environmental releases and wastes affecting ecological receptors—including pathways through surface water, biosolids, soil, and air, and corresponding inhalation exposure route affecting the aquatic species and terrestrial species.

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 acute, intermediate, chronic, and lifetime exposure scenarios, as applicable based on reasonably available exposure and hazard data as well as the relevant populations for each.

Human populations assessed include the following:

- Workers, including average adults;
- ONUs, including average adults;
- Consumers, including teenagers (16–20 years) and adults (21+ years); and
- General population, including fenceline communities and infants, children, youth, and adults.

In this draft risk evaluation, all human health hazard and exposure values were placed into one of four duration categories corresponding to human exposure scenarios for risk estimation and, where appropriate, EPA has provided rationale for when human health effects are categorized as being relevant for both acute and intermediate exposure durations:

- Acute (single dose or exposure to an air concentration for <24 hours);
- Intermediate (repeated dosing ranging from a few days to <10% of the lifetime of the test organisms, typically from short-term or subchronic hazard studies and applied as average 22 days exposure over 30 days for occupational scenarios);
- Chronic non-cancer (repeated dosing covering >10% of the lifetime of the test organisms) and exposure over 31 to 40 working years for occupational scenarios; and
- Chronic/lifetime cancer (repeated dosing averaged over the relevant chronic period up to a full lifetime of the test organisms).

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 5), including in the exposure assessment, hazard identification, and dose-response analysis supporting this assessment. EPA incorporated the following PESS into its assessment: people who frequently use consumer products containing ethylene dibromide; people exposed to ethylene dibromide in the workplace; and people who may be in proximity to releasing facilities, including fenceline communities, and people whose diets include large amounts of fish (*i.e.,* subsistence fisher and tribal populations). These subpopulations are PESS because some have greater exposure to ethylene dibromide per body weight (*e.g.,* infants, children, adolescents).

Section 4.3.6 describes details on how PESS considerations were incorporated into risk estimates, when possible, along with any underlying uncertainties.

1.3 Systematic Review

EPA applied systematic review principles in the development of this risk evaluation. TSCA section 26(h) requires the Agency to use scientific information, technical procedures, measures, methods, protocols, methodologies, and models consistent with the best available science and base decisions under TSCA section 6, based on the weight of scientific evidence.

Within the TSCA risk evaluation context, the weight of scientific evidence is defined as "a systematic review method, applied in a manner suited to the nature of the evidence or decision, that uses a pre-established protocol to comprehensively, objectively, transparently, and consistently identify and evaluate each stream of evidence, including strengths, limitations, and relevance of each study and to integrate evidence as necessary and appropriate based upon strengths, limitations, and relevance" (40 CFR 702.33).

The systematic review process steps are described below in Figure 1-8. Details regarding these steps are available in the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances Version 1.0: A Generic TSCA Systematic Review Protocol with Chemical-Specific Methodologies* (also called the "[2021] Draft Systematic Review Protocol") (U.S. EPA, 2021a) and in the *Draft Systematic Review Protocol for Ethylene Dibromide* (U.S. EPA, 2026ag). The latter provides additional information on the steps in the systematic review process, including literature inventory trees and evidence maps for each discipline (*e.g.,* human health hazard) containing results of the literature search and screening as well as sections summarizing data evaluation, extraction, and evidence integration. EPA systematically reviewed data sources identified in both the original and updated literature searches conducted in 2018 and 2025, respectively. All data sources identified in both literature searches underwent screening, data evaluation, data extraction, and evidence integration for different disciplines as described in the 2021 Draft Systematic Review Protocol (U.S. EPA, 2021a) and in the *Draft Systematic Review Protocol for Ethylene Dibromide* (U.S. EPA, 2026ag).

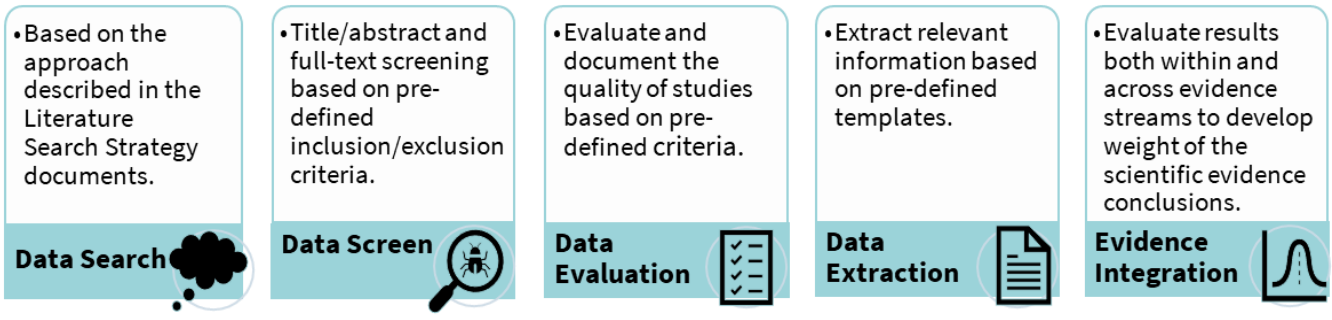


Figure 1-8. Diagram of the Systematic Review Process

EPA has considered findings from previous assessments and briefly outlined designations below. Additional details can also be found in Table 2-1 within the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t), which summarizes assessment PODs and the basis for non-cancer and cancer hazard conclusions as compared to previous assessment findings.

2 CHEMISTRY AND FATE AND TRANSPORT OF ETHYLENE DIBROMIDE

EPA considered all reasonably available information identified by the Agency through its systematic review process under TSCA (U.S. EPA, 2026ag). Physical and chemical properties determine the behavior and characteristics of a chemical that inform its conditions of use, fate and transport in the environment, potential toxicity, exposure pathways, routes, and hazards. Environmental fate and transport includes 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 and transport of ethylene dibromide allows EPA to identify the specific exposure pathways as well as the potential human and environmental exposed populations considered in this draft risk evaluation.

Due to its two bromine atoms, ethylene dibromide is much heavier than air and water. However, ethylene dibromide will partition to and persist in air based on its measured water solubility of 4,130 mg/L at 20 °C (Rumble, 2018a) and vapor pressure of 11.2 mm Hg at 25 °C (NLM, 2025). This volatile organic chemical (VOC) is expected to be insusceptible to direct photodegradation, which contributes to its persistence in air (Uthman et al., 1978).

Biodegradation occurs at a moderate rate in both aerobic and anaerobic environments, but this may be reduced at higher concentrations. Biodegradation occurs rapidly in soil. In aquatic and subsurface systems, biodegradation rates may be reduced at higher concentrations as microbial communities are increasingly affected by inhibition due to ethylene dibromide itself. Ethylene dibromide hydrolyzes very slowly in pure water. It is expected to be removed during wastewater treatment processes, mainly through volatilization. However, annual Toxic Release Inventory (TRI) releases are reported to the Agency as direct discharges, which is the amount of ethylene dibromide expected to enter receiving waters after any on-site treatment. Considering the very high solubility of ethylene dibromide, if discharges exceed the volatilization and degradation processes in the local environment, ethylene dibromide may persist in surface water. As described in Section 3.3.1, ethylene dibromide has been detected in surface water monitoring samples collected by water resource management groups across the country (0.06–0.29 µg/L), suggesting that despite the anticipated eventual volatilization of ethylene dibromide from surface water releases, ethylene dibromide has still been detected in water. Although ethylene dibromide may be present in water, it does not bioaccumulate or bioconcentrate, due to its high mobility and excretion within plants and animals. Sections 2.1 and 2.2 summarize the physical and chemical properties and environmental fate and transport of ethylene dibromide, respectively. For detailed information, see Sections 3 and 4 of the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

2.1 Summary of Physical and Chemical Properties

Ethylene dibromide is a colorless heavy liquid substance observed to have a mildly sweet, chloroform like odor (U.S. EPA, 2004b). It has a chemical formula of $C_2H_4Br_2$ and a molecular weight of 187.861 g/mole (Rumble, 2018a). EPA gathered and evaluated physical and chemical property data and information according to the process described in the *Draft Systematic Review Protocol for Ethylene Dibromide* (U.S. EPA, 2026ag). The Agency considered both measured and estimated physical and chemical property data/information as described in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). The selected values are summarized in Table 2-1, as applicable. Information on the full extracted dataset is available in the *Data Quality Evaluation and Data Extraction Information for Physical and Chemical Properties* (U.S. EPA, 2026i).

Table 2-1. Physical and Chemical Properties of Ethylene Dibromide

Property	Selected Value(s) [a]	Reference(s) [c]	Overall Quality Determination
Molecular formula	$C_2H_4Br_2$	Rumble (2018a)	High
Molecular weight	187.861 g/mole	Rumble (2018a)	High
Physical form	Colorless, heavy liquid that has a mildly sweet, chloroform-like odor	U.S. EPA (2004b)	High
Melting point	9.8 °C	Rumble (2018a)	High
Boiling point	131.3 °C	Rumble (2018a)	High
Density	2.172 g/cm^3 at 25 °C	O'Neil (2013)	High
Vapor pressure	11.2 mm Hg at 25 °C	NLM (2025)	High
Vapor density	6.48 (relative to air = 1)	NLM (2025)	High
Water solubility	4,130 mg/L at 20 °C	Rumble (2018b)	High
Octanol:water partition coefficient (log K_{OW})	1.96	U.S. EPA (2019a)	High
Octanol:air partition coefficient (log K_{OA})	3.54 [b] EPI Suite™ (KOAWIN)	U.S. EPA (2012d)	N/A
Henry's Law constant	6.50 E−4 atm·m^3/mol at 25 °C	U.S. EPA (2019a)	High
Viscosity	1.727 cP at 20 °C	NLM (2025)	High
UV-Vis Absorption	Chemical does not absorb wavelengths > 270 nm	Uthman et al. (1978)	High

[a] Measured unless otherwise noted
[b] Information was estimated using EPI Suite™ (U.S. EPA, 2012d)
[c] Full background and detail of methods used to derive these values is presented in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d)

2.2 Summary of Environmental Fate and Transport

EPA incorporated multiple lines of evidence including empirical measurements, modeling predictions, and a mechanistic understanding to characterize partitioning, transformation, and persistence across environmental compartments. The integration process followed a hierarchical framework that prioritized high-quality measured data while using predictive models including mechanistic modeling to fill data gaps and provide supporting evidence. Key fate parameters were selected by evaluating the full range of reliable data sources, with conservative values chosen where uncertainty existed to ensure protective risk characterization. Reasonably available environmental fate data, including biotic and abiotic biodegradation rates, removal during wastewater treatment, volatilization from lakes and rivers, and organic carbon:water partition coefficient (log K_{OC}) are the parameters used in this draft risk evaluation.

The assessment integrated information across temporal scales, spatial scales (laboratory microcosms to field studies), and environmental conditions (aerobic/anaerobic, varying temperatures and concentrations) to develop a comprehensive understanding of ethylene dibromide environmental fate. In assessing the environmental fate and transport of ethylene dibromide, EPA considered the full range of results from data sources that were rated high confidence. Information on the full extracted dataset is available in the supplemental file, *Draft Data Quality Evaluation and Data Extraction Information for Environmental Fate and Transport for Ethylene Dibromide* (U.S. EPA, 2026g). Table 2-2 provides selected environmental fate data EPA considered while assessing the fate of ethylene dibromide. Fate estimates were based on modeling results from Estimations Programs Interface Suite™ (EPI Suite™),

(U.S. EPA, 2025b), and the OECD POV and LRTP Screening Tool (Version 2.2) (Wegmann et al., 2009).

EPA found that dominant breakdown pathways include indirect photodegradation, hydrolysis, and biodegredation. Table 2-3 provides a summary of weight of scientific evidence fate properties with robust confidence. Figure 2-1 illustrates degradation rates and partitioning of discharges into the environment.

Given the consistent results from numerous high-quality studies discussed in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d) there is moderate or robust evidence of the following:

- Environmental Distribution
  - Ethylene dibromide is a volatile liquid that is soluble in water. Under the COUs, environmental releases are expected to partition primarily to air with lesser amounts to water, sediment, and land.
- Fate and Transport in Air
  - Ethylene dibromide is not expected to undergo significant direct photolysis but will undergo indirect photodegradation by reacting slowly with hydroxyl radicals (·OH) in the atmosphere and has a half-life of approximately 65 days.
  - Ethylene dibromide is expected to preferentially stay in air and, therefore, is not expected to undergo wet or dry deposition.
- Fate and Transport in Soil
  - Ethylene dibromide generally has a low sorption to soil and sediment, so it will moderately migrate to groundwater.
  - Ethylene dibromide degrades very rapidly in soil and is not expected to undergo dry or wet deposition.
- Fate and Transport in Surface Water and Sediment
  - Ethylene dibromide is expected to hydrolyze very slowly in water.
  - Ethylene dibromide is expected to undergo moderate biodegradation in surface water across a range of days. In sediments, under aerobic and anaerobic conditions, the biodegradation range is weeks to months.
  - Ethylene dibromide can inhibit its own biodegradation pathways. In these situations, where concentrations exceed 7 to 10 mg/L, abiotic degradation rates predominate.
  - Abiotic degradation rates in subsurface sediments can take weeks to years.
  - Ethylene dibromide is expected to be removed during wastewater treatment processes, mainly through volatilization. While the concentrations of ethylene dibromide are likely to be low in biosolids due to volatilization during the treatment process; however, there is uncertainty regarding the concentrations in biosolids that could be land applied because of a lack of monitoring data. In these cases, half-lives would be in days due to biodegredation within the biosolids and volatilization from their surfaces.
- Fate and Transport in Groundwater
  - Under certain subsurface conditions, ethylene dibromide may biodegrade in weeks. These conditions include groundwater under aerobic, methanogenic, and reducing conditions and with previous exposure to ethylene dibromide, appropriate microbes, and/or in the presence of nutrients and supplemental substrates such as acetate, lactate or methane.
  - In conditions without prior exposure and co-metabolites, degradation in groundwater may take years.
- Persistence and Bioaccumulation

- Ethylene dibromide is not bioaccumulative in aquatic and terrestrial organisms.

Table 2-2. Summary of Fate and Transport Properties for Ethylene Dibromide

Property	Value(s) [a]	Source(s) [c]	Overall Quality Determination
Direct photodegradation	Does not occur	N/A	N/A
Indirect photodegradation	Half-life (t½) = 65 d, K_{OH} = 2.4E−14, 2.5E−15 m^3/mol-s (assuming 12-hour day, 1.5E−15 ·OH/cm^3)	Arnts et al. (1989); Howard and Evenson (1976)	High
Hydrolysis	t ½ = 2.5 yr at 15 ºC. Varies with temperature, insensitive to pH; range: t½ = 0.89, 0.36, 2.2, and 5.86 years at 22, 30, 15, and 8 ºC;	Vogel and Reinhard (1986); Weintraub et al. (1986)	High
Octanol:water partition coefficient (log Kow)	Log K_{OW} = 1.96	Poole and Poole (1999)	High
Organic carbon:water partition coefficient (log Koc)	Log K_{OC} = 2.01; log K_{OC} = 1.68 to 1.82; 2.01 to 2.13, 1.66 to 1.75	RIVM (2007); Walton et al. (1992); Steinberg et al. (1987)	High
	Log K_{OM} = 1.11	Sharer (1998)	High
	Log K_{OC} = 1.60 (MCI Method) [b]	U.S. EPA (2012d)	High
	Log K_{OC} = 1.70 (Kow Method) [b]	U.S. EPA (2012d)	High
Volatilization from surface water	t ½ = 2.6 hour (estimated, HLC = 6.5E−04) [b]	U.S. EPA (2012d)	High
Bioaccumulation factor (BAF)	3.2 to 14.9 L/kg in fish (*Cyprinus carpio*)	NITE and CHRIP (1977)	High
	2.7, 6, 9, and 20 L/kg for *Aphelenchus avenae*, *Pelodera*, *Tylenchulus semipenetrans*, and *Anguina tritici*, respectively (nematodes)	Marks et al. (1968)	High
	No bioaccumulation, *Raphanus sativus L.* cv. Champion (radish)	Isaacson and Frink (1985), Frink and Bugbee (1989)	High
Biomagnification factor, includes biotransformation (BMF)	Upper trophic level = 8.269 [b] Middle trophic level = 6.326 [b] Lower trophic level = 5.813 [b]	U.S. EPA (2012d)	High
Ready biodegradation	t ½ = 95 day (Water: 5% after 7 days, remains 5% after 28 days weeks based on BOD (Closed Bottle Test); ethylene dibromide conc. 15 mg/L degradation effected by microbial inhibition)	LAB Research (2010d)	High
Aerobic biodegradation in water	t ½ = up to 0.33 year (upper bound)	McKeever et al. (2012)	High

BOD = biological oxygen demand; HLC = Henry's Law constant
[a] Measured unless otherwise noted

Property	Value(s) [a]	Source(s) [c]	Overall Quality Determination

[b] Information was estimated using EPI Suite™ (U.S. EPA, 2012d)
[c] Full background and detail of methods used to derive values are presented in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d)

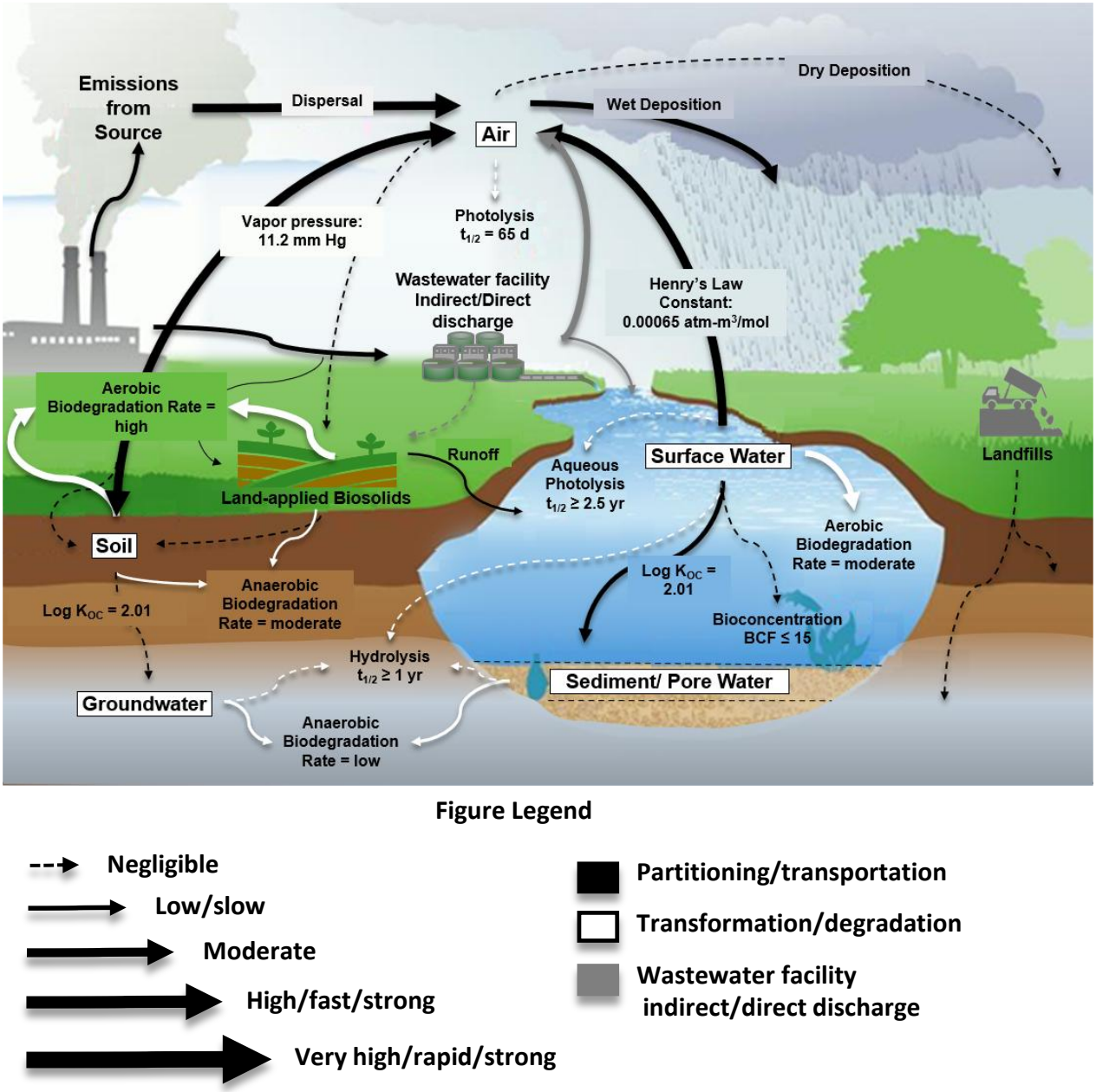


Figure 2-1. Transport, Partitioning, and Degradation of Ethylene Dibromide in the Environment
Depicts the distribution (grey arrows), transport, and partitioning (black arrows) as well as the transformation and degradation (white arrows) of ethylene dibromide in the environment. The width of the arrow is a qualitative indication of the likelihood the indicated partitioning will occur or the rate at which the indicated degradation will occur (*i.e.,* wider arrows indicate faster pathway).

2.2.1 Weight of Scientific Evidence Conclusions for Fate and Transport

This assessment employs a confidence framework using four descriptive categories: robust, moderate, slight, or indeterminate. The methodology aligns with established protocols outlined in the Draft Systematic Review Protocol (U.S. EPA, 2021a). A broad description of the scientific evidence, its weight, significance and the conclusions for fate and transport of ethylene dibromide can be found in the *Draft Chemistry, Fate, Release and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

Table 2-3. Weight of Scientific Evidence Confidence Framework Table

Degradation Pathways of Ethylene Dibromide Conclusions		
Parameter	**Endpoint Value**	**Confidence and Comments/Rationale**
Biodegradation		
Aerobic, ultimate	Fast	Robust: Multiples Lines across aquatic and terrestrial, w/o inhibition
Anaerobic, ultimate	Slow	Robust: Multiples Lines across aquatic and terrestrial, w/o inhibition
Volatilization	6.5E−04 atm·m^3/mol	Robust: Mature science, multiple lines
Photolysis	t ½ = 65 d, K_{OH} = 2.4 ± 0.5E−13, 2.5 ± 0.5E−13 m^3/mol-s (assuming 12-hour day, 1.5E−6 ·OH/cm^3)	Robust: Mature science, multiple lines
Hydrolysis	t ½ = 2.5 year 15 ºC; varies with temperature	Robust: Mature science, multiple lines
Publicly owned treatment works (POTW) removal		
Removal	0.5% to sludge	Robust: High HLC
Sorption to sludge	Log K_{OC} = 2.01	Robust: 2.01 to 60.0; represents most conservative organic matter fraction.
Stripping	93.8% volatilization to air	Robust: HLC (atm·m^3/mol)
Biodegradation	5.8% by biodegradation	Robust: Water and Soil $t_{1/2}$ are much faster, rate assumes inhibition
Sorption to soil and sediment		
Sorption to soil	Log K_{OC} = 2.01	Robust: Assumes low OM sorption
Migration to groundwater	Log K_{OC} = 2.01	Robust: Assumes low OM sorption
Persistence and bioaccumulation		
Persistence (Soil)	<2 months	Robust: Multiple lines
Persistence (Water)	<2 months	Robust: Multiple lines
Persistence (Sediment)	2 to 6 months	Robust: Multiple lines
Bioaccumulation	BCF < 20 L/kg	Robust: Multiple trophic levels, EPI Suite™
BCF = bioconcentration factor; HLC = Henry's Law constant; OM = organic matter		

3 RELEASES AND CONCENTRATIONS OF ETHYLENE DIBROMIDE IN THE ENVIRONMENT

3.1 Approach and Methodology

EPA estimated environmental releases and concentrations of ethylene dibromide. Section 3.1 describes the approach and methodology for estimating releases and Section 3.2 presents estimate of environmental releases. Section 3.3 presents the approach and methodology for estimating concentrations of ethylene dibromide in the environment as well as a summary of concentrations of ethylene dibromide in the environment.

3.1.1 Manufacture, Processing, Industrial and Commercial Uses

This section describes the grouping of manufacture, processing, industrial, and commercial COUs into occupational exposure scenarios (OESs) as well as the use of ethylene dibromide within each OES. Specifically, Section 3.1.1.1 provides a crosswalk of COUs to OESs, and Section 3.1.1.2 provides descriptions for use of ethylene dibromide within each OES.

3.1.1.1 Crosswalk of Conditions of Use to Occupational Exposure Scenarios

EPA categorized the COUs listed in Table 1-1 into OESs. Table 3-1 provides a crosswalk between the COUs and OESs whereas Table 3-2 provides the reverse: a crosswalk of OESs to COUs. Each OES is developed based on a set of occupational activities and conditions such that similar occupational exposures and environmental releases are expected from the use(s) covered under that OES. For each OES, EPA provided occupational exposure and environmental release results expected to be representative of the entire population of workers and sites for the given OES in the United States. In some cases, the Agency defined only a single OES for multiple COUs, while in other cases the Agency developed multiple OESs for a single COU. EPA made this determination by considering variability in release and use conditions and whether the variability required discrete scenarios or could be captured as a distribution of exposures. The *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d) provides further information on specifics OESs.

Table 3-1. Crosswalk of Conditions of Use to Assessed Occupational Exposure Scenarios

Conditions of Use			OES[d]
Life Cycle Stage[a]	Category[b]	Subcategory[c]	
Manufacture	Import	N/A	Import and Repackaging
Processing	Incorporation into formulation, mixture, or reaction product	Fuels and fuel additives in all other petroleum and coal products manufacturing	Incorporation into Formulation, Mixture, or Reaction Product
		Fuels and fuel additives in petroleum refineries	Incorporation into Formulation, Mixture, or Reaction Product
	As a reactant	*E.g.,* in Pigment and dye manufacturing; Plastic material and resin manufacturing	Incorporation into Formulation, Mixture, or Reaction Product
	Repackaging	N/A	Import and Repackaging
Distribution in commerce	N/A	N/A	Distribution in Commerce

Conditions of Use			OES[d]
Life Cycle Stage[a]	Category[b]	Subcategory[c]	
Industrial use	Fuel agent in petroleum refineries	N/A	Fuels and Related Products
	Other use	Processing aid not otherwise specified; Pigment and dye manufacturing	Incorporation into Formulation, Mixture, or Reaction Product
Commercial use	Fuels and related products	N/A	Fuels and Related Products
	Other uses	Laboratory chemical	Laboratory Use
Disposal	N/A	N/A	Waste Handling, Treatment, and Disposal

OES = occupational exposure scenario
[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.
- 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 life cycle diagram, reflect Chemical Data Reporting (CDR) codes, and broadly represent COUs of ethylene dibromide in industrial and/or commercial settings.
[c] These subcategories represent more specific activities within the life cycle stage and category of the COU of ethylene dibromide.
[d] An OES is based on a set of facts, assumptions, and inferences that describe how releases and exposures take place within an occupational COU. The occurrence of releases/exposures may be similar across multiple COUs mapped to single OES), or there may be several ways in which releases/exposures take place for a given COU (single COU mapped to multiple OESs).

Table 3-2. Crosswalk of Assessed Occupational Exposure Scenarios to Conditions of Use

OES[a]	COU		
	Life Cycle Stage[b]	Category[c]	Subcategory[d]
Import and Repackaging	Manufacture	Import	N/A
	Processing	Repackaging	N/A
Incorporation into Formulation, Mixture, or Reaction Product	Processing	Incorporation into formulation, mixture, or reaction product	Fuels and fuel additives in all other petroleum and coal products manufacturing
			Fuels and fuel additives in petroleum refineries
		As a reactant	*E.g.,* in Pigment and dye manufacturing; Plastic material and resin manufacturing
	Industrial use	Other Use	Processing aid not otherwise specified; Pigment and dye manufacturing
Fuels and Related Products	Industrial use	Fuel agent in petroleum refineries	N/A
	Commercial use	Fuels and related products	N/A

OES[a]	COU		
	Life Cycle Stage[b]	Category[c]	Subcategory[d]
Laboratory Use	Commercial use	Other uses	Laboratory chemical
Waste Handling, Treatment, and Disposal	Disposal	N/A	N/A

COU = condition of use; OES = occupational exposure scenario

[a] An occupational exposure scenario (OES) is based on a set of facts, assumptions, and inferences that describe how releases and exposures take place within an occupational condition of use (COU). The occurrence of releases/exposures may be similar across multiple conditions of use (multiple COUs mapped to single OES), or there may be several ways in which releases/exposures take place for a given condition of use (single COU mapped to multiple OESs).

[b] 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.
- 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.

[c] These categories of COUs appear in the life cycle diagram, reflect Chemical Data Reporting (CDR) codes, and broadly represent COUs of ethylene dibromide in industrial and/or commercial settings.

[d] These subcategories represent more specific activities within the life cycle stage and category of the COUs of ethylene dibromide.

3.1.1.2 Description of Ethylene Dibromide Use for Each OES

After EPA characterized the OES for the occupational exposure assessment of ethylene dibromide, the occupational uses of ethylene dibromide for all OESs were summarized. Brief summaries of the uses of ethylene dibromide for all OES are presented in Table 3-3.

Table 3-3. Description of the Function of Ethylene Dibromide for Each OES

OES	Role/Function of Ethylene Dibromide	Concentrations of Ethylene Dibromide
Import and Repackaging	Ethylene dibromide is primarily imported into the United States from foreign manufacturers in liquid form for use, repackaging, storage, and/or redistribution. It is repackaged for distribution in commerce in different forms, states, or quantities than originally received or stored by various industrial sectors, including chemical product and preparation manufacturing, wholesale and retail trade, and laboratory chemical manufacturing.	When imported as tetraethyl lead-ethylene dibromide (TEL-B), the concentration of ethylene dibromide may range from 30 weight percent (wt%) at the lower end to 60 wt% at the higher end (U.S. EPA, 2020a). When repackaging ethylene dibromide from large containers to small containers, the concentration may range from 0.07 wt% for 100 LL avgas (EAA, 2020) at the lower end to 100 wt% for laboratory use (Sigma-Aldrich, 2024) at the higher end.
Incorporation into Formulation, Mixture, or Reaction Product	Ethylene dibromide is incorporated into formulations as a fuel or fuel additive in petroleum and coal products manufacturing. The primary use of ethylene dibromide that requires incorporation into a formulation is leaded aviation fuel (avgas). Additionally, ethylene dibromide may serve as a reactant in pigment and dye manufacturing or as a	As a component in a formulation, mixture, or reaction product used in processing either as a feed or product, the concentration of ethylene dibromide may range from 0.07 wt% (EAA, 2020) at the lower end to 60 wt% (U.S. EPA, 2020a) at the higher end. As a reactant in a process for industrial processing use, the concentration of ethylene dibromide may

OES	Role/Function of Ethylene Dibromide	Concentrations of Ethylene Dibromide
	solvent in plastic material and resin manufacturing.	range from 10 wt% (U.S. PTO, 2010) at the lower end to 100 wt% (Sigma-Aldrich, 2024) at the higher end.
Fuels and Related Products	Ethylene dibromide is used industrially as a fuel additive in petroleum refineries. This represents a downstream use of ethylene dibromide after it has already been incorporated into the fuel additive. Ethylene dibromide is a component of the fuel additive typically known as TEL-B, which contains tetraethyl lead (TEL) and ethylene dibromide. Commercially, ethylene dibromide is used in fuels and fuel additives as a lead scavenger in leaded fuels.	As a lead scavenger, the concentration of ethylene dibromide in fuels may range from 0.07 wt% (EAA, 2020) at the lower end to 0.1 wt% (Chevron USA, 2024) at the higher end.
Laboratory Use	Ethylene dibromide is used as a laboratory chemical for various analyses and synthesis activities, including the preparation of chemical standards, research applications, equipment calibration, and sample preparation. The liquid form is typically concentrated, ranging from 1–100 %.	The concentration of ethylene dibromide for laboratory use may range from 0.07 wt% (EAA, 2020) at the lower end to 100 wt% (Sigma-Aldrich, 2024) at the higher end.
Waste Handling, Treatment, and Disposal	Upon formulation or use, ethylene dibromide is expected to be released to other environmental media through migration to water or waste disposal. Disposal methods may also include destruction and removal by incineration.	The concentration of ethylene dibromide in disposal may range from 0.07 wt% for 100 LL avgas (EAA, 2020) at the lower end to 100 wt% for laboratory use or processing (Sigma-Aldrich, 2024) at the higher end.
Distribution in Commerce	Distribution in commerce consists of the transportation of ethylene dibromide or ethylene dibromide-containing products and articles between importing and processing sites, to end-use sites, or to final disposal facilities.	N/A

3.1.2 Estimating the Number of Release Days per Year for Facilities in Each OES

The number of release days associated with the releases is included in the release tables for different OES in Section 5 of the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d) with a summary provided below in Table 3-4. Unless EPA identified conflicting information, the number of release days per year for a given release source was assumed to equal the number of operating days at the facility. The Agency used information from the National Emissions Inventory (NEI), generic scenarios (GSs), emission scenario documents (ESDs), and other literature sources obtained through systematic review to assess the number of operating days for releases.

Table 3-4. Generic Estimate of Number of Operating Days per Year for Each OES

OES	Operating Days (days/year)	Basis
Import and Repackaging	174–260	The expected operating range for repackaging facilities is 174–260 days per year, based on the Chemical Repackaging Generic Scenario for Estimating Occupational Exposure and Environmental Releases (Revised Draft) (U.S. EPA, 2022a).
Incorporation into Formulation, Mixture, or Reaction Product	256	The estimated number of operating days is approximately 256 days per year for this type of OES, based on the ESD on Chemical Additives Used in Automotive Lubricants (OECD, 2020).
Fuels and Related Products	365	Consistent with the Use of Chemicals in Fuels and Related Products – Generic Scenario for Estimating Occupational Exposures and Environmental Releases, the number of operating days associated with fuels and related products is assumed to be 365 days per year (U.S. EPA, 2021b).
Laboratory Use	174–260	Consistent with the Use of Laboratory Chemical (U.S. EPA, 2023c), the recommended default range is 174–260 days per year, with a default value of 260 days per year for this OES.
Waste Handling, Treatment, and Disposal	365	EPA identified facility operating schedule data for ethylene dibromide in the NEI dataset; therefore, the Agency assumes continuous operations of 365 days per year, as discussed in Section 4.1.4 of the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).
ESD = emission scenario document; NEI = national emission inventory; OES = occupational exposure scenario		

3.1.3 Daily Release Estimation

For each OES, EPA estimated releases to each media of release using TRI data (2019–2023), NEI data (2017 and 2020), and Discharge Monitoring Report (DMR) data (2019–2023), as shown in Figure 3-1. Where available, EPA used NEI, GSs, or ESDs to estimate number of release days, which EPA used to convert between annual release estimates and daily release estimates. EPA used 2024 and 2020 CDR, TRI, NEI, DMR, GSs, and ESDs to estimate the number of sites using ethylene dibromide within an OES. The *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d) describes EPA's approach and methodology for estimating daily releases and provides detailed facility level results for each OES.

For each OES, EPA estimated ethylene dibromide releases per facility to each release media applicable to that OES. For ethylene dibromide, the Agency assessed releases to water and air.

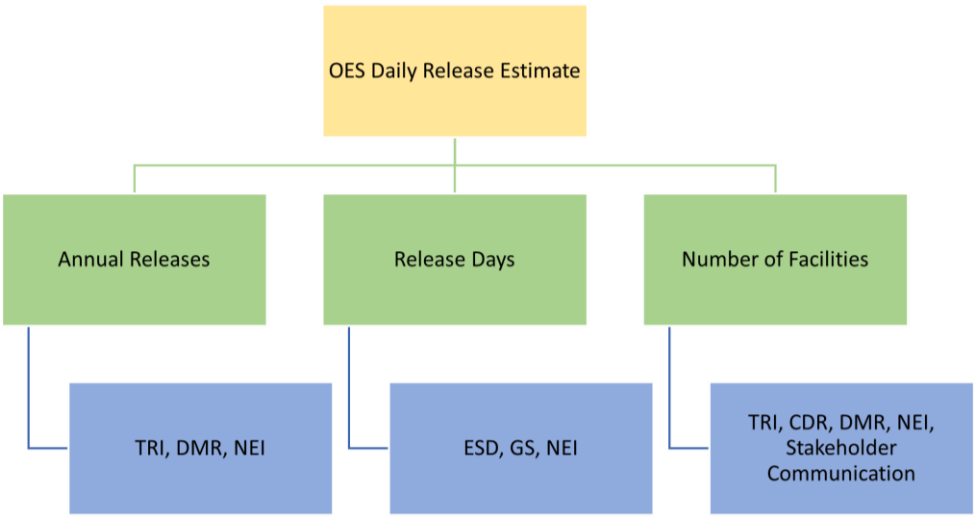


Figure 3-1. Overview of EPA's Approach to Estimate Releases for Each OES
TRI = Toxics Release Inventory; NEI = National Emissions Inventory; CDR = Chemical Data Reporting; DMR = Discharge Monitoring Report; GS = generic scenario; ESD = emission scenario document

3.1.4 Consumer (Down-the-Drain)

EPA only assessed one COU for consumers (Consumer use – Fuels and related products) and did not evaluate down-the-drain releases of ethylene dibromide from this COU because routine consumer's avgas refueling activities are not expected to involve disposal to sanitary sewers. However, the Agency acknowledges that some private pilots reportedly discard aviation fuel sump samples onto the ground, regardless of whether contamination is observed (TRB, 2014). This practice is improper and may constitute illegal disposal of hazardous waste. All About Fuel, Federal Aviation Adminstration (FAA) guidance (FAA, 2002) reminds pilots to manage and dispose of fuel in accordance with EPA requirements. At the federal level, disposal of general aviation fuel tank (sump) samples is governed primarily by the Resource Conservation and Recovery Act (RCRA) for hazardous waste management; depending on the disposal pathway, the Clean Water Act (CWA) and Clean Air Act (CAA) may also apply. These programs are implemented by EPA and largely administered by states, and state and local requirements vary widely.

3.2 Summary of Environmental Releases

3.2.1 Manufacture, Processing, Industrial and Commercial Uses

EPA combined its estimates for annual releases, release days, and number of facilities to estimate a range of daily release for each OES. Table 3-5 presents a summary of these ranges across facilities. See the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d) for additional details on deriving the overall confidence score for each OES.

Table 3-5. Summary of EPA's Annual and Daily Release Estimates for Each OES

OES	Type of Discharge[a] or Air Emission[b]	Estimated Annual Release (kg/site/year) [c]		Estimated Daily Release (kg/site/year) [d]		Number of Facilities[e]	Sources[i]
		Central Tendency	High-End	Central Tendency	High-End		
Import and Repackaging	Fugitive air	0	9.8E−03	0	3.8E−05	45	2017 and 2020 NEI
	Stack air	0	3.9	0	0.02	45	2017 and 2020 NEI
	Wastewater [f]	1.7E03	1.7E03	6.4	6.6	1	Environmental release modeling
	Wastewater [g]	71	131	0.27	0.50	45	Environmental release modeling
Incorporation into Formulation, Mixture, or Reaction Product	Stack air	6.0E−03	159	2.3E−05	0.62	7	2019 to 2023 TRI
	Stack air	0	15	0	0.06	102	2017 and 2020 NEI
	Fugitive air	1.5	14	6.0E−03	0.05	7	2019 to 2023 TRI
	Fugitive air	0	3.8	0	0.02	102	2017 and 2020 NEI
	Wastewater	0	35	0	0.14	7	2019 to 2023 TRI
Fuels and Related Products	Stack air [h]	1.4E−02	1.4E−02	3.7E−05	3.7E−05	1	2019 to 2023 TRI
	Stack air	0	5.6	0	0.02	1,706	2017 and 2020 NEI
	Fugitive air [h]	1.2	1.2	3.4E−03	3.4E−03	1	2019 to 2023 TRI
	Fugitive air	0	0.09	0	2.0E−04	1,706	2017 and 2020 NEI
	Wastewater [g]	3.8	6.6	1.1E−02	1.8E−02	43	Environmental release modeling
Laboratory Use	Stack air	0	0	0	0	3	2017 and 2020 NEI
	Fugitive air	0	0.82	0	3.0E−03	3	2017 and 2020 NEI
	Wastewater [h]	3.5E−03	3.5E−03	1.3E−05	1.3E−05	1	2019 to 2023 TRI
Waste Handling, Treatment, and Disposal	Stack air [h]	9.1E−03	9.1E−03	2.5E−05	2.5E−05	1	2019 to 2023 TRI
	Stack air	0	0.05	0	1.0E−04	773	2017 and 2020 NEI
	Fugitive air	0	0.22	0	6.4E−04	773	2017 and 2020 NEI
	Wastewater	5.0E−03	1.6	1.5E−05	4.0E−03	7	2019 to 2023 DMR

CDR = chemical data reporting; COU = condition of use; DMR = discharge monitoring report; ESD = emission scenario document; GS = generic scenario; NEI = national emission inventory; OES = occupational exposure scenario; POTW = public owned treatment works; TRI = toxics release inventory

[a] Direct discharge to surface water; indirect discharge to non-POTW; indirect discharge to POTW. Details on wastewater release streams for each facility are presented in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

OES	Type of Discharge[a] or Air Emission[b]	Estimated Annual Release (kg/site/year) [c]		Estimated Daily Release (kg/site/year) [d]		Number of Facilities[e]	Sources[i]
		Central Tendency	High-End	Central Tendency	High-End		

[b] Emissions via fugitive air and/or stack air.
[c] For programmatic release data (*i.e.,* TRI, NEI, and DMR), the presented central tendency is calculated from the median reported release amounts and high-end from the reported maximum release amounts. The specific central tendency and high-end values presented depends on the number of sites with programmatic data. For databases with 6 or more reporting facilities, EPA estimated central tendency and high-end releases using the 50th and 95th percentile values, respectively. For 3–5 facilities, EPA estimated the central tendency and high-end releases using the 50th percentile and maximum values, respectively. For 2 sites, the Agency presented the midpoint and the maximum value. Finally, EPA presented sites with only 1 data point as-is from the programmatic database. Because many programmatic records include 0 values, the central tendency (50th percentile) may be 0 where at least half of observations are reported as 0. Calculations are based on reported values only; missing entries were not replaced. A 0 central tendency does not imply zero releases at all facilities; the high-end value reflects upper-bound conditions.
[d] Where available, EPA used NEI data from facility operating schedules to estimate number of release days per year. Otherwise, EPA used peer-reviewed literature (*e.g.,* GSs or ESDs) to estimate the number of release days of ethylene dibromide within a COU.
[e] Number of facilities reporting releases is based on data from TRI, NEI, DMR, CDR databases and stakeholder outreach.
[f] Water releases from the 1 of the reporting CDR facilities.
[g] Water releases from the remaining reporting CDR facilities.
[h] Central tendency and high-end are identical because only 1 programmatic record is available for TRI; both reflect the single reported value. Calculations are based on reported values only.
[i] Full background and detail of methods used to derive these values is presented in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d)

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

For each OES, EPA considered the assessment approach, the quality of the data and models as well as the uncertainties in the assessment results to determine a level of confidence for the environmental release estimates. Table 3-6 provides EPA's weight of scientific evidence rating for each OES. It also summarizes EPA's overall weight of scientific evidence conclusions for its release estimates for each OES. TRI and NEI data obtained a high overall quality determination whereas DMR obtained a medium overall quality determination from EPA's systematic review process.

Table 3-6. Summary of Overall Confidence in Environmental Release Estimates by OES

OES	Weight of Scientific Evidence Conclusion in Release Estimates
Import and Repackaging	For this OES, EPA utilized air release information from TRI (U.S. EPA, 2024e) and NEI data (U.S. EPA, 2020c). EPA assessed air releases using reported data from the 2019–2023 TRI and the 2017 and 2020 NEI, both of which received high overall quality determination from the systematic review process. A key strength of the NEI data are its capture of additional sources not included in TRI due to reporting thresholds. However, several factors decrease the overall confidence for this OES. These include uncertainty in the accuracy of reported releases, limitations in representativeness across all sites (as TRI and NEI may not capture all relevant sites), and assumptions made regarding the number of operating days when estimating daily releases. Due to limited chemical-specific data for the Import and Repackaging OES, EPA assessed water releases to the environment using assumptions and values from the Chemical Repackaging Generic Scenario (U.S. EPA, 2022a), which received a high overall quality determination from the systematic review process. EPA employed EPA models combined with Monte Carlo modeling to estimate water releases, applying appropriate default input parameters from the GS and EPA models to assess the media of release. A key strength of the Monte Carlo modeling approach is that variation in model input values allows for estimation of a range of potential release values that are more likely to capture actual releases than discrete values. Additionally, Monte Carlo modeling uses a high number of simulations runs and the full distributions of input parameters, which increase the weight of evidence. The primary limitation of EPA's approach is uncertainty in the representativeness of estimated release values relative to the true distribution of potential releases at all sites in this OES. For water releases, the generic default values in the GS introduce uncertainty regarding how well these estimates characterize actual releases from real-world sites that repackage ethylene dibromide. Therefore, throughput estimates for these sites are based on the upper bound of the CDR national aggregate PV. These limitations decrease the weight of evidence. Based on this information, EPA concluded that the weight of scientific evidence for this assessment is moderate considering the strengths and limitations of the reasonably available data.
Incorporation into Formulation, Mixture, or Reaction Product	For this OES, EPA utilized water release information for from TRI (U.S. EPA, 2024e) and air release information from both TRI and NEI (U.S. EPA, 2020c). EPA assessed water releases using reported data from the 2019–2023 TRI, which received a high overall quality determination from the systematic review process. A key strength of TRI is that it compiles the most readily available facility-reported release data; however, because TRI applies only to facilities with 10 or more full-time employees, some small-size manufacturers and processers may not be captured. The primary limitation is that the water release assessment is based on only 7 reporting sites, and EPA did not have additional sources to estimate water releases from this OES. Based on other reporting databases (CDR, NEI, etc.), 102 additional sites report releases to other media but do not report releases to water. EPA assessed air releases using reported data from 2019–2023 TRI and 2017 and 2020 NEI, both of which received a high overall quality determination from the systematic review process. A key strength of NEI data are its capture of additional sources not

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	included in TRI due to reporting thresholds. However, several factors decrease the overall confidence for this OES, including uncertainty in the accuracy of reported releases, limitations in representativeness across all sites (as TRI and NEI may not capture all relevant sites), and assumptions made regarding the number of operating days when estimating daily releases. For this OES, EPA used the recommended default operating days parameter from the ESD on Chemical Additives Used in Automotive Lubricants developed by OECD (OECD, 2020), which received a high overall quality determination from the systematic review process. Based on the strengths and limitations of the reasonably available data, EPA concluded that the weight of scientific evidence for the water release assessment is moderate and EPA has robust confidence in the assessment of air releases.
Fuels and Related Products	For this OES, EPA had limited water release information from TRI (U.S. EPA, 2024e) and air release information from both TRI and NEI (U.S. EPA, 2020c). Due to limited chemical-specific data for the Fuels and Related Products OES, EPA assessed water releases to the environment using assumptions and values from two sources: the Use of Chemicals in Fuels and Related Products – Generic Scenario (U.S. EPA, 2021b) and the *General Methodology for Biofuels* (U.S. EPA, 2024d)—both of which received a high overall quality determination from the systematic review process. Given the uncertainty of site-specific data EPA also incorporated the estimated sites counts provided by the Eliminate Aviation Gasoline Lead Emissions (EAGLE) Initiative in collaboration with the FAA, based on their research and expertise, which received a medium overall quality determination from the systematic review process. EPA used EPA models combined with Monte Carlo modeling to estimate water releases to the environment, applying appropriate default input parameters from the GS, CDR, stakeholder data, and EPA models to assess the media of release. A key strength of the Monte Carlo modeling approach is that variation in model input values allows for estimation of a range of potential release values that are more likely to capture actual releases than discrete values. simulations runs and the full distributions of input parameters, which increase the weight of evidence. EPA assessed air releases using reported data from 2019–2023 TRI and 2017 and 2020 NEI, which both received a high overall quality determination from the systematic review process. A key strength of NEI data are it captures additional sources not included in TRI due to reporting thresholds. However, several factors decrease the overall confidence for this OES, including uncertainty in the accuracy of reported releases, limitations in representativeness across all sites (as TRI and NEI may not capture all relevant sites), and assumptions made regarding the number of operating days when estimating daily releases. For this OES, EPA used the recommended default operating days parameter from the Use of Chemicals in Fuels and Related Products – Generic Scenario for Estimating Occupational Exposures and Environmental Releases (U.S. EPA, 2021b), which received a high overall quality determination from the systematic review process. Based on this information, EPA concluded that the weight of scientific evidence for this assessment is moderate, considering the strengths and limitations of the reasonably available data.
Laboratory Use	For this OES, EPA utilized water release information from DMR (U.S. EPA, 2024c) and air release information from NEI (U.S. EPA, 2020c).

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	EPA assessed water releases using reported releases from 2019–2023 DMR, which received a medium overall quality determination from the systematic review process. A strength of using DMR data are that the Pollutant Loading Tool used to extract the data calculates an annual pollutant load by integrating monitoring period release reports provided to EPA and extrapolating over the course of the year. However, this approach assumes that the average quantities, concentrations, and hydrologic flows for a given period are representative of other times of the year. The primary limitation is that the water release assessment is based on only one reporting site, and EPA did not have additional sources to estimate water releases from this OES. Based on other reporting databases (CDR, TRI, NEI, etc.), 3 additional sites report releases to other media but do not report releases to water. Despite the small number of sites, the dataset may still be representative of the industry, given the low expected number of sites performing laboratory use in the United States. EPA assessed air releases using reported data from the 2017 and 2020 NEI, which received a high overall quality determination from the systematic review process. A key strength of NEI data are its capture additional sources not included in TRI due to reporting thresholds. However, several factors decrease the overall confidence for this OES, including uncertainty in the accuracy of reported releases and assumptions made regarding the number of operating days when estimating daily releases. For this OES, EPA used the recommended default operating days parameter from the *Use of Laboratory Chemical* (U.S. EPA, 2023c), which received a high overall quality determination from the systematic review process. Based on this information, EPA concluded that the weight of scientific evidence for this assessment is moderate, considering the strengths and limitations of the reasonably available data.
Waste Handling, Treatment, and Disposal	For this OES, EPA utilized water release information from TRI (U.S. EPA, 2024e) and DMR (U.S. EPA, 2024c) as well as air release information from TRI and NEI (U.S. EPA, 2020c). EPA assessed water releases using reported data from the 2019–2023 TRI, which received a high overall quality determination from the systematic review process. The key strength of TRI is that it compiles the most readily available facility-reported release data; however, because TRI applies only to facilities with 10 or more full-time employees, some small-size manufacturers and processers may not be captured. EPA also assessed water releases using reported data from the 2019–2023 DMR, which received a medium overall quality determination from the systematic review process. A strength of using DMR data are that the Pollutant Loading Tool used to extract the data calculates an annual pollutant load by integrating monitoring period release reports provided to EPA and extrapolating over the course of the year. However, this approach assumes that the average quantities, concentrations, and hydrologic flows for a given period are representative of other times of the year. The primary limitation of the water release assessment is that is based on only 7 reporting sites, and EPA did not have additional sources to estimate water releases from this OES. Based on other reporting databases (CDR, NEI, etc.), 794 additional sites report releases to other media but do not report releases to water. EPA assessed air releases using reported data from the 2019–2023 TRI and the 2017 and 2020 NEI, both of which received a high overall quality determination from the systematic review process. A key strength of NEI data are its capture of additional sources not included in TRI due to reporting thresholds. However, several factors decrease the overall confidence for this OES, including uncertainty in the accuracy of reported releases, limitations in representativeness across all sites (as TRI and NEI may not capture all

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	relevant sites), and assumptions made regarding the number of operating days when estimating daily releases. For this OES, EPA identified facility operating schedule data for ethylene dibromide in the NEI dataset, which received a high overall quality determination from the systematic review process. Based on the strengths and limitations of the reasonably available data, EPA concluded that the weight of scientific evidence for the water release assessment is moderate and EPA has robust confidence in the assessment of air releases.
Distribution in Commerce	These releases are assessed as part of individual OESs where the relevant activities occur.
CDR = chemical data reporting; DMR = discharge monitoring report; FAA = Federal Aviation Adminstration; GS = generic scenario; NEI = National Emission Inventory; OES = occupational exposure scenario; TRI = Toxics Release Inventory	

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3.2.2 Strengths, Limitations, Assumptions, and Key Sources of Uncertainty for the Environmental Release Assessment

Strengths

EPA compiled release information using reported releases from the 2019 through 2023 TRI (U.S. EPA, 2024e), 2017 and 2020 NEI (U.S. EPA, 2020c), and the 2019 through 2023 DMR (U.S. EPA, 2024c). TRI and NEI received high overall quality determinations from the systematic review process, while DMR received a medium overall quality determination.

TRI-reporting facilities are required to submit their "best available data" to EPA for reporting purposes. Some facilities must measure or monitor emission or other waste management quantities due to regulations unrelated to the TRI Program (*e.g.,* permitting requirements), or company policies. These existing, reasonably available data are often used for TRI reporting purposes as they represent the best available data. For example, stack releases can be directly measured through stack testing using EPA reference methods, providing a directly measured emission rate that can be used to calculate annual emissions. Although NEI does not require stack testing or continuous emissions monitoring and reporting agencies may use different emission estimation methods, reasonable estimates can be obtained through mass-balance calculations, emission factors, and engineering calculations.

A key strength of using DMR data are that the Pollutant Loading Tool calculates annual pollutant loads by integrating monitoring period release reports provided to EPA and extrapolating over the course of the year. However, this approach assumes that average quantities, concentrations, and hydrologic flows for a given period are representative of other times of the year.

Limitations

Facilities are only required to report to TRI if they have 10 or more full-time employees, are included in an applicable North American Industry Classification System (NAICS) code, and manufactures, processes, or use the chemical in quantities exceeding certain threshold (25,000 lb for manufacturers and processors; 10,000 lb for users). For NEI, the Air Emissions Reporting Requirements (AERR) only requires Criteria Air Pollutants (CAP) data reporting, while Hazardous Air Pollutants (HAP) data reporting is voluntary. Consequently, EPA augments SLT-provided HAP data with other information to better estimate point, nonpoint, and mobile source HAP emissions. For point sources, HAP augmentation is performed on each emissions source using the WebFIRE database or data from TRI.

DMR data are submitted by National Pollutant Discharge Elimination System (NPDES) permit holders to states or directly to the EPA according to their facility's permit monitoring requirements. States are only required to load major discharger data into DMR and may choose whether to load minor discharger data. The definition of major versus minor discharger is set by each state and could be based on discharge volume or facility size.

Due to these limitations across all three programs, some sites may release ethylene dibromide but are not included in TRI, NEI, or DMR. It is uncertain the extent to which sites not captured in these databases release ethylene dibromide into the environment.

Importers of ethylene dibromide submit CDR data to EPA if they meet reporting threshold requirements. Sites are only required to report production data to CDR if their yearly production volume exceeds 25,000 lb. Sites can claim their production volume as CBI, further limiting the production volume information in CDR. As a result, some sites that import or use ethylene dibromide may not be included in the CDR dataset, and the total production volume for a given OES may be underestimated.

Assumptions and Uncertainties

Some uncertainty exists in the DMR data extracted using the ECHO Pollutant Loading Tool Advanced Search option. Average measurements may be reported as a quantity (kg/day) or a concentration (mg/L). Calculating annual loads from concentrations requires incorporating wastewater flow data, which increases the uncertainty of the calculated annual load. Additionally, for facilities that report zero pollutant loads to DMR, the EZ Search Load Module uses a combination approach for non-detects (ND): if all values reported for a facility are non-detects, the loading tool sets the value to zero; for facilities reporting some values above zero, non-detects are set to one-half the detection limit to calculate annual pollutant loadings. While a strength of using DMR data and the Pollutant Loading Tool is that the tool calculates annual pollutant loads by integrating monitoring period release reports provided to EPA and extrapolating over the course of the year, this approach assumes average quantities, concentrations, and hydrologic flows for a given period are representative of other times of the year.

For one OES, EPA determined the maximum number of sites for use in Monte Carlo modeling from stakeholder outreach and the EAGLE Initiative in collaboration with the FAA, based on their research and expertise. Because the data provided by the EAGLE Initiative are not obtained directly from industry, this introduces additional uncertainty in the overall estimate of ethylene dibromide releases to the environment for that OES. For another OES, EPA determined the maximum number of sites for use in Monte Carlo modeling from programmatic data identified in the air releases assessment using NEI data. As previously mentioned, there is uncertainty in capturing all sites, which introduces uncertainty in the overall estimate of ethylene dibromide releases to the environment for that OES.

CDR information on the downstream processing and use of ethylene dibromide at facilities is also limited; therefore, some uncertainty exists regarding the production volume attributed to a given OES. For OES with limited CDR data, EPA developed potential production volume ranges based on reported CDR data, known reporting thresholds, and the national aggregate annual production volume of 1,000,000 lb/yr for ethylene dibromide. To understand environmental releases for an OES without programmatic data, EPA used the potential production volume ranges to determine the potential for release in comparison to other OES.

EPA has identified the following additional uncertainties that contribute to the overall uncertainty in the environmental release assessment:

- ***Number of Reporting Sites:*** The number of reporting releases in the TRI, NEI, and DMR databases are expected to capture the most significant environmental releases of ethylene dibromide from imports, processing, and downstream uses. However, EPA considers it likely that additional release sites exist beyond those captured in TRI, NEI, and DMR for several reasons. First, these programs have applicability and reporting thresholds; facilities handling or releasing ethylene dibromide below those thresholds may not be required to report, leading to an undercount of sites. Second, for some OESs (*e.g.,* Import and Repackaging; Fuels and Related Products), facilities reported air emissions to NEI but had no corresponding water-release. These threshold and coverage differences mean the set of reporting facilities may underrepresent the total number of sites with potential releases to the environment.
- ***Uncertainties Associated with Number of Release Days Estimate:*** For estimating the number of release days for an OES, EPA assumed that the number of release days equals the number of operating days. For most OESs, the Agency estimated the number of release days using programmatic data where available, or from GSs or ESDs when no programmatic data were found. In such cases, EPA used applicable sources to estimate a range of release days over the

course of an operating year. Due to uncertainty in ethylene dibromide-specific facility operations, release days may be underestimated or overestimated.

3.3 Summary of Concentrations of Ethylene Dibromide in the Environment

EPA evaluated the reasonably available information on concentrations of ethylene dibromide in the environment. Monitoring data found through systematic review along with data available from the applicable databases were all evaluated for relevant monitoring data.

EPA's systematic review identified limited references with monitoring data for surface water or sediment. Sediment data were gathered from Water Quality Portal (WQP) spanning the last 20 years of data. Only 20% of sediment monitoring data recorded a non-zero value over that span with 86% of these non-zero values being taken at confirmed superfund site locations. WQP surface water data were analyzed from 2002 to 2023, resulting in 40 data points. All but five of the surface water measurements were from superfund site locations, with those measurements ranging from 0.06 to 0.29 µg/L. The general population and environmental analyses use facility release data to model surface water concentrations downstream from releasing facilities.

For the air pathway, the Agency identified summarized monitoring data for ethylene dibromide from EPA's Ambient Monitoring Technology Information Center (AMTIC) for 2017 to 2022. The data ranged from 0.0 to 68.1µg/m^3 across all 24-hour sampling results. The general population and environmental analyses use industrial air release data to model ambient air concentrations near facilities using EPA's Integrated Indoor-Outdoor Air Calculator (IIOAC) Model and Human Exposure Model (HEM).

EPA identified several lines of evidence to support ethylene dibromide's presence in finished drinking water. There are direct TSCA releases of ethylene dibromide to surface water that are potential sources of drinking water reported from TRI and DMR. In addition, relevant studies were identified that provided monitoring data at public water systems. EPA conducted additional analyses for estimating the presence of ethylene dibromide in drinking water and groundwater sources by reviewing public water system data in support of EPA's fourth Six-Year Review[2] (also referred to as "SYR 4") of National Primary Drinking Water Regulations (NPDWRs) (U.S. EPA, 2024b) and the corresponding Information Collection Request dataset for the fourth Six-Year Review (SYR 4 ICR dataset) for ethylene dibromide.

For SYR 4, EPA's Office of Water collected Safe Drinking Water Act (SDWA) compliance monitoring data (public drinking water system data) for drinking water contaminants for 2012 through 2019. Compliance monitoring data were obtained through the ICR process, and EPA conducted a voluntary call-in from states, territories, and tribes to obtain the data. The SYR 4 ICR dataset was published in July 2024. OCSPP does not intend to use this dataset to be nationally representative for ethyene dibromide occurrence in drinking water across the United States but is using this dataset to demonstrate the possibility of ethylene dibromide exposure to the general population. Therefore, drinking water is evaluated as a possible route of exposure. This discussion is presented in Sections 3.3.2 and 3.3.3.

[2] Under the Safe Drinking Water Act (SDWA), EPA is required to conduct a review every 6 years of existing NPDWRs and determine which, if any, are any appropriate for revision. Based on the fourth cycle of the Six-Year Review, EPA did not determine that there were additional candidates identified for regulatory revision. Additional information is available at: Six-Year Review (accessed August 11, 2026).

3.3.1 Surface Water and Sediment Pathway

Ethylene dibromide released to surface water has a relatively short half-life (2.6 hours) and may volatilize (U.S. EPA, 2012d) however, due to its solubility (4,130 mg/L), and density (2.172 g/cm^3 at 25 °C) it may be present in surface water where discharge rates exceed removal rates. The Agency's assessment of water releases for the Import and Repackaging OES (Section 3.2.1) estimates a high-end annual wastewater total of 131 kg/year across 45 facilities, after on-site treatment to local receiving waters. Considering the high density, solubility and depending upon the discharge rates of ethylene dibromide, there is a potential for ethylene dibromide to be present in surface waters.

EPA found limited surface water monitoring data. In one study, researchers sampled a stream near an oil refinery and found ethylene dibromide concentrations of 1.13 and 1.05 ppb in the two samples (Midwest Research Institute, 1975). EPA also found monitoring data via the WQP (NWQMC, 2024), a publicly available resource which integrates water quality data from the U.S. Geological Survey (USGS) National Water Information System (NWIS) (USGS, 2013) and the EPA Water Quality Exchange (WQX) Data Warehouse (U.S. EPA, 2018). The NWIS database contains current and historical water data from more than 1.5 million sites across the nation. The WQX is the EPA's repository of water quality monitoring data collected by water resource management groups across the country. The set of data for surface water including sampling years 2002 to 2023 was retrieved July 2025.

The WQP surface water dataset returned 40 non-zero detected data points collected between 2002 and 2023. All but five of these data points were taken at sites confirmed to be Superfund locations. The range of these five monitoring data points were 0.06 to 0.29 µg/L taken from sites in Florida, Illinois, and New Jersey. The detection limits for these values ranged from 0.0024 to 1 µg/L.

Sediment monitoring data sampling were retrieved from the WQP in August 2025 and cover sampling years from 2005 to 2021 (Table 3-7 reflects the most recent year available in WQP). Over this period, 2,849 sediments samples were reported, of which 597 had values that were at or above detection level Reported concentrations range from 9.6×10^{-7} to 8,900 µg/kg, including 9 samples reported as 1 µg/L. All but 84 of the detected samples were from 2 sites identified as Superfund sites. Of the remaining samples, 81 were collected under the Great Lakes Legacy Act (GLLA) and 3 samples were collected in New Mexico by tribal organizations. Given the distribution of these samples, there is no clear link to any current COU or release facility. Monitoring programs generally were not designed to target specific chemical occurances (timing, frequency, site selection) or to align with the COUs. Detection limits varied widely across reporting organizations, locations, and events; but for all retrieved samples, values were recorded as at or below the reported detection limit indicating that monitored concentrations are uniformly low. Consistent with the physical and chemical and fate properties described in the *Draft Chemistry, Fate, Release and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d) (*i.e.,* high water solubility, high volatility, and low sorption tendencies) EPA did not assess the sediment pathway for exposure risk.

Table 3-7. Measured Concentrations of Ethylene Dibromide in Sediment Samples Obtained from the Water Quality Portal: 2005–2025[a]

Year(s)	Reporting Organization	Samples	Reported Values [b c]
2021, 2020	EPA Great Lakes National Program, Great Lakes, USA (6 locations)	81	Estimated value and/or under reported DL of 1–300 µg/kg depending on sample
2021	Palermo Wellfield Superfund Site, WA, USA (1 location)	3	All listed as less than reported DL of 0.96–4.8 µg/kg depending on sample

Year(s)	Reporting Organization	Samples	Reported Values [b c]
1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007	EPA Superfund Portland Harbor (2 locations)	513	All listed as less than reported DL of 0.58–8,900 µg/kg depending on sample

DL = detection limit
[a] Data were downloaded from the WQP (accessed August 11, 2026).
[b] Concentrations reported as µg/L are more consistent with saturation or unconsolidated sediments
[c] Not all samples reported a detection limit

3.3.2 Drinking Water

For drinking water, EPA utilized monitoring values from finished drinking water and conducted a screening analysis from TRI and DMR releases to surface waters. This screening-level assessment made several conservative assumptions which likely overestimate exposures to the general population via drinking water. These assumptions for the drinking water modeling from TSCA releases include no volatilization from surface water, utilizing concentrations at the point of discharge, and 0% drinking water treatment applied. These assumptions were part of the screening analysis described in the *Draft Chemistry, Fate, Release and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). Because no risks above the benchmarks were found (see Section 4.3.5.2), no further refinements to this analysis were performed.

EPA identified three studies that conducted monitoring for ethylene dibromide in drinking water samples. A USGS study reported non-detects for ethylene dibromide in drinking water sampling done along the Eastern U.S. (USGS, 2008). The other studies performed sampling in Appalachia (Bugher et al., 2024) and drinking water supply wells in South Carolina (Landmeyer and Campbell, 2014). The results from these studies reported ethylene dibromide concentrations ranging from below the level of detection (LOD) to 0.356 µg/L in surface waters and from below the LOD to 0.0608 and 0.502 µg/L in aquifers in South Carolina.

EPA also used the Office of Water's SYR database as monitoring data to assess the general population's exposure to ethylene dibromide via drinking water. According to "Analysis of Regulated Contaminant Occurrence Data from Public Water Systems in Support of the Fourth Six-Year Review of National Primary Drinking Water Regulations: Chemical Phase and Radionuclides Rules" (U.S. EPA, 2024b), the number of PWSs with ethylene dibromide detections is 174, detection frequency is 0.45% with 5th to 95th percentile detected concentrations ranging from 0.0094 to 0.14 µg/L. Under the SDWA, the Maximum Contaminant Level (MCL) for ethylene dibromide is 0.05 µg/L. As determined by EPA Office of Water's Six-Year Review, the number of systems with a detection greater than the MCL is 44 (0.110%).

According to the fourth SYR occurrence assessments (U.S. EPA, 2024b), the total number of records of ethylene dibromide is 243,161, and this information was reported to EPA from 57 states, territories and tribes. Ethylene dibromide data represents 38,371 public water systems, and the population served by systems that represent the data reported is approximately 230 million. EPA's Office of Water estimates that the number of systems with a detection greater than the MCL for ethylene dibromide (0.05 µg/L) is 44 (0.110%) systems. For the purposes EPA's Office of Water assessment, occurrence at the system-level is evaluated, not at the sample-level, and does not delineate sample records based on finished water or groundwater source types as reported to EPA.

OCSPP conducted a separate analyses of the ethylene dibromide data using the SYR 4 ICR dataset. In order to obtain this data, the SYR 4 ICR publicly available data was downloaded for ethylene dibromide.

This data was filtered in the column titled "Source Type Code" to only include "FN" and blanks, plus the column titled "Sampling Point Type" had "RW" unselected. This was done in order to ensure only finished water (FN) was shown in the data and raw water (RW) was not included. These data points, because they reflect drinking water that would be delivered to consumers, show that ethylene dibromide is present in finished drinking water and is a potential exposure to the general population via drinking water from PWSs.

OCSPP estimates that 99.8% of finished drinking water samples reported were non-detects out of the 139,956 samples reported to the Office of Water. Detected values ranged from 0.0027 to 1.2 µg/L for the 433 samples from sites across the United States. The median value for these samples was 0.029 µg/L. Detection limits ranged from 0 to 50 µg/L. Although these numbers were not mathematically utilized in the assessment, they are provided in this draft risk evaluation to give context for the dataset. If detection limits are reported to EPA, the SYR 4 ICR dataset may be one of several types: detection limits, method detection limits, method reporting limits, and others. For the purpose of the general population screening analysis, OCSPP treated these values the same. Even though most of the values from the SYR 4 ICR dataset were non-detects, the OCSPP analysis considered the 433 detects.

EPA used the release data from TRI and DMR facilities to assess the resulting concentrations of ethylene dibromide in receiving water bodies that might serve as sources for drinking water. Surface water concentrations were estimated using the same methodology outlined in the Section 3.3.1 and described in the *Draft Chemistry, Fate, Release and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). These calculations represented concentrations at the point of discharge with the assumption that reported releases are determined after any on-site water treatment. These were conservative assumptions that were intended as a screening assessment. Even with these assumptions, no evidence of risk to the general population was found via the drinking water pathway (see Section 4.3.5.2), therefore further refinements were not necessary. Concentrations from this modeling resulting from the 30Q5 flows ranged from 0 to 5.0 µg/L, though most modeled concentrations were less than 1 µg/L.

3.3.3 Groundwater

The complete set of reported concentrations of ethylene dibromide in untreated groundwater were extracted for OCSPP's analysis of the SYR 4 ICR dataset and summarized in the *Draft Chemistry, Fate, Release and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

For OCSPP's analysis, the publicly-available Six-Year 4 ICR dataset for ethylene dibromide was downloaded. To obtain values for untreated ground water, the column titled "Source Water Type" was filtered to only include "GW" and "GU" as to only represent ground water and ground water under the direct influence of surface water. The column titled "Source Type Code" was filtered to only include "RW" so that only raw water was represented in the dataset. The values in the summarized data informed the potential exposure to private well owners who use groundwater as a source of drinking water. The Six-Year Review does not include data from private well owners, however it does include data from groundwater that has not undergone treatment, therefore EPA utilized this dataset to estimate drinking water exposures to populations receiving their water from private wells. OCSPP's analysis of the SYR 4 ICR dataset found that 99.3% of all ethylene dibromide data in untreated groundwater were reported as non-detects. The detected values ranged from 0.01 to 0.71 µg/L, with a median of 0.03 µg/L. All samples were taken between 2012 and 2019.

In addition, EPA found six references that had some monitoring data. Four of these references contained non-zero point values ranging from 0.03 to 175 µg/L. All monitoring points were from studies on

groundwater sources that were from former petroleum underground storage tanks, with the 175 µg/L sample taken from a site of an underground storage tank spill site in Sobieski, Minnesota. Groundwater reported data from the SYR and systematic review found largely non-detects. The general population assessment considered these non-detects in the screening assessment of drinking water where it was determined that further assessment was not necessary. This screening assessment for the general population is described in Sections 4.1.3.4.1 and 4.3.5.2.

3.3.4 Ambient Air Pathway

EPA searched all reasonable available peer-reviewed literature and databases to obtain concentrations of ethylene dibromide in air. The Agency identified two studies that had some monitoring data available. One study evaluated ethylene dibromide concentrations in the residential area surrounding a chemical manufacturing facility (Cohen et al., 1989), but determined that ethylene dibromide was not detected in any air samples above the reported LOD (8.5 µg/m^3). Another study found point samples reporting values ranging from 0.069to 115.0 µg/m^3 (Midwest Research Institute, 1975). These values were from Midwest to Western U.S locations sampled in 1975. EPA acknowledges release and use patterns have changed since 1975, and this data may not be representative of current ambient air concentrations of ethylene dibromide. The ambient air analysis conducted in this draft risk evaluation is primarily based on recent environmental release (*i.e.,* TRI and NEI) and monitoring data (*i.e.,* EPA's AMTIC database). A full summary of AMTIC monitoring data from various nationwide sites is presented in the *Draft Chemistry, Fate, Release and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). EPA specifically examined the AMTIC data years 2017 to 2022 to coincide with the TRI and NEI reporting years to try to align monitoring data with facility-specific reported release data for ethylene dibromide. Over 93.5% (64,418/68,874 total samples) of all reported samples was reported as "0" in AMTIC during this timeframe. The remaining data ranged 0.007 to 68.08 µg/m^3 with reported MDLs ranging from 0.015 to 3.84 µg/m^3.

3.3.5 Weight of Scientific Evidence Conclusions for Environmental Concentrations

The monitoring data found during systematic review provided some context but most of the data collected and identified could not be linked to current COUs due to the length of time passed since the data were collected. Based on the physical and chemical properties of ethylene dibromide (*i.e.,* high water solubility, high volatility, and low sorption tendencies), along with the reported release volume to air and water, a quantitative assessment was conducted for drinking water, surface water, and ambient air pathways. Water releases and air releases reported are not expected to contribute significantly to sediment concentrations, given the low likelihood of ethylene dibromide to sorb to sediment. Sediment monitoring data were exclusively tied to two specific Superfund locations; however, it was determined that these data were not reflective of the current COUs. EPA did not conduct a quantitative assessment for the sediment pathway. The Agency has robust confidence in the overall characterization of environmental media concentrations for ethylene dibromide as it relies on databases that are publicly available and reviewed with quality control and assurance protocols. EPA has robust confidence that drinking water, surface water, and ambient air are potential pathways of general population exposure concern given the monitoring data available, reported releases, as well as the physical and chemical and fate properties of ethylene dibromide (see Sections 2.2.1 and 3.1.3). The monitoring data show ethylene dibromide presence in both air and surface water, which supports the characterization via modeling of exposure estimates for these exposure pathways.

As indicated in Sections 2.1 and 2.2, ethylene dibromide is volatile, very water soluble, and is unlikely to sorb to soil and sediment. If released into air, ethylene dibromide will largely remain volatile but may also undergo wet deposition and deposit onto land or water (Section 3.3.4). While volatilization from surface water is expected to occur (*i.e.,* half-life in surface water of about 2.6 hours due to volatilization

(U.S. EPA, 2012d), two other chemical properties counteract the complete volatilization of ethylene dibromide from water: (1) ethylene dibromide is very water soluble (4,130 mg/L) (Rumble, 2018a); and (2) at a density of 2.172 g/cm^3, ethylene dibromide is over twice as dense as compared to receiving waters (O'Neil, 2013).

There are reported surface water releases from TRI and DMR (174–365 days per year; Section 3.1.2), and identified monitoring data (Section 3.3.1 and 3.3.2) that shows it can be present in both surface water and drinking water. EPA modeled the TRI and DMR release data to estimate ethylene dibromide concentrations in surface water. From these release data, the Agency assumed that the reported concentrations were released to surface water without further treatment and no drinking water treatment was applied as a part of the screening assessment. The Agency has robust confidence in the reported release values from these sources. OCSPP's analysis of compliance monitoring data from the fourth SYR shows that, though ethylene dibromide is largely non-detect in samples identified for that report, there are 433 samples in which ethylene dibromide was measured in finished drinking water from 2012 to 2019. The median detected drinking water concentrations from the SYR 4 ICR dataset found from OCSPP's analysis was 0.029 µg/L. EPA's Office of Water Six-Year Review analysis identified 174 public water systems with detections of ethylene dibromide and of those public water systems, 44 public water systems had reported detections exceeding the MCL (U.S. EPA, 2024b). Reported concentration data for ethylene dibromide in finished drinking water from the SYR 4 ICR dataset reflects ethylene dibromide concentrations in water that may have undergone drinking water treatment.

Although the Six-Year Review 4 data cannot be tied back to TSCA COUs, it demonstrates that even with the physical and chemical properties of ethylene dibromide, it is present in finished drinking water. Because of the physical and chemical properties, releases to surface water reported from TRI and DMR, and monitoring data showing presence of ethylene dibromide in finished drinking water (reflecting potentially multiple treatment processes where ethylene dibromide may have undergone removal processes), EPA had robust confidence on the presence of ethylene dibromide in surface water and drinking water resulting from facility-specific reported water releases.

EPA has robust confidence that ethylene dibromide is present in ambient air. Across NEI and TRI, there are over 10,000 releases for the reporting years considered for this assessment (2019–2023 for TRI; 2017 and 2020 for NEI). These releases are modeled using IIOAC and HEM, as described in Section 4.1.3.2 of the *Draft Chemistry, Fate, Release and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). There are significantly more releases to ambient air than to surface water, when comparing NEI reported air releases to water releases reported in TRI and DMR. Fate and transport properties of ethylene dibromide suggest that it will remain in air when released. AMTIC monitoring data was discussed in Section 3.3.4, and EPA has robust confidence in this data. The AMTIC data included several "0" values; however, the Agency continued to evaluate where ethylene dibromide was present in order to consider the general population and environment that may be exposed. Because of the large amount of releases to ambient air and the fate properties, there is a strong potential for exposure via ambient air to the general population and the environment. Ethylene dibromide is expected to volatilize from surface water into ambient air and may be released into air for up to 365 days per year; considering these lines of evidence in parallel with the expected half-life of 65 days, EPA expects ethylene dibromide to be present in ambient air, resulting in a potential for exposure. Due to the robust confidence in the releases, EPA's HEM modeling estimates, and confidence in the AMTIC monitoring data, EPA is confident that ethylene dibromide is present in ambient air and there is potential for exposure to the general population and the environment.

4 HUMAN HEALTH RISK ASSESSMENT

EPA assessed human health risks of ethylene dibromide exposure. Section 4.1 provides a summary of human exposures; Section 4.2 summarizes human health hazard; and Section 4.3 summarizes risk characterization for human health risk.

Ethylene Dibromide – Human Health Risk Assessment: Key Points

EPA evaluated the reasonably available information to support human health risk characterization of ethylene dibromide for workers, ONUs, consumers, the general population, and PESS.

Exposure Key Points

- EPA assessed inhalation exposures to ethylene dibromide vapor for both workers and ONUs as well as dermal exposures to ethylene dibromide liquid for workers for each OES.
- EPA estimated consumer inhalation and dermal exposures to ethylene dibromide during avgas refueling activities.
- EPA evaluated general population exposures via ambient air by modeling TSCA releases.
- EPA evaluated general population exposures from TSCA releases to surface water via drinking water ingestion, fish ingestion, and incidental ingestion from swimming in surface waters.

Hazard Key Points

- There is robust evidence that exposure to ethylene dibromide can cause reproductive and developmental effects, respiratory effects, hepatic effects, mortality, and cancer.
- For oral and inhalation chronic exposure outcomes, EPA identified key studies with primarily hepatic endpoints.
  - Oral exposure had co-critical effects related to adrenal and reproductive outcomes; these key studies presented evidence for both cancer and non-cancer outcomes
  - Dermal effect levels were approximated through inhalation route to dermal route extrapolation.
- For acute and intermediate inhalation exposure, EPA identified a key study with reproductive/developmental endpoints; for acute and intermediate oral exposure, the key study had gastrointestinal outcomes.
  - Dermal effect levels were approximated through inhalation route to dermal route extrapolation.
- EPA identified mechanistic studies and evidence that support a genotoxic mode of action involving metabolic activation, DNA alkylation, and adduct formation, with mutagenicity findings across assay systems that are consistent with observed carcinogenic effects.

Risk Characterization Key Points

- EPA identified non-cancer and cancer risks to workers and ONUs from exposure to ethylene dibromide.
- Non-cancer risk estimates for consumers from inhalation and dermal exposure are above benchmark MOEs, whereas cancer risks were identified for consumers from exposure to ethylene dibromide via inhalation.
- EPA did not find acute, chronic, or cancer risk resulting from surface water exposures to ethylene dibromide to the general population.
- In the inhalation assessment for the general population, EPA was able to screen out chronic inhalation non-cancer risk to ethylene dibromide but found cancer risk above one in a million (1×10^{-6}) for communities surrounding 13 TSCA release facilities.

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 Exposure

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.

To assess the potential occupational inhalation and dermal exposures that result from the COUs of ethylene dibromide, EPA first determined OESs associated with each COU. The names of these OESs for each COU are given in Table 3-1. In some cases, multiple COUs are assessed via a single OES as shown in Table 3-2. EPA followed its standard practice to assess exposure to generic exposure groups (1) "workers" (*i.e.,* workers who work in close proximity to ethylene dibromide, and may handle and have direct contact with ethylene dibromide; and (2) ONUs who do not directly handle ethylene dibromide but may be indirectly get exposed to it as part of their employment. EPA identified tasks performed by the workers for each OES.

Ethylene dibromide has a vapor pressure of approximately 11.2 mmHg at 25 °C. Based on its volatility, EPA anticipates that workers and ONUs can be exposed to ethylene dibromide vapor via the inhalation route. EPA also expects worker exposure to liquids via the dermal route but does not expect dermal exposure for ONUs because they do not directly handle ethylene dibromide.

Occupational exposure limits (OELs) for ethylene dibromide vary by regulating body, reflecting different considerations. OSHA set a permissible exposure limit (PEL) of 20 ppm as an 8-hour time-weighted average (TWA), with a 30 ppm ceiling limit for any 15-minute period and a 50 ppm maximum peak for any 5 minutes within an 8-hour shift (established in 1970s) (OSHA, 2018). All ethylene dibromide specific inhalation exposure monitoring data points, surrogate data points and modeled data points that EPA used for the assessments were below the OSHA PEL. OSHA also assigned a "skin" notation to its PEL, indicating the potential for significant dermal absorption (OSHA, 2018). The National Institute for Occupational Safety and Health (NIOSH) recommended a more protective Recommended Exposure Limit (REL) of 0.045 ppm for a 10-hour TWA and a 0.13 ppm ceiling for any 15-minute exposure period. NIOSH also designated ethylene dibromide as a potential occupational carcinogen and sets an Immediately Dangerous to Life or Health (IDLH) level at 100 ppm, recommending the most protective respirators above its REL (NIOSH; accessed August 11, 2026). Furthermore, the American Conference of Governmental Industrial Hygienists (ACGIH) has not established a Threshold Limit Value (TLV) for ethylene dibromide but classified it as a confirmed animal carcinogen with unknown relevance to humans (ACGIH; accessed August 11, 2026).

The following sections briefly describe EPA's approach to assessing occupational exposures and estimating inhalation and dermal exposure for each COU assessed. For additional details on development of approaches and results refer to *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

4.1.1.1 Approach and Methodology

The steps that EPA followed in assessing occupational exposure to ethylene dibromide are illustrated below in Figure 4-1.

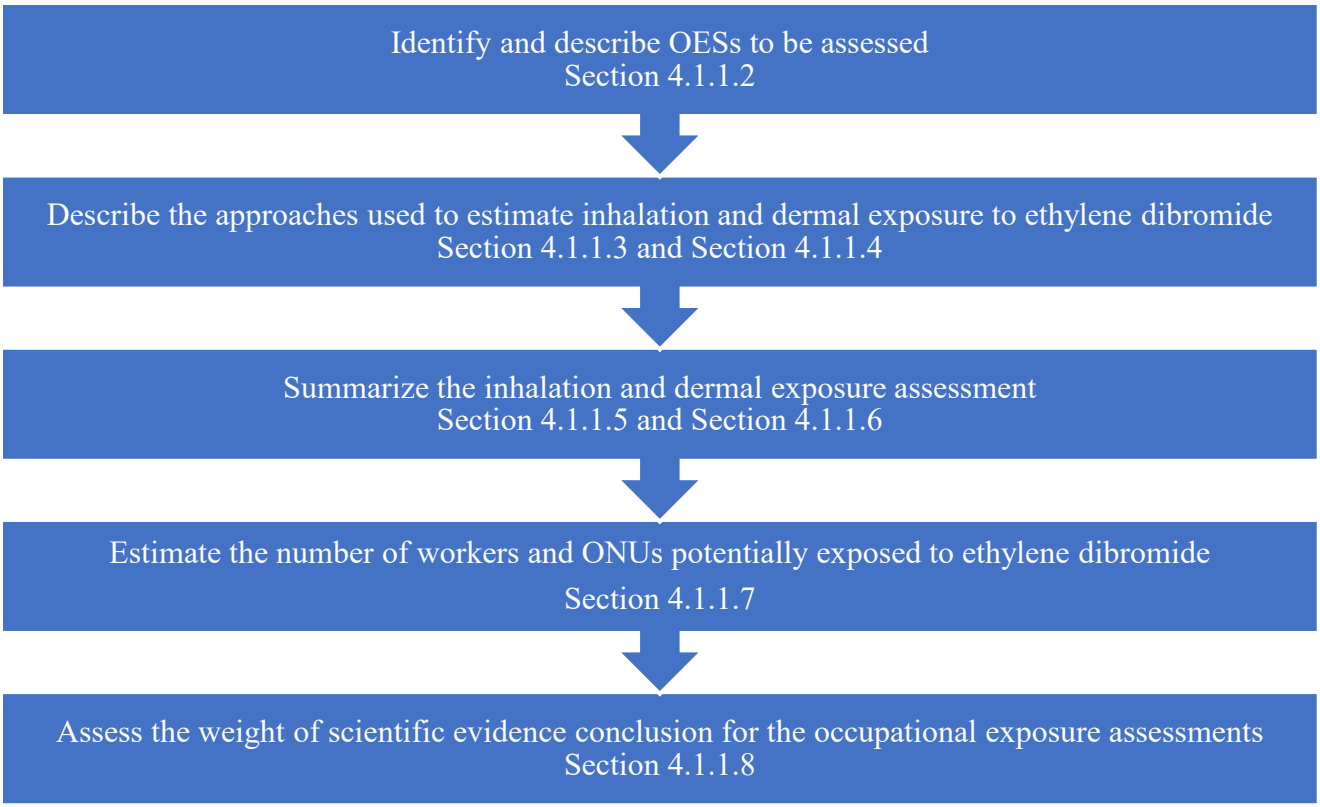

Figure 4-1. Overview of EPA's Approach to Estimate Occupational Exposure for Ethylene Dibromide

EPA follows the hierarchy established in Table 4-1 in selecting data and approaches for assessing occupational exposures (based on (CEB, 1991)).

Table 4-1. Hierarchy of Data and Approaches for Assessing Inhalation Exposures to Ethylene Dibromide

Type of Approach	Description
1. Monitoring data	a) Personal and directly applicable
	b) Area and directly applicable
	c) Personal and potentially applicable or similar
2. Modeling approaches	d) Area and potentially applicable or similar
	a) Surrogate or analogous monitoring data
	b) Fundamental modeling approaches
	c) Statistical regression modeling approaches
3. Occupational exposure limits (OELs) [a]	a) Company-specific occupational exposure limits (OELs) (for site-specific exposure assessments; for example, there is only one manufacturer who provided their internal OEL to EPA but did not provide monitoring data)
	b) OSHA permissible exposure limit (PEL)
	c) Voluntary limits: ACGIH Threshold Limit Value (TLV); NIOSH Recommended Exposure Limit (REL); Occupational Alliance for Risk Science (OARS) workplace environmental exposure level (WEELs)

Type of Approach	Description
[a] OELs may only be used when monitoring data and modeling approaches are not available for a given OES. EPA did not use OELs for any inhalation exposure assessment for ethylene dibromide as either monitoring data or modeling approaches were available for all the OESs.	

4.1.1.2 Identify and Describe Occupational Exposure Scenarios to Assess

As discussed in Section 3.1.1.1, EPA has identified OESs from the COUs to group scenarios with similar sources of exposure at industrial and commercial workplaces within the scope of the risk evaluation. The Agency identified exposure groups for each OES as presented below in Table 4-2. Additional details on worker activities performed by the exposure groups for each OES can be found in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

Table 4-2. Similar Exposure Groups (SEGs) Assessed for Ethylene Dibromide

OES	SEGs Assessed by OES
Import and Repackaging	EPA assessed the general SEG categories of workers and ONUs. Workers are potentially exposed to ethylene dibromide when transferring ethylene dibromide from bulk containers into smaller containers. Workers may also be exposed via inhalation of vapor or dermal contact with liquids when cleaning repackaging containers following emptying. ONUs include supervisors, managers, and other employees who work at sites that import and repackage ethylene dibromide but do not directly handle ethylene dibromide and are expected to have lower inhalation exposures and no dermal exposure. ONUs at the sites where monitoring data for this OES were used from had roles of production supervisor, crew leader, shift superintendent and compound bulk operator.
Incorporation into Formulation, Mixture, or Reaction Product	EPA assessed the general SEG categories of workers and ONUs. Workers are potentially exposed to ethylene dibromide in processing of ethylene dibromide into formulations, mixtures, or reaction products during container unloading, container cleaning, equipment cleaning, and packaging of formulation into containers. They may also be exposed to vapors due to volatilization during the mixing process itself, during product sample collection and analysis, and process maintenance. ONUs are expected to have lower inhalation exposures and no dermal exposure. ONUs at the sites where monitoring data for this OES were used from had roles of shift superintendent and compound bulk operator.
Laboratory Use	EPA assessed the general SEG categories of workers and ONUs. Workers are potentially exposure to ethylene dibromide during the following activities: transferring ethylene dibromide from transport containers to labware, sampling/analyses, and container/equipment cleaning. ONUs are expected to have lower inhalation exposures and no dermal exposure. EPA did not identify any ONUs activities or exposure monitoring data for this OES.
Fuels and Related Products	EPA assessed the general SEG categories of workers and ONUs. The Agency did not identify any workers exposure monitoring data, or ONUs activities or exposure monitoring data for this OES.
Waste Handling, Treatment, and Disposal	EPA assessed the general SEG categories of workers and ONUs. Workers are potentially exposed to ethylene dibromide via inhalation of vapors or dermal contact with liquids during the unloading and cleaning of transport containers. ONUs are

OES	SEGs Assessed by OES
	expected to have lower inhalation exposures and no dermal exposure. EPA did not identify any ONUs activities or exposure monitoring data for this OES.
OES = occupational exposure scenario; ONU = occupational non-user ; SEG = similar exposure group	

For each OES, EPA characterized inhalation exposures for workers and ONUs, and dermal exposure for workers as described in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). EPA found descriptions of processes involved in each OES and identified worker activities that may result in ethylene dibromide exposure based on literature review, submissions or using GSs. The Agency estimated central tendency and high-end inhalation exposures for each relevant acute, intermediate, and chronic exposure scenario based on available chemical-specific, or surrogate monitoring data and/or modeling information with adjustments based on OES-specific information on exposure frequency and duration (*i.e.,* refueling scenario). Where ethylene dibromide-specific monitoring data were reasonably available, EPA used these data to characterize central tendency and high-end inhalation exposures (see Figure 4-2). Where ethylene dibromide-specific monitoring data was not sufficient or data was not relevant to the OES, or data was unavailable, EPA used OES-specific, surrogate monitoring data (*e.g.,* exposure monitoring data on 1,2-dichloroethane for the Waste Handling, Treatment, and Disposal OES) and estimated central tendency and high-end inhalation exposures. Where no inhalation monitoring data were available, but inhalation exposure models were reasonably available, the Agency estimated low-end, or central tendency and high-end exposures using only modeling approaches (*e.g.,* Fuels and Related Products OES).

In the absence of monitoring information, dermal exposure estimates were modeled based on OES-specific information on product concentrations, amount in contact with skin, and exposure frequency and duration. EPA did not identify any dermal exposure monitoring data for any OES; therefore, EPA used modeling approaches for estimating dermal exposure for all OESs.

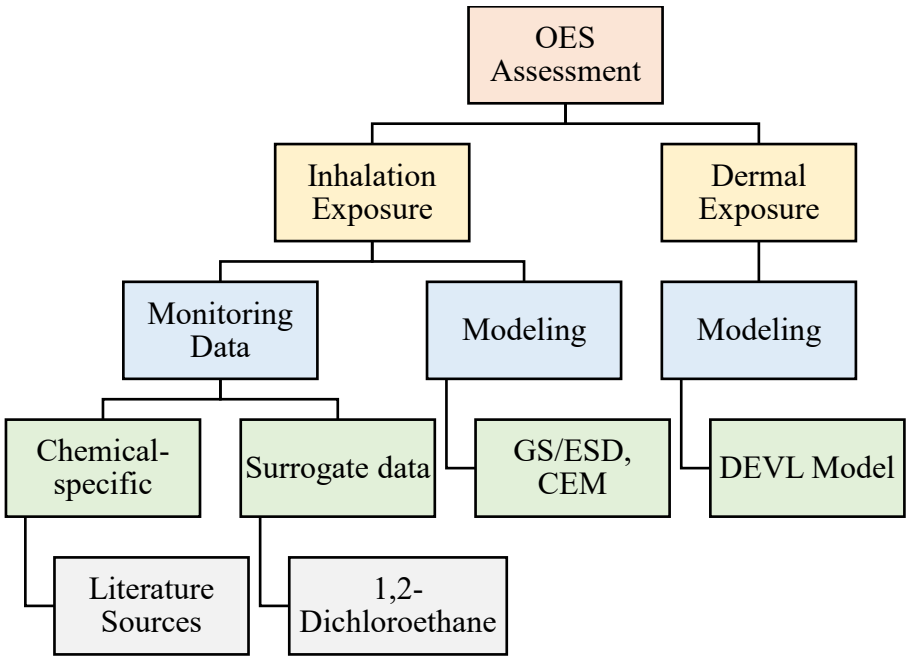

Figure 4-2. Approaches Used for Each Component of the Occupational Assessment for Each OES
GS = generic scenario; OES = occupational exposure scenario; ESD = emission scenario document; CEM = Consumer Exposure Model; DEVL = Dermal Exposure to Volatile Liquids

For inhalation and dermal exposure routes, EPA provided occupational exposure results representative of central tendency and high-end exposure conditions except for one OES (*i.e.,* Fuels and Related Products – Refueling OES). The central tendency is expected to represent occupational exposures in the center of the distribution for a given COU. For inhalation exposure assessment of OESs where EPA identified and used chemical-specific, or surrogate monitoring data, EPA used the 50th percentile (median) of the monitoring data distribution (8-hour TWA) to represent the central tendency scenario. For inhalation exposure assessment of OES (*i.e.,* Fuels and Related Products – Refueling OES) where EPA modeled exposure, EPA used the modeled peak concentration in combination with duration of a single exposure event (*i.e.,* 5.3 minutes) to represent a low-end scenario. Peak concentration (as a CEM output), in this scenario, is almost the average concentration during the continuous event (refueling of avgas in aircraft) of 5.3 minutes. Because the CEM assumes an outdoor setting with continuous ventilation, the modeled ethylene dibromide vapor concentration increases rapidly at the onset of a refueling event, remains essentially steady throughout the refueling duration, and then falls to zero immediately once refueling stops. This behavior reflects the model's parameterization of an outdoor environment with constant air movement, which quickly disperses vapors once the emission source ceases.

For this OES, EPA provided inhalation exposure results representative of low-end and high-end exposure conditions as there is more uncertainty with the distribution of various parameters used in modeling to represent the central tendency. To estimate low-end acute, intermediate, and non-cancer chronic exposures, the Agency used the modeled peak concentration and an exposure frequency of one refueling event per workday. To estimate high-end acute, intermediate, and non-cancer chronic exposures, EPA used the same peak concentration and an exposure frequency of eight refueling events per workday. The difference between the low- and high-end estimates for chronic, cancer estimates is mainly the assumption of one exposure event per day (low-end), 31 working years versus eight exposure events per day (high-end), and 40 working years for workers.

The high-end exposure is expected to represent occupational exposures that occur at probabilities above the 90th percentile but below the highest exposure for any individual (U.S. EPA, 1992b). For all other inhalation exposure assessments for other OESs assessed for workers and ONUs in this document, EPA provided high-end results at the 95th percentile. For the Fuels and Related Products – Refueling OES, since the full distribution is not known and the preferred statistics are not reasonably available, EPA could not estimate 95th percentile value of exposure to represent high-end, rather estimated a maximum or bounding estimate in lieu of the high-end.

For all dermal exposure assessments, EPA used the arithmetic mean value of ethylene dibromide concentrations for a given COU to represent the central tendency scenario. EPA also used the maximum or bounding value of concentrations for the given COU in lieu of the high-end.

Table 4-3 provides a summary of whether monitoring data were reasonably available for each OES, and if data were available, the number of data points, and the quality of that data. It also provides EPA's overall confidence rating in the exposure estimates and whether the Agency used modeling to estimate inhalation and dermal exposures for workers.

Table 4-3. Summary of Inhalation and Dermal Exposure Monitoring and Modeling Data for Each OES

OES	Inhalation Exposure									Dermal Exposure			
	Monitoring					Modeling		Weight of Scientific Evidence Conclusion for Exposure Estimates [c]		Modeling		Weight of Scientific Evidence Conclusion for Exposure Estimates [c]	
	# Worker Data Points [a,f]	# of NDs (Workers)	# ONU Data Points [b,f]	# of NDs (ONUs)	Overall Quality Determination	Worker	ONU	Worker	ONU	Worker	ONU	Worker	ONU
Import and Repackaging	47	5	8	0	Medium–High	×	×	Moderate	Moderate	✓	N/A	Moderate	N/A
Incorporation into Formulation, Mixture, or Reaction Product	39	2	5	0	Medium–High	×	×	Moderate	Moderate	✓	N/A	Moderate	N/A
Laboratory Use [d]	21	2	0	0	Medium–High	×	×	Moderate	Slight – Moderate	✓	N/A	Moderate	N/A
Fuels and Related Products – Bulk Terminals [d,e]	N/A	N/A	N/A	N/A	N/A	✓	✓	Moderate	Slight – Moderate	✓	N/A	Moderate	N/A
Fuels and Related Products – Refueling [d]	N/A	N/A	N/A	N/A	N/A	✓	✓	Moderate	Slight – Moderate	✓	N/A	Moderate	N/A
Waste Handling, Treatment, and Disposal – Landfill [d]	12	0	0	0	Medium	×	×	Moderate	Slight – Moderate	✓	N/A	Moderate	N/A

OES	Inhalation Exposure									Dermal Exposure			
	Monitoring					Modeling		Weight of Scientific Evidence Conclusion for Exposure Estimates [c]		Modeling		Weight of Scientific Evidence Conclusion for Exposure Estimates [c]	
	# Worker Data Points [a,f]	# of NDs (Workers)	# ONU Data Points [b,f]	# of NDs (ONUs)	Overall Quality Determination	Worker	ONU	Worker	ONU	Worker	ONU	Worker	ONU
Waste Handling, Treatment, and Disposal – Wastewater [d]	5	0	0	0	Medium	×	×	Moderate	Slight – Moderate	✓	N/A	Moderate	N/A
Distribution in Commerce	EPA assessed activities within this OES as part of other individual OESs and not as a standalone OES.												

OES = occupational exposure scenario; ONU = occupational non-user
Where EPA was not able to estimate ONU inhalation exposure from monitoring data or models (indicated by an "×"), this was assumed equivalent to the central tendency air concentration experienced by workers for the corresponding OES.
Overall quality determinations for reported data are based on EPA systematic review and include ratings of low, medium, and high.
[a] EPA assumed as workers based on job title or activity described in literature sources.
[b] EPA assumed as ONUs based on job title or activity described in literature sources.
[c] Weight of Scientific Evidence conclusions are derived by evaluating the totality of available scientific information.
[d] ONUs exposures are assessed based on workers' central tendency values from monitoring data.
[e] Assessed based on surrogate data from generic scenario.
[f] Number of non-detects in datasets used for the assessment of each OES can be found in Table 4-7.

4.1.1.3 Approaches Used to Estimate Inhalation Exposure for Ethylene Dibromide

EPA followed the exposure assessment hierarchy depicted in Table 4-1 and used the highest rated approach available for each OES. A summary of the approaches used to estimate inhalation exposure for each OES for ethylene dibromide is presented below in Table 4-4. Additional details on worker activities performed by the exposure groups for each OES can be found in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

1571 **Table 4-4. Approaches Used to Estimate Inhalation Exposure for Each OES for Ethylene Dibromide**

OES	Approach Used to Estimate Inhalation Exposure [a]
Import and Repackaging	***OES-Specific, Chemical-Specific, Personal Breathing Zone (PBZ) Monitoring Data from Literature*** For the Import and Repackaging OES, the inhalation exposure assessment was based on historical PBZ monitoring data collected by NIOSH in 1977 from U.S. facilities involved in ethylene dibromide manufacturing, blending, and anti-knock product processing (NIOSH, 1977a, b, c, d). Worker activities based on these literature sources include loading and unloading containers, unhooking and hooking lines from tank cars, cleaning containers that previously stored ethylene dibromide, handling, and taking samples. The dataset included 47 PBZ samples for workers, covering activities such as loading, unloading, shipping, receiving, operating blending from control room, drum washing, and raw material handling, and 8 PBZ datapoints for ONUs. Of these 47 data points: 9 were from shipping/receiving, 21 from loading/unloading, 2 from direct raw-material handling, and 20 from closed-system operations. Twenty out of these 47 data points were from sites where various types of PPEs were worn by workers during activities (*e.g.,* rubber gloves for most activities, and respirators with organic vapor cartridges when additional protection was needed). EPA did not use any surrogate or model data for assessing this OES. The reported limit of detection (LODs) for these samples varied from 4.0E−05 to 0.03 mg/m³, depending on sampling method. Among the worker samples, a total of 5 were non-detects (NDs), and for ONUs, all 8 samples were above the LOD. NDs were used by substituting half the LOD value in exposure calculations. The measured concentrations for workers ranged from below detection up to 13 mg/m³, reflecting both lower concentration of ethylene dibromide in liquid mixtures (*e.g.,* 18–35 wt%) and neat forms (*i.e.,* 100 wt%) of ethylene dibromide. Key uncertainties with this dataset include its age (reported in 1977), potential differences in workplace practices and engineering controls compared to current operations, and the lack of clarity in these reports regarding whether the operations were fully indoor or outdoor, which may overestimate exposures for facilities where all activities now occur outdoors. Despite these limitations, the dataset was considered relevant due to the similarity of tasks and ethylene dibromide concentration ranges to current import and repackaging operations.
Incorporation into Formulation, Mixture, or Reaction Product	***OES-Specific, Chemical-Specific, PBZ Monitoring Data from Literature*** For the Incorporation into Formulation, Mixture or Reaction Product OES, the inhalation exposure assessment was based on monitoring data from two reports (NIOSH, 1977b, c) and one industrial hygiene survey (Velsicol Chem Corp, 1978). EPA used a total of 38 PBZ exposure monitoring datapoints from these three reports for workers, covering activities such as blending, laboratory analysis, drum loading, drum washing, and general process operations in facilities where ethylene dibromide was used in anti-knock blending and other chemical processing. Although antiknock use has ceased, EPA considers these blending data analogous to other processing (*e.g.,* avgas, other products). A total of 35 of these 38 data points used in this assessment are from ethylene dibromide processing sites that reported closed system operations, and workers wearing various types of PPEs (*e.g.,* goggles, rubber gloves for most activities, and respirators with organic vapor cartridges when additional protection was needed). EPA used 5 datapoints for ONUs. The reported LODs varied from 4.0E−05 mg/m³ to 0.02 mg/m³. Out of 38 total datapoints for workers, two measured samples were NDs and 36 datapoints were above the LOD. All ONUs measured samples were above the LOD. NDs were handled by substituting half the LOD value in exposure calculations. The measured concentrations for workers ranged from below detection up to 0.45 mg/m³, reflecting both lower concentration of ethylene dibromide in liquid mixtures (*e.g.,* 18–35 wt%) and neat forms (*i.e.,* 100 wt%) of ethylene dibromide.

OES	Approach Used to Estimate Inhalation Exposure [a]
	Key uncertainties with this dataset include the age of the data (collected in the late 1970s), potential differences in workplace practices and engineering controls compared to current operations, and the lack of clarity whether the dataset were collected outdoor or indoor which may not fully represent exposures in fully outdoor settings. Despite these limitations, the dataset was considered relevant due to the similarity of tasks, processes, and ethylene dibromide concentration ranges to current ethylene dibromide processing operations. As indicated in the Executive Summary, EPA is seeking information that may be more representative and reliable for characterizing current exposure scenarios.
Laboratory Use	***OES-Specific, Chemical-Specific, PBZ Monitoring Data from Literature*** For the Laboratory Use OES, the inhalation exposure assessment was based on OES-specific, chemical-specific, PBZ monitoring data identified in 4 reports (NIOSH, 1977a, c, d, e), which together provided a total of 21 PBZ exposure monitoring datapoints for workers classified as laboratory technicians. These data covered activities such as laboratory analysis, quality control testing, and sample handling in laboratory sites within facilities where ethylene dibromide was manufactured, processed, or blended. The laboratory technicians typically performed quality-control analyses related to ethylene dibromide production, often in ventilated hoods within laboratory buildings, with occasional non-routine sampling in plant areas. Ten of these 21 data points used in this assessment are from laboratory facilities within ethylene dibromide manufacturing processing sites that reported closed system operations, and workers wearing various types of PPEs (*e.g.,* goggles, rubber gloves for most activities, and respirators with organic vapor cartridges when additional protection was needed). The reported LODs for these datasets ranged from 2.0E−04 mg/m^3 to 0.05 mg/m^3. Among the worker samples, 2 samples were not detected (ND), while the remainder of the samples were above the LOD. NDs were handled by substituting half the LOD value in exposure calculations. The measured concentrations for workers ranged from at/below the LOD up to 26.72 mg/m^3—reflecting both lower concentrations associated with laboratory handling of diluted mixtures and higher concentrations potentially encountered when handling neat ethylene dibromide. Key uncertainties with this dataset include the age of the data (collected in the late 1970s), potential differences in current laboratory settings (*e.g.,* locations, potential for secondary exposure to ethylene dibromide), workplace practices and engineering controls compared to current laboratory operations. These factors may limit the representativeness of the data for current laboratory environments, especially isolated laboratory sites with advanced engineering controls or lower ethylene dibromide test frequency. Despite these limitations, the dataset was considered relevant due to the similarity of laboratory tasks, processes, and ethylene dibromide concentration ranges to current laboratory use scenarios. EPA did not identify any ONU-specific exposure monitoring data for this OES; therefore, EPA based the ONUs exposure estimates on the central tendency of workers exposure.
Fuels and Related Products	***Exposure Modeling*** EPA did not identify inhalation exposure monitoring data related to the use of ethylene dibromide as a fuel agent in petroleum refineries or in fuels and related products. Therefore, EPA modeled inhalation exposure for both workers and ONUs for this OES. For the Fuels and Related Products – Bulk Terminals OES, the inhalation exposure assessment was based on surrogate monitoring data from the Fuels and Related Products Generic Scenario (GS) (U.S. EPA, 2021b). Worker activities under this OES may include various fuel handling-related activities such as transferring fuel from 1 tank to another, connecting hoses and valves, managing spills, conducting inspections and repairs, and cleaning tanks. Exposure concentrations were estimated by applying the fraction of ethylene dibromide present in 100LL avgas vapor to measured volatile organic compound (VOC) concentrations reported at petroleum bulk

OES	Approach Used to Estimate Inhalation Exposure [a]
	terminals. This approach allowed the assessment to approximate ethylene dibromide exposures for workers engaged in activities such as fuel transfer, storage, and handling at bulk terminals, using petroleum VOC data as a surrogate for modeling. The method accounts for the composition of avgas and the physical-chemical properties of ethylene dibromide but may not fully capture the variability in engineering controls, work practices, or environmental conditions present in current operations. Despite these limitations, the approach was considered appropriate due to the lack of chemical-specific monitoring data and the similarity of tasks and exposure scenarios to current fuels and related products operations. For the Fuels and Related Products – Refueling OES, worker activities related to refueling aircraft tanks with avgas may include sampling avgas, connecting and disconnecting fuel hose. For this OES, the inhalation exposure assessment was based on a two-steps modeling approach for assessing inhalation exposure to ethylene dibromide from refueling for both workers and ONUs. First, to estimate the total avgas emissions into the ambient air due to the transfer of fuel from the airport's fuel storage tank into the airplane fuel tank during one refueling event, EPA used the AP-42 guidance document (U.S. EPA, 2008a) on modeling VOC emissions (loading loss, *i.e.,* the emissions which "escape" to the ambient air) from transferring petroleum liquids from a large tank to a smaller tank through a pipe. EPA estimated the total ethylene dibromide emissions from the total avgas VOC (loading loss) by accounting for the weight fraction, vapor pressure and molecular weight of each component of the avgas. In the second step, EPA used the Consumer Exposure Model (CEM) to model dispersion of the ethylene dibromide "loading loss" emissions within the PBZ of the worker or consumer refueling the airplane, to estimate the inhalation exposure. User-defined parameterization was incorporated (*e.g.,* windspeed, breathing zone volume, air exchange rate). The model was used to approximate an outdoor refueling scenario by estimating the peak air concentration of ethylene dibromide within the breathing zone (0.2 m^3 air bubble) of a refueler (worker or consumer) during one refueling event. The peak air concentration of ethylene dibromide is the average concentration of ethylene dibromide in breathing zone of a refueler during one refueling event. The peak air concentrations of ethylene dibromide, in combination with other exposure factors, were then used to estimate inhalation exposure from refueling. For this OES, EPA estimated low-end exposure values and high-end exposure values based on the assumption that a worker refuels one to eight aircraft in an 8-hour workday; and is exposed to peak concentration of ethylene dibromide during each refueling event only and not continuously during the entire work shift. EPA did not identify sufficient information to assume an exposure frequency value that would represent the 50th percentile or central tendency of this distribution; therefore, presented low- and high-end exposure estimates for this scenario.
Waste Handling, Treatment, and Disposal	EPA did not identify any exposure monitoring data from U.S. facilities for this OES; but identified limited exposure monitoring data from foreign countries as described below. Worker activities under this OES may include loading, unloading, cleaning of transport containers for ethylene dibromide containing waste, neutralization, incineration, and site cleanup activities. ***OES-Specific, Chemical-Specific, PBZ Monitoring Data from Literature*** For the wastewater treatment scenario under Waste Handling, Treatment, and Disposal OES, EPA identified 2 identical ethylene dibromide-specific PBZ monitoring data points (no NDs) from a hazardous waste incineration facility in Turkey (Bakoğlu et al., 2004). The measured concentrations were 7.7E−05 mg/m^3. While these data provide direct, chemical-specific PBZ measurements, EPA considered these data to be insufficient, and therefore, supplemented with surrogate monitoring data on 1,2-dichloroethane. The surrogate dataset was gathered from a waste treatment facility study in Finland (Lehtinen and Veijanen, 2011), which included 3 PBZ samples collected from workers at a hazardous waste incinerator handling 1,2-dichloroethane. All samples were measured values, with

OES	Approach Used to Estimate Inhalation Exposure [a]
	concentrations ranging from 0.15–0.52 mg/m³ and sample durations of 480 minutes. EPA adjusted these surrogate data to account for differences in vapor pressure and molecular weight between 1,2-dichloroethane and ethylene dibromide. Key uncertainties with this approach include the use of a surrogate chemical, potential differences in waste composition and facility operations, and the non-U.S. origin of the data. Additionally, the limited number of samples and lack of detailed contextual information about engineering controls or workplace practices at the time of sampling introduce further uncertainty. Despite these limitations, the combination of chemical-specific, and surrogate dataset was considered appropriate for this OES primarily due to the relevance of the waste treatment activities for these 2 chemicals. ***OES-Specific, Surrogate, Area Monitoring Data from Literature*** For landfill scenario under the Waste Handling, Treatment, and Disposal OES, EPA did not identify ethylene dibromide-specific monitoring data. Instead, surrogate area monitoring data for 1,2-dichloroethane (a structurally similar halogenated ethane) were used. The primary surrogate dataset was from a landfill study in Greece (Loizidou and Kapetanios, 1992), which included 12 area air samples collected at various locations within and near the landfill. All samples were measured values, with concentrations ranging from 7.0E−04 to 0.014 mg/m³ and sample durations of approximately 60 minutes. EPA adjusted these surrogate data for differences in vapor pressure and molecular weight between 1,2-dichloroethane and ethylene dibromide to estimate relevant exposure concentrations. Key uncertainties include the use of a surrogate chemical, differences in waste composition and facility operations, and the non-U.S. origin of the data. Despite these limitations, the surrogate dataset was considered appropriate due to the structural and physicochemical similarities between the two chemicals and the relevance of landfill and waste handling activities.

OES = occupational exposure scenario; ONU = occupational non-user
[a] Values below the limit of detection (LOD) were replaced with LOD ÷ 2, unless otherwise noted

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4.1.1.4 Approaches Used to Estimate Dermal Exposure for Ethylene Dibromide

Dermal exposure monitoring data were not available for any OES in the assessment from systematic review of the literature. No test order data on dermal absorption was available. Therefore, to assess dermal exposure, the Agency used a modeling approach. EPA used the EPA Dermal Exposure to Volatile Liquids (DEVL) Model to calculate the acute potential dose rate (APDR) for each OES. The dose estimates assume one dermal exposure event (applied dose) per workday and approximately 1.6% of the applied dose is absorbed through the top-most layer of the skin and retained in the viable epidermis layer of the skin, based on fractional absorption data that was predicted by IH SkinPerm modeling, which assumes exposure to an aqueous solution.

The DEVL (see Equation 4-1) modifieds EPA/OPPT Dermal Exposure to Liquids Model (peer-reviewed) by incorporating a "fraction absorbed (*fabs*)" parameter to account for the evaporation of volatile chemicals and estimates the APDR:

Equation 4-1.

$$APDR = S \times Qu \times fabs \times Yderm \times FT \div BW$$

Where:

- S = Surface area of skin in contact with the chemical formulation (cm^2)
- Qu = Dermal load (*i.e.,* the quantity of the chemical formulation on the skin after the dermal contact event, mg/cm^2-event)
- $fabs$ = Fractional absorption, (*i.e.,* the portion of chemical formulation retained in the epidermis layer of the skin and available for systemic absorption, accounting for evaporation of the chemical from the dermal load, Qu (unitless, $0 \leq fabs \leq 1$)
- $Yderm$ = Weight fraction of the chemical of interest in the liquid (unitless, $0 \leq Yderm \leq 1$)
- FT = Frequency of events (integer number/day)
- BW = Body weight (kg)

A summary of the dermal model input parameters is provided below in Table 4-5.

Table 4-5. Summary of Dermal Model Input Values

Input Parameter	Symbol	Value(s)	Unit	Reference
Dermal load	Qu	1.4–2.1	mg/cm^2	U.S. EPA (1992c)
Surface area	S	267–1,070	cm^2	U.S. EPA (2011a)
Weight fraction of chemical	Yderm	0.07–100	wt%	EAA (2020); Sigma-Aldrich (2024)
Frequency of events	FT	1	Unitless	
Fractional absorption	fabs	0.016	Unitless	Based on IH SkinPerm model
Body weight	BW	80	kg	U.S. EPA (2011a)

The weight fraction is determined based on EPA's review of currently available products and formulations containing ethylene dibromide, and feedback from stakeholders. The weight fraction used for each OES is summarized in Table 4-6.

Table 4-6. Summary of Occupational Exposure Scenario (OES) Weight Fraction Values

OES	Approach Used to Estimate Dermal Exposure
Import and Repackaging	The concentration evaluated for this OES is from 30–60 wt% for activities related to import of ethylene dibromide (U.S. EPA, 2020a), and from 0.07–100 wt% for activities related to repackaging of ethylene dibromide in avgas, and laboratory chemicals, respectively (Sigma-Aldrich, 2024; EAA, 2020). EPA applied a fractional absorption value for this dermal exposure assessment.
Incorporation into Formulation, Mixture, or Reaction Product	The concentration evaluated for this OES is from 0.07–60 wt% for activities related to the use of ethylene dibromide as a component in a formulation, mixture, or reaction product used in processing either as a feed or product (EAA, 2020; U.S. EPA, 2020a), and from 10–100 wt% for activities related to the use of ethylene dibromide as a reactant in a process (U.S. PTO, 2010). EPA applied a fractional absorption value of 0.016 for this dermal exposure assessment.
Laboratory Use	The concentration evaluated for this OES is from 0.07–100 wt% for activities related to the testing of avgas and as a neat reagent for laboratory use, respectively (Sigma-Aldrich, 2024; EAA, 2020). EPA applied a fractional absorption value of 0.016 for this dermal exposure assessment.
Fuels and Related Products	The concentration evaluated for this OES is from 0.07–0.1 wt% for activities related to the use of ethylene dibromide as a lead scavenger in fuels and related products (Chevron USA, 2024; EAA, 2020). EPA applied a fractional absorption value of 0.016 for this dermal exposure assessment.
Waste Handling, Treatment, and Disposal	The concentration evaluated for this OES is from 0.07–100 wt% for activities related to the disposal and treatment of avgas and disposal of neat chemical from laboratory or processing as a reactant use, respectively (Sigma-Aldrich, 2024; EAA, 2020; U.S. PTO, 2010). EPA applied a fractional absorption value of 0.016 for this dermal exposure assessment.

4.1.1.5 Summary of Inhalation Exposure Assessment

Table 4-7 presents a summary of inhalation exposure results based on reasonably available monitoring data and exposure modeling approaches used for each OES as described in Table 4-4. The *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d) provides additional details regarding all calculations along with EPA's approach and methodology for estimating inhalation exposures for all OESs.

Table 4-7. Summary of Occupational Inhalation Exposure Assessment Results for Ethylene Dibromide by OES

OES	COU(s)	Population	No. of Mon. Data Points	No. of NDs [g]	Duration of Mon. Data (min)	LOD	CT 8-Hour TWA Exp. Conc. (mg/m^3)	HE 8-Hour TWA Exp. Conc. (mg/m^3)	Sources/ Notes for Inhalation Data
Import and Repackaging	Manufacture – Import Processing – Repackaging	Workers	47	5	480	4.0E−05 to 0.03	0.19	5.4	Workers and ONUs activity-specific PBZ monitoring data from 5 ethylene dibromide facilities reported in 4 reports (NIOSH, 1977a, b, c, d).
		ONUs	8	0	480	4.0E−05	0.035	4.85	
Incorporation into Formulation, Mixture, or Reaction Product	Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in all other petroleum and coal products Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in petroleum refineries Processing – As a reactant [a] Industrial use – Other use [a]	Workers	38	2	430 to 480	4.0E−05 to 0.03	0.042	0.28	Workers activity-specific PBZ monitoring data from 3 ethylene dibromide facilities reported in 2 reports (NIOSH, 1977b, c) and an industrial hygiene report (Velsicol Chem Corp, 1978). ONUs activity-specific PBZ monitoring data from 2 ethylene dibromide facilities reported in 2 reports (NIOSH, 1977b, c).
		ONUs	5	0	480	4.0E−05	0.003	0.062	
Laboratory Use	Commercial use – Other use –Laboratory chemical	Workers	21	2	180 to 480	2.0E−05 to 0.05	0.054	1.69	Workers activity-specific PBZ monitoring data from laboratory sites within 5 ethylene dibromide facilities reported in 4r reports (NIOSH, 1977a, c, d, e). EPA used workers CT estimates for ONUs assessment as surrogate.
		ONUs	0	0	N/A	N/A	0.054	N/A	
Fuels and Related Products – Bulk Terminals	Industrial use – Fuel agents in petroleum refineries	Workers	N/A	N/A	N/A	N/A	0.034	0.102	Modeled exposure concentration using surrogate fuel VOC data from GS document and accounting for the composition, and the physical and chemistry properties of each component of avgas as described in Section

OES	COU(s)	Population	No. of Mon. Data Points	No. of NDs [g]	Duration of Mon. Data (min)	LOD	CT 8-Hour TWA Exp. Conc. (mg/m^3)	HE 8-Hour TWA Exp. Conc. (mg/m^3)	Sources/ Notes for Inhalation Data
		ONUs	N/A	N/A	N/A	N/A	0.034	N/A	5.6.3.4.3 and Appendix C.2.1 of the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). EPA used workers CT estimates for ONUs assessment as surrogate.
Fuels and Related Products – Refueling (Low Exposure) [a b f]	Commercial use – Fuels and related products	Workers	N/A	N/A	N/A	N/A	0.63	0.63	Modeled ethylene dibromide vapor emission during one refueling event and then modeled peak exposure concentration of ethylene dibromide near breathing zone in outdoor conditions using CEM as described in Section 5.6.3.4.3 and Appendix C.2.3 of the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). EPA used workers CT estimates for ONUs assessment as surrogate.
		ONUs	N/A	N/A	N/A	N/A	0.63	N/A	
Fuels and Related Products – Refueling (Medium Exposure) [a b f]	Commercial use – Fuels and related products	Workers	N/A	N/A	N/A	N/A	0.94	0.94	
		ONUs	N/A	N/A	N/A	N/A	0.94	N/A	
Fuels and Related Products – Refueling (High Exposure) [a b f]	Commercial use – Fuels and related products	Workers	N/A	N/A	N/A	N/A	1.6	1.6	
		ONUs	N/A	N/A	N/A	N/A	1.6	N/A	
Waste Handling, Treatment, and Disposal (Landfill) [a]	Disposal	Workers	12	0	~60	Not reported	1.0E−03	3.0E−03	OES specific area monitoring data for 1,2-dichloroethane was used from an international study (Loizidou and Kapetanios, 1992) as a surrogate for workers exposure by factoring in the difference between physical and chemical properties of these two chemicals. EPA used workers CT estimates for ONUs assessment as surrogate.
		ONUs	0	0	N/A	N/A	1.0E−03	N/A	

OES	COU(s)	Population	No. of Mon. Data Points	No. of NDs [g]	Duration of Mon. Data (min)	LOD	CT 8-Hour TWA Exp. Conc. (mg/m^3)	HE 8-Hour TWA Exp. Conc. (mg/m^3)	Sources/ Notes for Inhalation Data
Waste Handling, Treatment, and Disposal (Wastewater) [a]	Disposal	Workers	5	0	480	Not reported	9.0E−03	0.028	Ethylene dibromide-specific, OES specific PBZ data (Bakoğlu et al., 2004) and OES specific PBZ data for 1,2-dichloroethane used from an international study (Lehtinen and Veijanen, 2011) as a surrogate for workers exposure. EPA used workers CT estimates for ONUs assessment as surrogate.
		ONUs	0	0	N/A	N/A	9.0E−03	N/A	
Distribution in Commerce	EPA assessed activities within this OES as part of other individual OESs and not as a standalone OES								

Conc. = concentration; COU = condition of use; CT = central tendency; Exp = exposure; HE = high-end estimate; LOD = limit of detection; Mon = monitoring; ND = non-detect; No. = number; OES = occupational exposure scenario; ONUs = occupational non-user; PBZ = personal breathing zone; TWA = time-weighted average

[a] EPA assumed as workers based on job title or activity described in literature sources.

[b] EPA assumed as ONUs based on job title or activity described in literature sources.

[c] Weight of Scientific Evidence conclusions refer to confidence in the precision of the exposure estimates.

[d] ONUs central tendency exposures are assessed based on workers' central tendency values from monitoring data.

[e] Assessed based on surrogate data from generic scenario.

[f] The CT and HE exposure concentration values are not 8-hour TWAs rather peak concentrations during a single refueling event of a 5.3-minute duration.

[g] EPA assessed non-detects at LOD ÷ 2 when calculating 8-hour TWA concentrations.

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4.1.1.6 Summary of Dermal Exposure Assessment

Table 4-8 presents a summary of dermal exposures results that were used for risk calculations using both default and physiologically based pharmacokinetic (PBPK) hazard approaches. Dermal exposure monitoring data were not reasonably available for any OES; therefore, EPA modeled dermal exposure for workers under OES in this assessment.

The DEVL Model was used to calculate retained doses of ethylene dibromide in the viable epidermis layer of the skin which is the expected dose available for systemic absorption. The deterministic model calculates an acute retained dose (ARD) rate based on an assumed amount of liquid ethylene dibromide on skin during one contact event per day, and a fractional absorption of 0.016. EPA did not identify any data on fractional absorption of ethylene dibromide on skin, therefore, estimated a fractional absorption of 0.016 using IH SkinPerm tool by incorporating various input parameters that reflect the exposure scenarios (*e.g.,* concentration of ethylene dibromide, exposure frequency) and chemical-specific properties (*e.g.,* molecular weight, vapor pressure, octanol-water partition coefficient). IH SkinPerm assumes an aqueous solvent.

EPA used range of concentrations applicable for each COU in the dermal exposure assessments. The COU used the mean value of the concentration range for a given COU as the central tendency value, and the upper limit of the concentration range for the same COU as the high-end value for the exposure estimates. For example, for Manufacture – Import COU, the concentration of ethylene dibromide used ranges from 30 to 60 wt%. Therefore, EPA used 45 wt% value for estimating central tendency exposures and 60 wt% value for estimating high-end exposures.

In the absence of worker activity or use-specific information, EPA assumed a variable skin surface area equivalent to one hand (*i.e.,* 535 cm^2) for central tendency estimates and two hands (*i.e.,* 1,070 cm^2) for high-end estimates for all COUs. This is mainly because all worker activities (*e.g.,* loading, operating equipments) identified under all OESs require use of one or both hands. For Fuels and related products COU, EPA presents a more refined analysis with an assumption that the variable skin surface area is equivalent to one palm (*i.e.,* 267.5 cm^2) for central tendency estimates and one hand or two palms (*i.e.,* 535 cm^2) for high-end estimates. This is because typical worker activities under this COU (*i.e.,* sampling avgas, holding avgas nozzle) that may result in dermal exposure to ethylene dibromide liquid does not require use of both hands. Similarly, For Laboratory chemical COU, EPA presents a more refined analysis with an assumption that the variable skin surface area is equivalent to one palm (*i.e.,* 267.5 cm^2) for central tendency estimates and one hand or two palms (*i.e.,* 535 cm^2) for high-end estimates. This is because EPA identified that some of the uses under this COU require a small amount of ethylene dibromide (*e.g.,* 5 mL) that may not be sufficient to cover a skin surface area equivalent to two hands. Therefore, for scenarios where a worker uses a small volume of ethylene dibromide liquid, the refined assessment would be more representative of exposure.

In the dermal exposure modeling equation, the frequency of events (FT) is shown as a linear relationship with the acute absorbed dose (AAD); however, this fails to account for time between contact events. Since ethylene dibromide simultaneously evaporates from and absorbs into the stratum corneum, or the top-most layer of the skin, dermal exposure is a function of both the number of contact events per day and the time between contact events. EPA did not identify information on how many contact events may occur and the time between contact events. Therefore, the Agency assumed a single contact event per day for estimating dermal exposures. The values of the dermal load (Qu) were based on experimental studies of non-aqueous liquids to measure the quantity remaining on the skin after contact. In the study, an initial wipe test was performed that consisted of the subjects wiping their hands with a cloth saturated in the liquid. The amount of liquid retained on the hands was measured immediately after the

application. The values from the study ranged from 0.7 to 2.1 mg/cm^2 with a midpoint of 1.4 mg/cm^2 (U.S. EPA, 1992c). EPA used this 1.4 mg/cm^2 value for estimating the central tendency exposures and 2.1 mg/cm^2 for estimating the high-end exposures. The liquids used in the study were oils and selected for better retention and ease of measuring the amount retained on skin. Given ethylene dibromide is a less viscous and more volatile liquid than the oils used in the study, these dermal loadings values may be an overestimate.

In summary, using the DEVL Model, EPA estimated the retained dose of ethylene dibromide, which is the dose of ethylene dibromide absorbed through the stratum corneum of the skin and retained in the viable epidermis based on the predicted fractional absorption data from IH SkinPerm. The Agency used these retained dose values in the risk assessment acknowledging that this may represent a conservative estimate of the dose that is systemically absorbed into the body based on the uncertainty with the dermal load value used for these estimates. The loading values used are from the wipe study and do not reflect the true absorption and volatilization of ethylene dibromide. EPA did not assess dermal exposures to ONUs because ONUs are not expected to directly handle ethylene dibromide liquid as part of their duties. Therefore, ONUs are not expected to have dermal exposures in the workplace.

Specific details of the fractional absorption are presented in Section 5.4.4.2 of the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). For average adult workers, the surface area of contact was assumed equal to the area of one palm (*i.e.,* 267.5 cm^2), or one hand (*i.e.,* 535 cm^2), or two hands (*i.e.,* 1,070 cm^2), for central tendency exposures, or high-end exposures, respectively, depending on the exposure scenario (U.S. EPA, 2011a). Specific details of the dermal exposure assessment for each OES and equations for estimating dermal exposures can be found in Appendix B of the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

Consideration of Information on Dermal PPE Protection and Use

Hand protection provisions are provided in CFR 1910.138, but OSHA has not established quantitative protection factors for gloves. OSHA's hand protection standard (29 CFR 1910.138) requires that employers select and require employees to use appropriate hand protection when expected to be exposed to hazards such as those from skin absorption of harmful substances; severe cuts or lacerations; severe abrasions; punctures; chemical burns; thermal burns; and harmful temperature extremes. Dermal protection selection provisions are provided in CFR 1910.138(b) and require that appropriate hand protection is selected based on the performance characteristics of the hand protection relative to the task(s) to be performed, conditions present, duration of use, and the hazards to which employees will be exposed. OSHA provides various guidance documents on the selection of protective gloves (OSHA, 2017) and (OSHA, 2023; accessed August 11, 2026). These guidance documents note that glove permeability and breakthrough rates are affected by a number of factors, including temperature, glove thinning due to performance of tasks with increased pressure or friction, glove degradation, wear time, and reuse of gloves.

Table 4-8. Summary of Occupational Dermal Exposure Results of Ethylene Dibromide by OES [a]

OES	COU	Exposure Potential	Conc. of Ethylene Dibromide Used (wt%)	Skin Surface Area (cm²)	Loading Rate (mg/cm²)	APDR [b] (mg/day)	ARD (mg/kg-day)	IRD (mg/kg-day)	CRD [c] (mg/kg-day)	LCRD [c] (mg/kg-day)
Import and Repackaging	Manufacture – Import	CT	45	535	1.4	5.4	6.7E−02	4.9E−02	4.6E−02	1.8E−02
		HE	60	1,070	2.1	22	0.27	0.20	0.18	9.5E−02
	Processing – Repackaging	CT	50	535	1.4	6.6	7.5E−02	5.5E−02	5.1E−02	2.0E−02
		HE	100	1,070	2.1	36	0.45	0.33	0.31	0.16
Incorporation into Formulation, Mixture, or Reaction Product	Processing – Incorporation into formulation, mixture, or reaction product	CT	30	535	1.4	3.6	4.5E−02	3.3E−02	3.1E−02	1.2E−02
		HE	60	1,070	2.1	22	0.27	0.20	0.18	9.5E−02
	Processing – As a reactant	CT	55	535	1.4	6.6	8.2E−02	6.0E−02	5.6E−02	2.2E−02
		HE	100	1,070	2.1	36	0.45	0.33	0.31	0.16
Laboratory Use	Commercial use – Other use – Laboratory chemical (2-Hands)	CT	50	535	1.4	3.3	7.5E−02	5.5E−02	5.1E−02	2.1E−02
		HE	100	1,070	2.1	18	0.45	0.33	0.31	0.16
	Commercial use – Other use – Laboratory chemical (1-Hand)	CT	50	267	1.4	1.7	3.8E−02	2.7E−02	2.6E−02	1.0E−02
		HE	100	535	2.1	9	0.23	0.16	0.15	7.9E−02
Fuels and Related Products – Bulk Terminals	Industrial use – Fuel agents in petroleum refineries (2-Hands)	CT	8.5E−02	535	1.4	1.0E−02	1.3E−04	9.3E−05	8.7E−05	3.5E−05
		HE	1.0E−02	1,070	2.1	3.6E−02	4.5E−04	3.3E−04	3.1E−04	1.6E−04
Fuels and Related Products – Refueling	Commercial use – Fuels and related products (1-Hand)	CT	8.5E−02	267	1.4	5.E−03	6.4E−05	4.7E−05	4.4E−05	2.2E−05
		HE	1.0E−02	535	2.1	1.8E−02	2.3E−04	1.6E−04	1.5E−04	7.9E−05
Waste Handling, Treatment, and Disposal (Landfill)	Disposal	CT	50	535	1.4	6.6	7.5E−02	5.5E−02	5.1E−02	2.0E−02
Waste Handling, Treatment, and Disposal (Wastewater)		HE	100	1,070	2.1	36	0.45	0.33	0.31	0.16
Distribution in Commerce	Distribution in commerce	EPA assessed activities within this OES as part of other individual OESs and not as a standalone OES								

APDR = acute potential dose rate; ARD = acute retained dose; Conc. = concentration; COU = condition of use; CRD = chronic retained dose – non-cancer; CT = central tendency; IRD = intermediate retained dose; HE = high-end estimate; LCRD = lifetime chronic retained dose – cancer; OES = occupational exposure scenario

[a] The dermal exposure estimates presented in this table were used for separate risk calculations using default and PBPK hazard approaches.

[b] EPA assumed 1.6E−02 fractional absorption value for ethylene dibromide based on IH SkinPerm tool for all OESs and calculated APDR based on this value.

[c] EPA assumed 250 days/year exposure frequency for exposure calculations for chronic durations.

4.1.1.7 Estimate the Number of Workers and Occupational Non-Users Potentially Exposed

An assessment objective is to estimate the number of workers and ONUs potentially exposed to ethylene dibromide in the workplace. Normally, a primary difference between workers and ONUs is that workers may handle ethylene dibromide and have direct contact with the chemical, while ONUs are working in the general vicinity of workers but do not handle ethylene dibromide nor have direct contact with ethylene dibromide. 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. Where available, EPA used CDR data to provide a basis to estimate the number of workers and ONUs. Data were available from the 2020 and 2024 CDR for two companies; however, the Agency determined this was not sufficient to determine the total number of workers for that OES. EPA supplemented the available CDR data using available market data; NAICS and Standard Industrial Classification (SIC) code data from TRI, DMR, and NEI sites identified for each COU; and analyzed U.S. Bureau of Labor Statistics (BLS) and U.S. Census data using the methodology described in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). Where market penetration data and site-specific NAICS/SIC codes from TRI/DMR/NEI were not available, EPA estimated the number of workers using data from GSs and ESDs. For additional details on development of estimates of number of workers refer to Section 5.4.2 of the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

EPA also determined the number of days per year that workers are potentially exposed to ethylene dibromide. 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 such that the maximum exposure days per year was still 250.

Results

Table 4-9 provides a summary for the number of workers and ONUs potentially exposed to ethylene dibromide per facility. The estimates are provided for a facility within each OES.

Table 4-9. Total Number of Workers and ONUs Potentially Exposed to Ethylene Dibromide for Each OES

OES [a]	Exposure Days Per Year	Potential Number of Sites	Potential Number of Workers per Site[b]	Potential Number of ONUs per Site
Import and Repackaging	250	47	1.4	1.2
Incorporation into Formulation, Mixture, or Reaction Product	250	108	27.9	13.8
Fuels and Related Products	250	1,806	2	2.3
Laboratory Use	250	4	5.6	9.3
Waste Handling, Treatment, and Disposal	250	801	2.1	5
Distribution in Commerce[a]	Not assessed as a standalone OES			

CDR = chemical data reporting; DMR = discharge monitoring report; NEI = National Emissions Inventory; OES = occupational exposure scenario; ONU = occupational non-user; TRI = Toxics Release Inventory
[a] The following OES was qualitatively assessed: Distribution in Commerce

OES [a]	Exposure Days Per Year	Potential Number of Sites	Potential Number of Workers per Site[b]	Potential Number of ONUs per Site
[b] Number of workers and ONUs estimates based on U.S. Census Bureau Data, U.S. BLS data, CDR, DMR, TRI, and NEI (U.S. BLS, 2023; U.S. Census Bureau, 2017)				

4.1.1.8 Weight of Scientific Evidence Conclusions for Occupational Exposure

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, including quality of the data/information, applicability of the exposure data to the OES (including considerations of temporal and locational relevance) and the representativeness of the estimate for the whole industry. The best professional judgment, based on consideration of the reasonably available information, is summarized using the descriptors of robust, moderate, slight, or indeterminate, in accordance with the 2021 Draft Systematic Review Protocol (U.S. EPA, 2021a). For example, a conclusion of moderate weight of scientific evidence is appropriate where there are measured exposure data from a limited number of sources, such that there is a limited number of data points that may not be representative of worker activities or potential exposures, whereas a robust rating would be considered representative of all potential exposures. A conclusion of slight weight of scientific evidence is appropriate where there is limited information that does not sufficiently cover all potential exposures within the OES, and the assumptions and uncertainties are not fully known or documented.

EPA assigned overall confidence descriptions of robust, moderate, or slight to the exposure assessments, based on the strength of the underlying scientific evidence. When the assessment is supported by robust evidence, the Agency's overall confidence in the exposure assessment is robust; when supported by moderate evidence, EPA's overall confidence is moderate; when supported by slight evidence, the Agency's overall confidence is low.

Inhalation Exposure

Weight of scientific evidence conclusion on the inhalation exposure assessment for each OES are presented below in Table 4-10. In general, for all OESs, there is uncertainty regarding the representativeness of supporting data with respect to the full distribution of exposures. This uncertainty is due to the variability in the full distribution for each OES and how well the exposure estimates reflect that variability. Although each exposure assessment is intended to present a set of conditions from which an understanding of occupational risks may be constructed, the variability in the determinants of exposure (*e.g.,* frequency, duration, etc.) from facility to facility within the full distribution of any OES is unknown. As a result, the worker exposure estimates uncertainties, as part of the integrated evidence streams, may impact the weight of scientific evidence conclusion for any OES. Unless otherwise stated, each inhalation exposure scenario (except for the Fuels and Related Products – Refueling OES) represents a worker with 8 exposure hours per day and 250 exposure days per year with continuous ethylene dibromide exposure each working day. See the 2021 Draft Systematic Review Protocol (U.S. EPA, 2021a) for additional information on weight of scientific evidence conclusions.

Overall confidence in inhalation exposure estimates varies across OESs and worker populations. The availability of PBZ monitoring data to support many of the occupational OESs increases confidence in inhalation exposure estimates. While there is some uncertainty around the representativeness of that data for specific OESs, the high-end exposure estimates are known to reflect actual exposures experienced by individuals included in sampling efforts. For ONUs, limited inhalation monitoring data were available.

In some cases, ONU exposures were estimated based on central tendency estimates for workers. In those cases, EPA has slight-to-moderate confidence in the exposure estimates.

Dermal Exposure

Weight of scientific evidence conclusion on the dermal exposure assessment for all OESs are presented below in Table 4-10. In general, for all OESs, there is uncertainty regarding the representativeness of assumed DEVL modeling input parameters (*e.g.,* skin surface area, loading rate) and exposure factors (*e.g.,* frequency of exposure) with respect to the full distribution of exposures. This uncertainty is due to the variability in the full distribution for each OES and how well the exposure estimates reflect that variability. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and that dermal contact to ethylene dibromide occurs once per day. Absorption of ethylene dibromide from occupational dermal contact with materials containing ethylene dibromide may extend for as long as ethylene dibromide remains on the skin. However, from IH SkinPerm modeling, it is predicted that after a brief exposure to ethylene dibromide liquid, over 98% of ethylene dibromide gets volatilized from skin in less than 2 hours. Descriptions on the approach for modeling fractional absorption using the IH SkinPerm tool and results are presented in Section 5.4.4.2 of the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

Exposure estimates are therefore presented in terms of retained dose in the epidermis layer of the skin and include adjustments for absorption and evaporation. For average adult workers, with 2-hands assumption, the surface area of contact was assumed equal to the area of one hand (*i.e.,* 535 cm^2), or two hands (*i.e.,* 1,070 cm^2), for central tendency exposures, or high-end exposures, respectively (U.S. EPA, 2011a). For average adult workers, with 1-hand assumption, the surface area of contact was assumed equal to the area of one palm including fingers (*i.e.,* 237.5 cm^2), or one hand (*i.e.,* 535 cm^2), for central tendency exposures, or high-end exposures, respectively (U.S. EPA, 2011a). The skin surface area and body weight for average adult worker were gathered from EPA's *Exposure Factors Handbook* (also called the "EFH" (U.S. EPA, 2011a), which received high ratings through EPA's systematic review process. The occupational dermal exposure assessment for contact with liquid materials containing ethylene dibromide was based on dermal exposure at the median and highest concentrations expected for a given OES, as well as exposure durations and area of contact, as described above.

Based on the strengths and limitations of the assessments, EPA has concluded that the overall confidence in dermal exposure estimates for all OESs is moderate. The Agency expects that high-end dermal exposure assumptions are a reasonable representation of potential acute exposure scenarios for some workers. EPA has less confidence that high-end exposures for workers handling ethylene dibromide are likely to occur every workday over longer durations represented by chronic exposure scenarios. Therefore, EPA expects that the central tendency dermal exposure estimates for workers are more representative for chronic exposure scenarios.

Table 4-10 summarizes the weight of scientific evidence ratings for the occupational exposures for each OES.

Table 4-10. Summary of Assumptions, Uncertainty, and Overall Confidence in Occupational Exposure Estimates by OES

OES	Confidence Rating	Weight of Scientific Evidence Conclusion in Occupational Exposure Estimates [a]
Import and Repackaging	Moderate	EPA used inhalation monitoring data identified through systematic review from industrial sites where the activities represent similar activities that occur during the Import and Repackaging OES. 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 full-shift TWA inhalation exposure estimates for Import and Repackaging OES. This assessment utilizes chemical-specific PBZ monitoring data for ethylene dibromide, providing direct and relevant exposure measurements for worker activities. EPA used 47 PBZ monitoring data points for workers and 8 data points for ONUs from 4 reports (NIOSH, 1977a, b, c, d). All monitoring data points used in estimating TWA concentrations received a medium or high overall quality determination through the systematic review process. The majority of the monitoring data points (*i.e.,* 42 of 47) for workers and all data points for ONUs (*i.e.,* 8) were measured values above the LODs, increasing confidence in the exposure estimates. Some of the monitoring data points used in this assessment are from facilities that reported operations being closed systems. Furthermore, the assessment incorporates a comprehensive scope by considering all relevant worker activities and exposure pathways identified through systematic review. This assessment covers a range of typical industry activities, including loading, unloading, shipping, receiving, and container cleaning which are representative of ongoing operations. The assessment applies well-validated equations and established EPA methodologies for calculating acute, intermediate, and chronic exposure concentrations, supporting consistency and transparency in exposure estimation. Exposure factors such as breathing rate are informed by robust data sources, enhancing the reliability of the exposure calculations. These strengths increase EPA's confidence in the exposure assessment for the Import and Repackaging OES. The occupational inhalation exposure assessment for Import and Repackaging OES also has several uncertainties. First, the assessment relies on monitoring data from industrial hygiene reports published in 1977, which may not reflect current workplace practices, engineering controls, or personal protective equipment (PPE) usage, and were collected at manufacturing and processing facilities rather than at dedicated import and repackaging sites. The monitoring data used for this assessment were collected at manufacturing and processing facilities, not specifically at import and repackaging facilities. While activities are similar, there may be differences in exposure potential. As a result, the representativeness of these data for present-day exposures is uncertain. Therefore, the primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA relied on 47 PBZ monitoring datapoints, including 5 non-detects (NDs) for estimating worker inhalation exposures gathered from ethylene dibromide manufacturing and processing facilities that are relevant to Import and Repackaging OES based on description of worker activities. The dataset for ONUs is limited, with only 8 PBZ samples (0 NDs) was used. The assessment further assumes 8-hour work shifts and 250 exposure days per year and treats task-based samples as representative of full-shift exposures, which

OES	Confidence Rating	Weight of Scientific Evidence Conclusion in Occupational Exposure Estimates [a]
		may not accurately reflect actual work patterns or exposure frequencies. For samples below the LODs, values were set to one-half the LOD, introducing additional uncertainty. The assessment is also limited by the small number of facilities represented in the data, which may not capture the full range of operational variability across the industry. Facility-specific information is also lacking regarding the extent to which the exposure monitoring data used for this assessment are relevant to and representative of this particular OES. EPA acknowledges that the monitoring data may not fully represent current exposure scenarios, especially for fully outdoor operations or facilities with significantly improved exposure control measurements compared to the facilities the data was originally gathered from. Further, the concentration of ethylene dibromide used at the facilities in the industrial hygiene reports was not always reported. Because in one report, ethylene dibromide was reported as being manufactured, EPA assumed the concentration was 100 wt%, and the other processing facilities were using ethylene dibromide at 18–35% (as reported in 1 report). The assessment assumes that concentrations are comparable to the main current use of ethylene dibromide under this OES (*i.e.,* 30–60 wt% in TEL-B). Another uncertainty is that EPA did not identify any facility-specific exposure days for this OES. The assessment assumes 250 exposure days per year (5 days/week, 50 weeks/year), which may overestimate exposure for facilities with less frequent operations. Where sample or shift durations were not reported, the assessment assumes an 8-hour work shift and that all relevant activities are performed by the same worker during that shift. Also, task-based samples were treated as representative of full-shift exposures, which may not always be accurate. These limitations decrease confidence in the assessment. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for both workers and ONUs inhalation exposure assessment is moderate.
Incorporation into Formulation, Mixture and Reaction Product	Moderate	EPA used inhalation monitoring data identified through systematic review from industrial sites where the activities represent similar activities that occur during the Incorporation into Formulation, Mixture and Reaction Product OES. 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 full-shift TWA inhalation exposure estimates for this OES. This assessment utilizes chemical-specific PBZ monitoring data for ethylene dibromide, providing direct and relevant exposure measurements for worker activities. The primary strength of this assessment is its reliance on ethylene dibromide-specific PBZ monitoring data. The assessment used 38 full-shift PBZ inhalational exposure measurements for workers and 5 PBZ data points for ONUs reported in 2 reports (NIOSH, 1977b, c) and an EPA industrial hygiene survey report (Velsicol Chem Corp, 1978). These three reports presented exposure monitoring data at 3 different industrial facilities where ethylene dibromide was processed. These processing sites included processes blending ethylene dibromide to produce anti-knock products for fuel use, and two of these 3 reported facilities were reported as operated in closed systems. The exposure monitoring data points used from these 3 reports are directly applicable to the worker activities (*e.g.,* blending, loading) evaluated under this OES, allowing the exposure estimates to be grounded in empirical evidence rather than solely on modeled or surrogate data. All monitoring data points used in estimating TWA concentrations received a medium or high overall

OES	Confidence Rating	Weight of Scientific Evidence Conclusion in Occupational Exposure Estimates [a]
		quality determination through the systematic review process. The majority of the monitoring data points (*i.e.,* 5 of 38) for workers and all data points for ONUs (*i.e.,* 5) were measured values above the LODs, increasing confidence in the exposure estimates. Two out of 3 of the facilities where data was gathered from reported operations being closed systems. This assessment applies well-validated equations and established EPA methodologies for calculating acute, intermediate, and chronic exposure concentrations, supporting consistency and transparency in exposure estimation. Exposure factors such as breathing rate are informed by robust data sources, enhancing the reliability of the exposure calculations. These strengths increase EPA's confidence in the exposure assessment for this OES. The occupational inhalation exposure assessment for Incorporation into Formulation, Mixture and Reaction Product OES also has several uncertainties. First, the assessment relies on monitoring data from industrial hygiene reports published between 1977 and 1980, which may not reflect current workplace practices, engineering controls, or PPE usage. The monitoring data used for this assessment were collected at three ethylene dibromide processing facilities operating with batch processes where two facilities were reported to be producing anti-knock formulations containing ethylene dibromide at a concentration range from 18 to 35 wt%. EPA expects that in current avgas producing facilities, the concentration of ethylene dibromide is typically from 30 to 60 wt% in the feed prior to blending with other fuel components (*e.g.,* gasoline) and the concentration of ethylene dibromide in the produce or avgas in from 0.07–0.1 wt%. While activities are similar, there may be differences in exposure potential based on the difference in concentration of ethylene dibromide used. As a result, the representativeness of these data for present-day exposures is uncertain. Furthermore, a stakeholder, Innospec, reported that the refineries who blend Innospec's TEL-B product into avgas operate their processes outdoor, in batch processes, using PPE and precautions necessary to prevent lead exposure (EPA-HQ-OPPT-2018-0488-0062). The exposure monitoring data from systematic review that EPA used lack necessary metadata to accurately characterize the applicability of the exposure data to current exposure potential at facilities where all operations are completely outdoor. However, there is some evidence based on a map that one of the facilities from where the exposure monitoring data was gathered from had blending operations occur at outdoor (see p. 11 of (NIOSH, 1977c)). Therefore, the primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. The dataset for ONUs is limited, with only 5 PBZ samples (0 NDs) being used. The assessment further assumes 8-hour work shifts and 250 exposure days per year and treats task-based samples as representative of full-shift exposures, which may not accurately reflect actual work patterns or exposure frequencies. For processing plants that operate on batch processes, the exposure may likely be more intermittent throughout a workday unlike continuous steady exposure at the same level for the entire duration. However, EPA did not identify necessary information to accurately characterize exposure patterns that would be applicable across all facilities operating within this OES. The assessment is also limited by the small number of facilities represented in the data, which may not capture the full range of operational variability across the industry. Facility-specific information is also lacking regarding the extent to which the exposure monitoring data used for this assessment are relevant to and representative of this particular OES. EPA acknowledges that the monitoring data may not fully represent current exposure scenarios—especially for fully

OES	Confidence Rating	Weight of Scientific Evidence Conclusion in Occupational Exposure Estimates [a]
		outdoor operations or facilities with significantly improved exposure control measurements compared to the facilities the data was originally gathered from. For samples below the LODs, values were set to one-half the LOD, introducing additional uncertainty. Where sample or shift durations were not reported, the assessment assumes an 8-hour work shift and that all relevant activities are performed by the same worker during that shift. Also, task-based samples were treated as representative of full-shift exposures, which may not always be accurate. These limitations decrease confidence in the assessment. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for both workers and ONUs inhalation exposure assessment is moderate.
Fuels and Related Products	Moderate	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine the weight of scientific evidence conclusion for the full-shift inhalation exposure estimates for Fuels and Related Products OES. To assess exposure at bulk terminals under Fuels and Related Products OES, EPA used surrogate exposure estimates using the Fuels and Related Products GS doc by accounting for the mole fraction and vapor pressure of ethylene dibromide in the vapor phase. Because there is uncertainty regarding the use of vapor recovery systems in these bulk terminals, EPA used a combination of "typical" and "worst case" exposure monitoring data from the GS in this exposure assessment for bulk terminals. To assess exposure from refueling aircraft with avgas, EPA used a modeling approach which accounted for the vapor loss of avgas during refueling an aircraft assuming 53-gallon tank capacity, physical and chemical properties of ethylene dibromide (*e.g.,* vapor pressure, molecular weight, octanol-water partition coefficient), and ventilation similar to outdoor conditions. For the refueling scenario, the Agency assumed that the exposure occurs periodically throughout a workday, and therefore characterized exposure based on 1–8 events of exposures in a workday. EPA also assumed 3 sub-scenarios with low, medium, and high inhalation exposure based on variations in windspeed (*i.e.,* high, medium, and low windspeed) and modeled exposure estimates based on these parameters. For both scenarios under this OES (*i.e.,* Fuels and Related Products), EPA used the concentration of ethylene dibromide from an active safety data sheet (SDS) and comments from stakeholders. These strengths increase EPA's confidence in the exposure assessment for this OES. The primary limitation is uncertainty in the assumptions of exposure factors. EPA did not identify site-specific number of operating days; therefore, the Agency assumed 250 days/year as maximum frequency of exposure. For the refueling scenario, the Agency did not identify any specific number of flights that refuel at a given airport on day, therefore, assumed 1–8 exposure events/day based on several analysis on local and national statistics of avgas usage. Analysis of these statistics on avgas usage and the rationale for 1–8 exposure events/day assumption are presented in Appendix C.2.5.2 of the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). To estimate the loading loss of avgas, EPA used an equation that has an uncertainty factor up to 30%. There are uncertainties with some parameters the Agency used for this assessment, such as usage volume of 53 gallons of avgas per 1 refueling event, flow rate of avgas as 10 gallons/min, EPA's assumption for a worker's breathing zone being always within 0.2 m^3

OES	Confidence Rating	Weight of Scientific Evidence Conclusion in Occupational Exposure Estimates [a]
		of ethylene dibromide emission source from refueling activity and varying ambient air flow. For ONUs exposures, EPA assumed the exposure to be similar to the central tendency of workers exposure. There is uncertainty with the proximity of ONUs to exposure sources in both scenarios under this OES. These limitations decrease confidence in the assessment for this OES. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this inhalation exposure assessment is moderate for workers and is slight-to-moderate for ONUs inhalation exposure assessment for both Bulk Terminals and Refueling scenarios.
Distribution in Commerce	N/A	The occupational exposure for this OES is assessed as part of individual OESs where the relevant activities occur.
Laboratory Use	Moderate	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 full-shift TWA inhalation exposure estimates for this OES. EPA used inhalation monitoring data identified through systematic review from industrial sites where the activities represent similar activities that occur during the Laboratory Use OES. All the data points utilized to estimate inhalation exposure estimates were rated medium primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA relied on 21 PBZ monitoring datapoints that are analogous from manufacturing, processing and blending sites that were classified as laboratory technicians. However, EPA lacks facility-specific information regarding the extent to which these monitoring data are relevant to and representative of this particular OES. EPA used workers central tendency exposure estimates to estimate ONUs exposure as the Agency did not identify any ONU-specific monitoring data. There is uncertainty with the proximity of ONUs to exposure sources in laboratory settings. Another uncertainty is that EPA set the number of exposure days as maximum 250 days/year as the Agency did not identify any facility-specific exposure days for this OESs These limitations decrease confidence in the assessment. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence is moderate for workers and slight-to-moderate for ONUs inhalation exposure assessment.
Waste Handling, Treatment, and Disposal	Slight-to-Moderate	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 full-shift TWA inhalation exposure estimates for this OES. For this assessment, the Agency used a combination of a chemical-specific monitoring data point with surrogate data from 1,2-dichloroethane risk evaluation. EPA selected 1,2-dichloroethane as a surrogate chemical as it has a structural similarity to estimate exposure, and the surrogate data was adjusted to account for the molecular weight and vapor pressure of ethylene dibromide; therefore, increasing the confidence in the monitoring data used. All the data points utilized to estimate inhalation exposure estimates were rated either medium or high for data quality from the systematic review process. EPA presented 2 separate assessments for landfill and wastewater treatment under the Waste Handling,

OES	Confidence Rating	Weight of Scientific Evidence Conclusion in Occupational Exposure Estimates [a]
		Treatment, and Disposal OES. These strengths increase the Agency's confidence in the exposure assessment for this OES. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA relied on very limited data points for this OES. This assessment lacks ethylene dibromide-specific monitoring data from any facility in the United States. EPA did not identify any ONU data and assumed that worker central tendency exposure values were representative of ONU exposures. There is uncertainty with the proximity of ONUs to exposure sources during worker activities relevant to this OES. Another uncertainty is that EPA set the number of exposure days as maximum 250 days/year as the Agency did not identify any facility-specific exposure days for this OES. These limitations decrease confidence in the assessment. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence is slight-to-moderate for both workers and ONUs inhalation exposure assessment.
Dermal Exposure Assessment	Moderate	EPA used specific concentrations (low- and high-end) related to each COU to account for variations in exposure depending on the concentration used. EPA estimated model parameter (*i.e.,* fractional absorption) using a peer-reviewed, IH Skin Perm tool to estimate dermal exposure, which accounts for the empirical physical and chemical properties of ethylene dibromide. The dermal exposure model DEVL used for dermal exposure assessment incorporated model parameters (*i.e.,* concentration, body weight, human skin surface area, loading rate) which were informed by high quality references. The Agency also used scenario-specific surface area assumptions; for example, when assessing dermal exposure for Fuels and Related Products OES, and Laboratory Use OES, EPA used 4 different surface areas, including the surface area of 1 palm to reflect exposure scenario of a small volume of chemical is handled. These strengths increase EPA's confidence in the exposure assessment for all OESs. The major limitation of dermal exposure assessment is that the Agency did not find any measured or monitoring data for dermal exposure, and all dermal absorption studies identified by systematic review were uninformed. Furthermore, EPA assumed several parameters based on best professional judgement as the Agency did not find any information from systematic review or public comments to accurately inform or characterize various parameters influencing dermal exposure scenarios (*e.g.,* skin surface area, exposure frequency, loading rate). There is also uncertainty with the modeled fractional absorption estimate, and with other parameters used in the DEVL Model, such as dermal loading value of 1.4–2.1 mg/cm^2. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for all dermal exposure assessments are moderate.

COU = condition of use; CT = central tendency; HE = high-end; LOD = limit of detection; OES = occupational exposure scenario; ONU = occupational non-user

[a] EPA assessed non-detects at LOD ÷ 2

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Overall, the exposure scenarios and exposure factors underlying the inhalation and dermal assessment are supported by moderate evidence. Occupational inhalation exposure estimates were informed by sources of directly applicable exposure monitoring data or modeling inputs with medium to high data overall quality determinations. Exposure factors for occupational inhalation exposure include duration of exposure, body weight, and breathing rate, which were informed by data sources with medium to high overall quality determinations.

EPA assumed that a worker typically works 8 hours per day, 5 days per week, for 31 to 40 years duration at the same exposure level for all OESs. Individuals may change jobs during the course of their career such that they are no longer exposed to ethylene dibromide, which would cause the actual chronic exposure estimates to be lower than the estimates presented. EPA collected tenure data to estimate central tendency and high-end working years of exposure, which is assumed to inherently take into account workers' changing jobs. There is also uncertainty as to the representativeness of the parameter distributions for all OESs because there are some gaps in site-specific information (*e.g.,* process descriptions, concentrations of ethylene dibromide used). In general, the effects of these uncertainties on the exposure estimates are unknown, as the uncertainties may result in either overestimation or underestimation of exposures depending on the assumptions.

Regarding ONU exposure, for some OESs, EPA assumed the exposure would be similar to the central tendency of workers exposure. The Agency calculated chronic average daily dose (ADD) values assuming workers and ONUs are exposed at the same level for their entire working lifetime, which may not reflect actual exposure.

4.1.2 Consumer Exposures

EPA evaluated reasonably available information for consumer products containing ethylene dibromide. The Agency did not find consumer uses from systematic review references but rather identified ethylene dibromide containing products from market research for products containing ethylene dibromide. EPA identified one product, 100LL avgas, that is available to consumers in the United States. 100LL avgas used for single engine small aircraft contains ethylene dibromide as a fuel agent or additive, specifically as a lead scavenger in leaded fuels to minimize lead deposits in engines. Consumers, or pilots of small non-commercial airplanes, may be exposed to ethylene dibromide when refueling small aircraft which use avgas. EPA identified SDSs for avgas that confirmed the presence of ethylene dibromide and the weight fraction at which it was present in the product (Chevron USA, 2024; Innospec, 2020). Given the products identified and the use patterns of the product, it was reasonable to conclude that oral exposure would not be an appropriate pathway of exposure to quantitatively assess.

EPA characterized inhalation exposure ($\mu g/m^3$) and dermal exposure (mg/kg-day) to ethylene dibromide during avgas refueling, and in the absence of monitoring data, used exposure modeling to develop low-, medium-, and high-intensity scenarios for both routes. To assess consumer exposure, the Agency grouped input parameters by intensity level, where as an example, the highest reported values or assumptions were used to estimate high-intensity exposure and risk (the same approach was applied to the medium- and low-intensity scenarios for the respective parameters, as characterized in Table 4-12 and Table 4-14). The three exposure scenarios encompass varying levels for different assumptions, including the parameters of skin surface area in contact with ethylene dibromide, dermal loading, weight fraction of ethylene dibromide in the fuel, exposure duration, and exposure frequency.

4.1.2.1 Summary of Consumer Exposure Scenarios

EPA identified two exposure routes for consumer use of ethylene dibromide, as summarized in Table 4-11: inhalation and dermal exposure during avgas refueling activities. According to the EAGLE

Initiative (last updated February 19, 2025), an estimated 461,000 pilots fly aircrafts that utilize 100LL avgas in the United States. After excluding Airline Transport Pilots (ATPs) and commercial pilots, approximately 264,000 pilots, including student pilots, remain as the potential consumer population (EAGLE, 2026). Because no pilot breakdown by aircraft type is available, EPA used the Cessna 172S—one of the most widely used small piston aircraft powered by avgas—as a benchmark to estimate refueling volume and to model consumers' inhalation and dermal exposures to ethylene dibromide in avgas. During self-service refueling, which is a common refueling practice among pilots or small non-commercial airplanes, the consumer or pilot must hold the nozzle while the fuel tank is being filled, which can lead to inhalation of vapors released from the fuel tank. Per FAA guidelines, the consumer or pilot is required to check for fuel impurities or contaminants after refueling to prevent engine damage (Cessna Aircraft Company, 1998; FAA, 1998).

Although sampling techniques vary, one stakeholder, Professional Aviation Maintenance Association (PAMA), noted that fuel sampling (also called "sumping") can result in dermal contact and the potential for dermal exposure increases when proper aviation fuel sump tools are not used (U.S. EPA, 2025c). Based on stakeholder input, it is common for avgas to drip on the hand that holds the sump tool during sampling and disposal of the sample. When proper sump tools are not available, the potential for dermal contact increases because fuel can easily get on both hands when improvised tools (*e.g.,* a screwdriver and a clear container) are used. The entire sampling process is estimated to take approximately 5 minutes (U.S. EPA, 2025c).

For the modeling approach, EPA used professional judgment supported by reasonably available information and stakeholder engagement to select model inputs. Key parameters included exposure duration, exposed skin surface area, exposure frequency, lifetime exposure duration, wind speed, and dermal loading (quantity remaining on skin), with additional details provided in Sections 4.1.2.2 and 4.1.2.3 regarding the key model input parameters for the inhalation and dermal exposure assessments, respectively.

For the ethylene dibromide consumer assessment, EPA considered two age groups, the Adult (21+ years) and Youth (16–20 years), as the minimum age requirement to become a student pilot is 16 years (14 CFR 61.83). FAA does not regulate the minimum age for refueling but regulates the minimum age requirement to be a student pilot. FAA also requires pilots to know the theoretical and safety management aspects of fuel before they grant a certificate (FAA, 2021). Therefore, EPA expects both adult and youth consumers to refuel aircraft at self-service stations infrequently but they may also refuel aircraft at fixed base operators (FBOs) where refueling is performed by workers depending on the availability of self-service fuel stations as permitted by applicable rules and regulations (FAA, 2026).

Table 4-11. Summary of Consumer COUs, Exposure Scenarios, and Exposure Routes

Condition of Use	Exposure Route	Media/ Exposure Pathway	Exposure Scenario	Populations/ Life Stage (Age)	Analysis (Quantitative or Qualitative)
Consumer use	Inhalation	Vapor released from fuel tank	Inhalation exposure to ethylene dibromide in vapor released from fuel tank	Adult (21+ years) Youth (16–20 years)	Quantitative
Consumer use	Dermal	Liquid avgas contact	Dermal exposure of ethylene dibromide from sampling	Adult (21+ years) Youth (16–20 years)	Quantitative

4.1.2.2 Summary of Inhalation Exposure Assessment

Due to the absence of consumer inhalation exposure monitoring data for ethylene dibromide, EPA assessed inhalation exposure through modeling using CEM (U.S. EPA, 2023a). Because CEM cannot directly estimate vapor-phase inhalation exposure to avgas, EPA calculated the emission rate of ethylene dibromide from vapor during refueling by determining evaporation losses during loading, known as loading loss (LL) (U.S. EPA, 2008a). This estimated emission rate was incorporated into CEM as a user-defined parameter, alongside the mass of the product and various other parameters, to calculate the peak concentration of ethylene dibromide in the inhalable vapor phase. The peak concentration in this scenario is the average concentration of ethylene dibromide in the breathing zone of a refueler or consumer. EPA then utilized this peak concentration from a single event to estimate low-, medium-, and high-end exposure values for consumers, based on the intensity of exposure. Further details are provided in Section 9.2 the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

EPA presents parameters used to estimate inhalation exposure in Table 4-12. The Agency identified a range of reported ethylene dibromide weight fractions in SDSs for leaded avgas 0.07 to 0.1 wt%. EPA estimated total ethylene dibromide emissions from avgas VOC loading losses using an ethylene dibromide weight fraction of 0.001 and component vapor pressure/molecular weight data. The detailed sources and the rationale of the parameters are presented in Section 9.2 of the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

Table 4-12. Parameters Used to Estimate Inhalation Exposure

Parameters	Symbol	Low-Intensity	Medium-Intensity	High-Intensity
Modeled Peak Exposure Concentration from One Event (mg/m³) [a]	C	0.63	0.94	1.57
Wind Speed (m/s) [b]	N/A	4.49	2.99	1.79
Exposure Frequency (days/year) [c]	EF	12	26	52
Lifetime Exposure Duration (=working years) (years/lifetime) [d]	WY	14	32	56
Exposure Duration (minutes/event) [e]	ED	5.3		
Breathing Zone Volume (m^3) [f]	N/A	0.20		
Breathing Rate Ratio [g]	BR	2.04		
Acute Averaging Time (hours)	AT_{acute}	24		
Averaging Time (hours) for Intermediate Exposure	AT_{int}	168 (= 1 week)		
Averaging Time (hours) for Cancer Risk	AT_c	683,280 (= 78 years)		

[a] EPA used the Consumer Exposure Model (CEM) to model dispersion of the ethylene dibromide "loading loss" emissions within the personal breathing zone of the worker or consumer refueling the airplane, to calculate peak exposure concentration to estimate the inhalation exposure. User-defined parameterization was incorporated (*e.g.,* windspeed, breathing zone volume, air exchange rate).
[b] Estimated based the 5th, 50th, and 95th percentiles of average wind speeds (1.79, 2.99, and 4.49 m/s) recorded from Automated Surface Observing System (ASOS) located at 917 airports across the United States, covering the period from January 1, 2005, to January 28, 2026 (NCEI, 2026).
[c] The low-intensity estimate of 12 days per year is based on the Federal Aviation Administration (FAA) requirement for retaining pilot licensing. The medium-intensity exposure estimate of 26 days per year is derived from information received from the Professional Aviation Maintenance Association (PAMA), which estimates that pilots flying for leisure, hobby, or personal use average about 100 flight hours annually (U.S. EPA, 2025c). The high-intensity

Parameters	Symbol	Low-Intensity	Medium-Intensity	High-Intensity
exposure estimate of 52 days per year is based on the assumption that individuals pursuing commercial pilot certification require at least 250 hours of flight time as a pilot annually (14 CFR part 61 subpart F). [d] The lifetime exposure duration was estimated based on the total pilot population. For the high-intensity exposure estimate, the 95th percentile age distribution is 72 years, which corresponds to 56 years of exposure if flying is assumed to begin at age 16. The medium-intensity exposure estimate uses the 75th percentile age of 48 years, resulting in an exposure duration of 32 years. For the low-intensity exposure estimate, the 50th percentile age is 30 years, leading to an estimated exposure duration of 14years (FAA, 2025). [e] Estimated duration to refuel 53 gallons of avgas per event. [f] A assumed sphere of 0.2 m^3 within where the source of emission/opening of aircraft fuel tank is located. This is the Low default for the near zone in CEM. [g] EPA uses a BR, which is the ratio between the worker (or consumer) breathing rate and resting breathing rate, to account for the amount of air a worker breathes during exposure. The typical worker breathes about 10 m^3 of air in 8 hours, or 1.25 m^3/h (CEB, 1991) while the resting breathing rate is 0.6125 m^3/h (U.S. EPA, 2011b). The ratio of these 2 values is equivalent to 2.04.				

Table 4-13 provides a summary of estimated non-cancer acute and intermediate inhalation exposure concentrations (mg/m^3) and cancer inhalation exposure concentrations (mg/m^3) of ethylene dibromide resulting from the consumer use of avgas at fuel pumps. EPA presented three distinct exposure estimates low-, medium-, and high-intensity based on variations in breathing zone volume, wind speed, exposure frequency, and exposure duration.

For consumers, EPA assessed risk due to inhalation acute and intermediate exposure, as well as cancer. However, non-cancer chronic exposures were not used for exposure and risk calculation. For chronic exposure scenarios, cancer risk predominates over non-cancer risk based on the relative magnitude of the selected toxicity values. Furthermore, the use of a LADC better accounts for both periods of exposure and periods of non-exposure through the application of an averaging time (AT) parameter, which is relevant for the consumer refueling exposure scenario being characterized.

Table 4-13. Estimated Consumer Inhalation Exposure to Ethylene Dibromide for Avgas Refueling Scenario

Exposure Intensity	Non-Cancer Acute Exposure Concentration (AC) (mg/m^3)	Non-Cancer Intermediate Average Daily Concentration (IADC) (mg/m^3)	Lifetime Average Daily Concentration (LADC) for Chronic Cancer Risk (mg/m^3)
Low	4.70E−03	1.55E−04	2.78E−05
Medium	7.06E−03	5.05E−04	2.06E−04
High	1.18E−02	1.69E−03	1.21E−03

Inhalation exposure estimates for non-cancer acute and intermediate exposure generated from low-, medium- and high-intensity exposure scenarios resulted in margin of exposures (MOEs) above benchmark (MOE=100). However, inhalation exposure estimates resulted in cancer risks above 1.0×10^{-6} for all three intensity scenarios, which indicates potential risk to consumers via inhalation from avgas use. EPA estimated lifetime exposure duration based on the total pilot population data from 2024 Active Civil Airmen Statistics (FAA, 2025). For the high-intensity exposure estimate, the 95th percentile age distribution is 72 years, which corresponds to 56 years of exposure if flying is assumed to begin at age 16. The medium-intensity exposure estimate uses the 75th percentile age of 48 years, resulting in an exposure duration of 32 years. For the low-intensity exposure estimate, the 50th percentile age is 30 years, leading to an estimated exposure duration of 14 years. Accordingly, based on the consumer

inhalation exposure estimates that it is reasonable to assume that greater lifetime exposure duration is associated with increased risk from avgas use even though the consumer exposure is intermittent.

4.1.2.3 Summary of Dermal Exposure Assessment

Dermal exposure monitoring data were not reasonably available for the consumer exposure scenario of refueling. Because ethylene dibromide is a volatile liquid that evaporates from the skin, EPA estimated dermal exposures using DEVL. Using the DEVL Model, EPA estimated the retained dose of ethylene dibromide, which is the dose of ethylene dibromide absorbed through the stratum corneum of the skin and retained in the viable epidermis based on the predicted fractional absorption data from IH SkinPerm. The deterministic model calculates an acute retained dose rate based on an assumed amount of liquid ethylene dibromide on skin during one contact event per day and a fractional absorption of 0.016. EPA did not identify any dermal fractional absorption data for ethylene dibromide and therefore estimated a fractional absorption value of 0.016 using IH SkinPerm tool by incorporating various input parameters that reflect the exposure scenarios (*e.g.,* concentration of ethylene dibromide, exposure frequency) and chemical-specific properties (*e.g.,* molecular weight, vapor pressure, octanol-water partition coefficient). IH SkinPerm modeling indicates that over 98% of dermally applied ethylene dibromide volatilizes within less than 2 hours—most of it immediately—leaving about 1.6% to be absorbed. IH SkinPerm assumes an aqueous solvent. EPA assumes this entire non-evaporated fraction of ethylene dibromide enters the viable epidermis and then steadily transfers to the bloodstream, with the model treating the viable epidermis as providing no barrier to systemic permeation given the approximately 0.4% lipid content of blood and interstitial fluids. Specific details of the fractional absorption are presented in Section 5.4.4.2 of the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). Specific details of the dermal exposure assessment for consumer exposure and equations for estimating dermal exposures can be found in Appendix C of the that TSD (U.S. EPA, 2026d).

To assess dermal risk, EPA applied a tiering approach where dermal exposure and risk were estimated using a default and PBPK approach that utilized route-to-route extrapolations from inhalation PODs to estimate dermal PODs. For dermal exposure, based on the default approach, non-cancer acute and intermediate MOEs were above the non-cancer benchmark MOEs (available in Section 4.2.7) as presented in Table 4-24. However, cancer risk estimates calculated based on the default dermal approach were above the cancer risk benchmark, resulting in consideration of the PBPK approach as a refinement based on specific exposure scenario assumptions *(e.g.,* exposure frequency – 1 event per day and 12, 26, and 52 times per year). The PBPK approach did not identify any dermal cancer risk since the internal dose metric was unable to be predicted due to ethylene dibromide being present in the formulation at such low concentrations.

EPA presents input parameters used for estimating potential dermal exposure in Table 4-14, that were used to estimate low-, medium-, and high-intensity exposure estimates. The detailed sources and the rationale of the parameters are presented in Section 9.3 of the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

Table 4-14. Parameters Used for Consumer Dermal Exposure Estimates

Parameters	Symbol	Low-Intensity	Medium-Intensity	High-Intensity
Exposed Skin Surface Area (m^2) – Adult Male >21 years[a]	S	268	535	1,070
Exposed Skin Surface Area (m^2) – Youth 16 to <21 years[a]		208	415	830

Parameters	Symbol	Low-Intensity	Medium-Intensity	High-Intensity
Quantity Remaining on Skin (Dermal Loading) (mg/cm^2-event)	Q_u	0.7	1.4	2.1
Weight Fraction of Chemical (unitless)	Y_{derm}	7.0E−04	8.5E−04	1.0E−03
Exposure Frequency, Intermediate (days/week)	$EF_{int.}$	0.23	0.5	1
Exposure Frequency (days/year) [b]	EF	12	26	52
Lifetime Exposure Duration (= working year) (years/lifetime) [c]	WY	14	32	56
Fractional Absorption[d]	f_{abs}	0.016		
Frequency of Events (events/day) [e]	FT	1		
Days for Intermediate Duration (days)	$D_{int.}$	7		
Lifetime Years (years)	LT	78		
Body Weight (kg) – Adult >21 years	BW	80		
Body Weight (kg) – Youth 16 to <21 years		71.6		

[a] For high-intensity exposure estimates of consumers, EPA assumed the exposure surface area was equivalent to mean values for 2-hand surface area (*i.e.,* 1,070 cm^2 for adult male and 830 cm^2 for youth 16 to <21 years) per Table 7-2 from Chapter 7 of the *Exposure Factors Handbook* (U.S. EPA, 2011a). For medium-intensity exposure estimates of consumers, EPA assumed the exposure surface area was equivalent to only a single hand (or 1 side of 2 hands) and used half the mean values for 2-hand surface areas (*i.e.,* 535 cm^2 for adult male and 415 cm^2 for youth 16 to <21 years). For low-intensity exposure estimates of consumers, EPA assumed the exposure surface area was equivalent to only 1 palm of 1 hand (*i.e.,* 1 side of a hand) and used half the mean values for a single hand (or 1 side of 2 hands) surface areas (*i.e.,* 267.5 cm^2 for adult male and 207.5 cm^2 for youth 16 to <21 years).
[b] The low-intensity estimate of 12 days per year is based on the FAA's requirement for retaining pilot licensing. The medium-intensity exposure estimate of 26 days per year is derived from information received from PAMA, which estimates that pilots flying for leisure, hobby, or personal use average about 100 flight hours annually (U.S. EPA, 2025c). The high-intensity exposure estimate of 52 days per year is based on the assumption that individuals pursuing commercial pilot certification require at least 250 hours of flight time as a pilot annually (14 CFR part 61 subpart F).
[c] The lifetime exposure duration was estimated based on the total pilot population. For the high-intensity exposure estimate, the 95th percentile age distribution is 72 years, which corresponds to 56 years of exposure if flying is assumed to begin at age 16. The medium-intensity exposure estimate uses the 75th percentile age of 48 years, resulting in an exposure duration of 32 years. For the low-intensity exposure estimate, the 50th percentile age is 30 years, leading to an estimated exposure duration of 14 years (FAA, 2025).
[d] EPA estimated a fractional absorption of 0.016 using IH SkinPerm tool and the fractional absorption was used for estimating low-, medium and high-intensity exposures for consumers.
[e] EPA assumes a single contact event per day for estimating dermal exposures for consumer.

Table 4-15 summarizes the APDR (mg/day), ARD (mg/kg-day), intermediate retained dose (IRD) (mg/kg-day), and lifetime chronic retained dose (LCRD) (mg/kg-day) for average youth and adults used for the default approach. EPA presented three distinct exposure estimates low-, medium-, and high-intensity based on variations in exposed skin surface area, dermal loading, weight fraction of chemical exposure frequency, and exposure duration. These exposure estimates are specifically used to estimate potential dermal risk using the default method.

For consumers, EPA assessed risk due to dermal acute and intermediate exposure, as well as cancer. However, non-cancer chronic exposures were not used for exposure and risk calculation. For chronic exposure scenarios, cancer risk predominates over non-cancer risk based on the relative magnitude of the selected toxicity values. Furthermore, the use of a LCRD better accounts for both periods of

exposure and periods of non-exposure through the application of an averaging time (AT) parameter, which is relevant for the consumer refueling exposure scenario being characterized.

Table 4-15. Estimated Consumer Dermal Exposure to Ethylene Dibromide for Avgas Refueling Scenario Using the Default Approach

Age Group	Exposure Level	Acute Potential Dose Rate (APDR) (mg/day)	Non-Cancer Acute Retained Dose (ARD) (mg/kg-day)	Non-Cancer Intermediate Retained Dose (IRD) (mg/kg-day)	Lifetime Chronic Retained Dose, Cancer (LCRD) (mg/kg-day)
Youth (16–20 year)	Low-Intensity	1.6E−03	2.3E−05	7.5E−07	1.3E−07
	Medium-Intensity	7.9E−03	1.1E−04	7.9E−06	3.2E−06
	High-Intensity	2.8E−02	3.9E−04	5.6E−05	4.0E−05
Adults (21+ year)	Low-Intensity	2.1E−03	2.6E−05	8.6E−07	1.6E−07
	Medium-Intensity	1.0E−02	1.3E−04	9.1E−06	3.7E−06
	High-Intensity	3.6E−02	4.5E−04	6.4E−05	4.6E−05
Weighted Average[a]	Low-Intensity	N/A	N/A	8.5E−07	1.5E−07
	Medium-Intensity	N/A	N/A	9.0E−06	3.7E−06
	High-Intensity	N/A	N/A	6.4E−05	4.6E−05

[a] The weighted average of skin surface area and body weight for intermediate and chronic, cancer average daily retained dose was estimated by incorporating a youth exposure duration of 5 years into the overall adult exposure estimation.

The acute and intermediate non-cancer risk estimates generated from low-, medium- and high-intensity exposure scenarios were above the benchmark (MOE = 100), therefore refinement was not needed. However, the dermal cancer risk estimates were above the benchmark of 1.0×10^{-6} in youth high-intensity, adults medium-and high-intensity and weighted average medium-and high-intensity exposure scenarios. Because the youth life stage spans only 5 years, which is shorter than the low-intensity lifetime exposure duration (14 years), it is reasonable to use weighted-average values for this assessment. EPA refined the dermal risk approach by conducting PBPK analysis because the dermal cancer risk estimates were above the benchmark. As described in Section 4.2.5, PBPK modeling was conducted to convert inhalation PODs to dermal human equivalent doses (HEDs) based on the internal dose metric associated with toxicity. Specifically, dermal HEDs are reported as the retained doses, or biologically effective doses, necessary to reach the cancer internal dose threshold.

Because absorption is simulated with the PBPK model, it acts as a function of chemical-specific physiochemical properties and scenario-specific exposure parameters, where time-dependent changes in the systemically absorbed dose under defined exposure conditions can ultimately be compared with retained dose estimates from the exposure assessment. As shown in Table 4-26, cancer slope factors (CSFs) could not be calculated because an HED could not be reached given the low ethylene dibromide concentration within the fuel formulation. As a summary, PBPK simulations for the consumer level of exposure indicate that the formulation of ethylene dibromide in the refueling scenario is too low for any consumer exposure to reach the internal dose metric, making it unable to predict a hazard value, which informs that no dermal risk is expected.

4.1.2.4 Weight of Scientific Evidence Conclusions for Consumer Exposure

Based on reasonably available information, EPA did not identify empirical data quantifying the number of refueling days or events for consumer use of avgas. To bound plausible use patterns for a screening-level assessment, the Agency developed three refueling-frequency scenarios using stakeholder input and activity benchmarks: (1) a low-intensity estimate of 12 days per year, aligned with FAA requirements for maintaining pilot currency; (2) a medium-intensity estimate of 26 days per year, informed by PAMA input indicating that leisure, hobby, or personal pilots average about 100 flight hours annually U.S. EPA (2025c); and (3) a high-intensity estimate of 52 days per year, reflecting individuals flying as many hours as those pursuing commercial pilot certification who may accrue up to approximately 250 flight hours annually. For each scenario, EPA assumed one refueling event per refueling day and estimated inhalation and dermal exposures accordingly.

The Agency acknowledges uncertainty in mapping flight-hour benchmarks to refueling frequency. Actual refueling behavior varies by aircraft type, fuel consumption, tank capacity, mission length, operating practices, geographic region, and season. These limitations reduce confidence in the consumer exposure scenario. Considering these strengths and limitations, EPA concluded the weight of scientific evidence for the consumer inhalation and dermal exposure assessments to be moderate, and the resulting exposure estimates to be plausible.

4.1.3 General Population Exposures

General population exposures occur when ethylene dibromide is released into the environment. Figure 4-3 provides a graphic representation of where and in which media ethylene dibromide is estimated to be found and the corresponding route of exposure. As described in Section 3.2, releases of ethylene dibromide are expected in air and water, with minimal releases to landfills. Section 3.3 provides a summary of the monitoring, database, and modeled data on concentrations of ethylene dibromide in the environment.

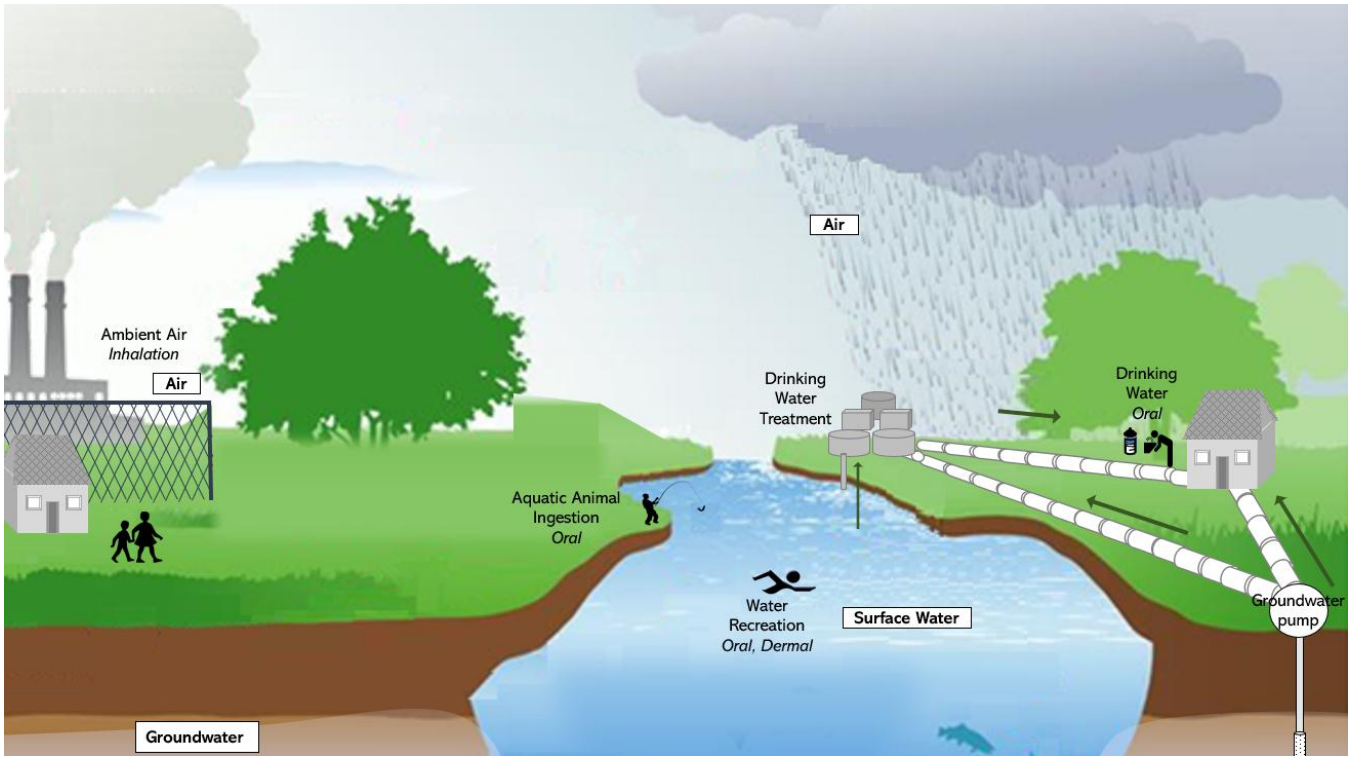

Figure 4-3. Potential Human Exposure Pathways to Ethylene Dibromide for the General Population

Potential routes of exposure are shown in italics under each potential pathway of exposure.

4.1.3.1 Summary of General Population Exposure Scenarios

EPA expects the ambient air pathway to be the predominant human exposure pathway to ethylene dibromide in the outdoor environment as shown in Figure 4-3. In summary, ethylene dibromide is released from industrial facilities as fugitive releases and stack releases. Once released to ambient air, ethylene dibromide can move off-site into the surrounding areas where human populations may be exposed through inhalation. If released into air, ethylene dibromide will largely remain volatile but may also undergo photodegradation or wet deposition and deposit onto land or water (Section 3.3.4). This ambient air exposure assessment focuses on exposures to a subset of the general population living near industrial facilities that are releasing ethylene dibromide to the ambient air. Ethylene dibromide also has the potential for substantial atmospheric transport, as described in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

EPA conducted a screening analysis for general population exposures via surface water releases. The Agency evaluated exposure to ethylene dibromide via drinking water ingestion, incidental ingestion via swimming, dermal exposure from swimming, and fish ingestion. While volatilization from surface water is expected to occur (*i.e.,* half-life in surface water of about 2.6 hours due to volatilization (U.S. EPA, 2012d), two other chemical properties counteract the complete volatilization of ethylene dibromide from water. Ethylene dibromide is very water soluble (4,130 mg/L) (Rumble, 2018a) and at a density of 2.172 g/cm^3, ethylene dibromide is over twice as dense as compared to receiving waters (O'Neil, 2013). Facilities release ethylene dibromide to surface water throughout the year with release days ranging from 174 to 365 days per year (Section 3); therefore, chronic exposure is relevant for the drinking water scenario. The Import and Repackaging OES had release days ranging from 174 to 260 release days per year, so for this OES the 260 days of release was used for modeling. EPA identified monitoring data (Section 3.3.1 and 3.3.2) that shows ethylene dibromide is present in both surface water and finished

drinking water. Therefore, EPA evaluated drinking water exposure from drinking water treatment facilities downstream of these releases and from this drinking water monitoring data. The Agency used E-FAST™-modeled surface water concentrations and SYR 4 data to conduct a screening analysis of the general population's exposure to ethylene dibromide in drinking water.

As a result of these surface water releases and identified surface water monitoring data, the general population may also be exposed to ethylene dibromide by swimming in the contaminated surface waters. EPA evaluated incidental oral and dermal exposure to ethylene dibromide for this scenario. The Agency utilized the E-FAST-modeled concentrations in a screening assessment for acute exposure from swimming in surface water where ethylene dibromide is released.

EPA also evaluated fish ingestion for fish living in waters where ethylene dibromide is released. Although no fish tissue concentrations were identified, EPA utilized modeled surface water concentrations and the BAF to model fish tissue concentrations in surface waters where ethylene dibromide is released. This screening analysis allowed the Agency to evaluate fish ingestion exposures to the general population, sustenance fishers, and tribal populations.

EPA also evaluated exposure to ethylene dibromide via drinking water ingestion. Facilities release ethylene dibromide to surface water (see Section 3). The Agency evaluated drinking water exposure from drinking water treatment facilities downstream of these releases and from drinking water monitoring data. As a result of these surface water releases, the general population may also be exposed to ethylene dibromide by swimming in the contaminated surface waters. EPA evaluated incidental oral and dermal exposure to ethylene dibromide for this scenario. EPA also evaluated fish ingestion for fish living in waters where ethylene dibromide is released.

4.1.3.2 Summary of Inhalation Exposure Assessment

EPA implemented a tiered approach to assess the general population's exposure to ethylene dibromide. EPA then estimated ambient air concentrations of ethylene dibromide using reported air releases in TRI (from 2019–2023) and NEI (2017 and 2020 reporting years). For the inhalation assessment, the Agency considered 11 COUs for the general population, which included 10 COUs with reported releases, plus the Distribution in commerce COU. After estimating ambient air concentrations from TRI releases in IIOAC using the Agency's American Meteorological Society/Environmental Protection Agency Regulatory (AERMOD) Model scenarios, EPA identified that because of these releases, (1) the chronic non-cancer MOEs were above the benchmark MOE and (2) the cancer risk estimates were below the screening cutoff of 1.0×10^{-6}. Ambient air concentrations and the screening approach are discussed in Section 7.2 of the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). This risk screen was used to identify a need for further modeling using HEM, which was used to refine the results by calculating exposures to populations surrounding the air releases of ethylene dibromide to assess cancer risk via inhalation exposures and utilize site-specific parameters.

The first HEM simulation was run using an inhalation unit risk (IUR) of 5.6×10^{-5} per µg/m^3. The IUR was updated to include an age-dependent adjustment factor (ADAF) of 1.59, resulting in a new IUR value of 8.9×10^{-5} per µg/m^3. The second HEM simulation was run using this new IUR value that incorporates the ADAF, which was roughly 60% higher than the original IUR. Based on the preliminary results using the IUR of 5.6×10^{-5} per µg/m^3, EPA identified the NEI facilities resulting in the top 15% of cancer risk, which covered approximately 300 facilities per year. This subset of NEI facilities allowed EPA to see all facilities with cancer risk above one-in-a-million with an adequate margin to also assess aggregate exposure. See *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d) for more details on the modeling approach. The analysis prioritized the

most recent year in which each facility reported releases. For facilities that did not report in that year but did report in the alternate year analyzed, the HEM used releases from the other year. Table 4-33 lists the years in which facilities did not report; however, a lack of reporting does not necessarily indicate an absence of releases. Facility 14217811 had the largest population with cancer risk above the cancer benchmark of 1.0×10^{-6} based on air release data reported to NEI in 2017; however, this facility did not report to NEI in 2020. To determine whether EPA had confidence in the potential cancer risk resulting from air releases from this facility, due to a lack of data for this facility in 2020, the Agency utilized preliminary 2023 NEI reporting data to confirm that this facility does in fact continue to release ethylene dibromide at similar levels to reported releases in 2017. The 2023 NEI data will be available publicly in the future.

When using HEM to estimate exposures to ambient air, EPA used the default chronic exposure scenario, which assumes that an individual breathes the ambient air at a given receptor site (*i.e.,* census block centroid) 24 hours per day over a 70-year lifetime (see *Draft Human Exposure Model (HEM) Exposure and Risk Calculator for General Population for Ethylene Dibromide* (U.S. EPA, 2026u)). HEM was used to estimate ambient air concentrations in addition to IIOAC as a standalone program because IIOAC does not account for populations that may or may not be living near releasing facilities, which is an essential consideration for determination of risk. Therefore, EPA ran HEM to characterize populations living near releasing facilities.

Results of Exposure Modeling

Maximum modeled ambient air concentrations from HEM across all TRI facility reporting from 2019 to 2023 ranged from 1.0×10^{-6} to 4.25 µg/m³, with the greatest concentrations modeled within the first 30 to 100 m from industrial facilities. NEI releases were also modeled using HEM. Based on the preliminary results using the IUR or 5.6×10^{-5} per µg/m^3, EPA identified the NEI facilities resulting in the top 15% of cancer risk, which covered approximately 300 facilities per year, sufficiently modeling all facilities who had risk above 1.0×10^{-6}. Once the IUR incorporating the ADAF was developed, EPA ran HEM with the IUR of 8.9×10^{-5} per µg/m^3 for only the NEI facilities showing the top 15% of cancer risk. This allowed adequate margin to incorporate risks as low as 1.0×10^{-9}, accounting also for potential aggregate risk across facilities within the census blocks and include the highest releases from each COU and OES.

TRI and NEI maximum modeled concentrations by facility are presented in Table 4-16 for facilities with cancer risk in any year above 1.0×10^{-6}, which was used as a cutoff value for presentation purposes. Additional exposures and details can be found in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d) and *Draft Human Exposure Model (HEM) Exposure and Risk Calculator for General Population for Ethylene Dibromide* (U.S. EPA, 2026u).

HEM provides risk estimates based on the human hazard values provided in Table 4-16 with additional results available in the *Draft Human Exposure Model (HEM) Exposure and Risk Calculator for General Population for Ethylene Dibromide* (U.S. EPA, 2026u) Table 4-16. No census blocks had risk above the benchmark for chronic health effects. Only one TRI facility showed cancer risk above 1.0×10^{-6} for the surrounding community. 2019 had the highest TRI releases for this facility, and the census blocks with cancer risk above 1.0×10^{-6} had a cumulative population of 306.

Among the NEI facility emissions modeled in HEM, 13 facilities had resulting cancer risk to the surrounding communities above 1.0×10^{-6}. Table 4-16 shows all facilities among TRI and NEI across all reporting years that have at least one year with HEM modeled cancer risk above 1.0×10^{-6}.

Table 4-16. Modeled Maximum Ethylene Dibromide Concentration and Resulting Cancer Risk by Facility

Source	Facility ID	Condition of Use	Occupational Exposure Scenario	State	Year	Maximum Concentration Modeled in HEM (µg/m³)
TRI	70805XXNBT4050S	Processing − Incorporation into formulation, mixture, or reaction product; Processing − As a reactant; and/or Industrial use − Other use	Incorporation into Formulation, Mixture, or Reaction Product	LA	2019	4.25
					2020	4.0E−02
					2021	0.27
					2022	0.27
					2023	0.27
NEI	4208011	Processing − Incorporation into formulation, mixture, or reaction product; Processing − As a reactant; and/or Industrial use − Other use	Incorporation into Formulation, Mixture, or Reaction Product	WI	2017	2.13
					2020	3.02
	7154411	Processing − Incorporation into formulation, mixture, or reaction product; Processing − As a reactant; and/or Industrial use − Other use	Incorporation into Formulation, Mixture, or Reaction Product	MS	2017	0
					2020	1.79
	993411	Processing − Incorporation into formulation, mixture, or reaction product; Processing − As a reactant; and/or Industrial use − Other use	Incorporation into Formulation, Mixture, or Reaction Product	AR	2017	4.15
					2020	0
	6678711	Processing − Incorporation into formulation, mixture, or reaction product; Processing − As a reactant; and/or Industrial use − Other use	Incorporation into Formulation, Mixture, or Reaction Product	WI	2017	0.14
					2020	Not Reported
	8467211	Processing − Incorporation into formulation, mixture, or reaction product; Processing − As a reactant; and/or Industrial use − Other use	Incorporation into Formulation, Mixture, or Reaction Product	LA	2017	0.16
					2020	0.42
	7549811	Processing − Incorporation into formulation, mixture, or reaction product; Processing − As a reactant; and/or Industrial use − Other use	Incorporation into Formulation, Mixture, or Reaction Product	NJ	2017	Not Reported
					2020	1.0E−02
	4193911	Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	WI	2017	0.32
					2020	7.0E−02
	5681411			CA	2017	0.66

Source	Facility ID	Condition of Use	Occupational Exposure Scenario	State	Year	Maximum Concentration Modeled in HEM (µg/m³)
		Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products		2020	0.3
	14217811	Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	CA	2017	16.13
					2020	Not Reported
	6074911	Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	MI	2017	2.0E−02
					2020	2.0E−02
	17215811	Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	CA	2017	Not Reported
					2020	0.13
	1396411	Disposal	Waste Handling, Treatment, and Disposal	CA	2017	0.88
					2020	0.88

HEM = Human Exposure Model
This table only presents the facilities that have a resulting cancer risk above 1.0×10^{-6} as a result of air releases modeled in HEM. Cancer risks from these facilities are reported in Table 4-33 and the full HEM results for the top 15% of facilities by risk can be found in the *Draft Human Exposure Model (HEM) Exposure and Risk Calculator for General Population for Ethylene Dibromide* (U.S. EPA, 2026u).

4.1.3.3 Summary of Dermal Exposure Assessment

Dermal exposure of the general population to ethylene dibromide may occur through swimming in surface water containing ethylene dibromide due to facility releases to surface water. Because facilities reporting surface water releases of ethylene dibromide can often be associated with COUs, EPA evaluates dermal exposures to ethylene dibromide in this assessment. For the dermal assessment, EPA considered 11 COUs for the general population, which included 10 COUs with reported releases, plus the Distribution in commerce COU.

Modeled estimated surface water concentrations were used to estimate acute dose rate (ADR) and ADD from dermal exposure while swimming, these estimates are presented in Table 4-17. EPA calculated incidental dermal (swimming) doses for adults, youth, and children in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

Table 4-17 summarizes the derived ADRs and ADDs resulting from dermal exposure while swimming for adults, youth, and children. As a screening analysis, dermal doses were calculated using the highest ethylene dibromide surface water concentration for each OES resulting from the corresponding facility-specific discharges. Of the OESs in Table 4-17, the highest dermal exposures are anticipated for adults from Incorporation into Formulation, Mixture, or Reaction Product OES.

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Facility Information		Ethylene Dibromide Surface Water Concentrations			Adult (21+ years)		Youth (11–15 years)		Child (6–10 years)	
COU	OES	Primary NPDES Permit Number	30Q5 Conc (µg/L)	Harmonic Mean Conc. (µg/L)	ADR (mg/kg-day)	ADD (mg/kg-day)	ADR (mg/kg-day)	ADD (mg/kg-day)	ADR (mg/kg-day)	ADD (mg/kg-day)
Processing − Incorporation into formulation, mixture, or reaction product; Processing − As a reactant; and/or Industrial use − Other use	Incorporation into Formulation, Mixture, or Reaction Product [a]	MSG130178	26	21	7.0E−05	3.9E−05	5.3E−05	1.2E−07	3.2E−05	7.2E−08
Disposal	Waste Handling, Treatment, and Disposal	CA0029947	0.60	0.23	1.6E−06	6.0E−07	1.2E−06	1.3E−09	7.5E−07	7.7E−10
Disposal	Waste Handling, Treatment, and Disposal [a]	AZ0024911	0.32	0.22	8.5E−07	5.9E−07	6.5E−07	1.2E−09	4.0E−07	7.5E−10
Disposal	Waste Handling, Treatment, and Disposal	CAZ197711	0.22	0.08	5.9E−07	2.3E−07	4.5E−07	4.8E−10	2.7E−07	2.9E−10
Disposal	Waste Handling, Treatment, and Disposal	KS0098809	0.13	0.16	3.5E−07	4.2E−07	2.7E−07	8.7E−10	1.6E−07	5.3E−10
Disposal	Waste Handling, Treatment, and Disposal [a]	AZMS66176	4.0E−03	2.0E−03	9.9E−09	5.0E−09	7.6E−09	1.1E−11	4.6E−09	6.4E−12
Commercial use − Other uses − Laboratory chemical	Laboratory Use [a]	N/A	0	0	4.9E−10	3.5E−10	3.8E−10	7.5E−13	2.3E−10	4.5E−13
Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	IDG911008	0	0	4.1E−11	2.7E−11	3.1E−11	5.7E−14	1.9E−11	3.4E−14

Facility Information		Ethylene Dibromide Surface Water Concentrations			Adult (21+ years)		Youth (11–15 years)		Child (6–10 years)	
COU	OES	Primary NPDES Permit Number	30Q5 Conc (µg/L)	Harmonic Mean Conc. (µg/L)	ADR (mg/kg-day)	ADD (mg/kg-day)	ADR (mg/kg-day)	ADD (mg/kg-day)	ADR (mg/kg-day)	ADD (mg/kg-day)
Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	NIACS Code 324110 - Petroleum Refineries (Central Tendency) [b]	0	0	5.8E−10	5.8E−10	4.5E−10	1.2E−12	2.7E−10	7.4E−13
Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	NIACS Code 324110 - Petroleum Refineries (High-end) [b]	0	0	10.0E−10	10.0E−10	7.6E−10	2.1E−12	4.6E−10	1.3E−12
Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	NAICS Code 21112 - Crude Petroleum Extraction (Central Tendency) [b]	3.0E−02	3.0E−02	8.5E−08	8.6E−08	6.5E−08	1.8E−10	3.9E−08	1.1E−10
Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	NAICS Code 21112 - Crude Petroleum Extraction (High-End) [b]	0.05	0.06	1.5E−07	1.5E−07	1.1E−07	3.1E−10	6.8E−08	1.9E−10
Manufacture − Import and/or Processing − Repackaging	Import and Repackaging	NAICS Code 424710 - Repackaging Facilities (Petroleum Bulk Stations and Terminals) (High-End) [b]	4.8	4.6	1.3E−05	8.8E−06	9.8E−06	2.6E−08	6.0E−06	1.6E−08

Facility Information	Ethylene Dibromide Surface Water Concentrations				Adult (21+ years)		Youth (11–15 years)		Child (6–10 years)	
COU	OES	Primary NPDES Permit Number	30Q5 Conc (µg/L)	Harmonic Mean Conc. (µg/L)	ADR (mg/kg-day)	ADD (mg/kg-day)	ADR (mg/kg-day)	ADD (mg/kg-day)	ADR (mg/kg-day)	ADD (mg/kg-day)
Manufacture − Import and/or Processing − Repackaging	Import and Repackaging	NAICS Code 424710 - Repackaging Facilities (Petroleum Bulk Stations and Terminals) (Central Tendency) [b]	4.6	4.4	1.3E−05	8.8E−06	9.8E−06	2.5E−08	5.8E−06	1.5E−08

30Q5 = lowest 30 consecutive day flow, on average, over the course of 5 years; ADD = average daily dose; ADR = acute dose rate; Conc = concentration; COU = condition of use; NAICS = North American Industry Classification System; NPDES = National Pollutant Discharge Elimination System; OES = occupational exposure scenario

[a] Flow lookup failed and therefore flows were estimated from nearest water body.

[b] Modeled release. Utilized flows derived from distribution of facilities within presented NAICS codes.

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4.1.3.4 Summary of Oral Exposures Assessment

Facilities reported ethylene dibromide releases to surface waters. Ethylene dibromide concentrations in surface water can be impacted by deposition from ambient air, volatilization from surface water, and degradation in surface water. The physical and chemical, and fate and transport properties are discussed in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

Releases to surface water can lead to general population exposure to ethylene dibromide via drinking water and incidental ingestion from swimming in receiving water bodies. EPA conducted an analysis of the highest exposures resulting from facility reported releases. The *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d) describes the methodology and results of estimation of surface water concentration from facility specific releases. For the oral assessment, EPA considered 11 COUs for the general population, which included 10 COUs with reported releases, plus the Distribution in commerce COU.

As described in *The Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d), ethylene dibromide facility-specific releases are monitored and permitted via NPDES permits and EPA is therefore able to estimate concentrations in the receiving water bodies at the point of discharge of facilities reporting releases of ethylene dibromide. EPA uses E-FAST along with the National Hydrography Dataset Plus (NHDPlus) flow data of the receiving water body and the amount of ethylene dibromide reported in the effluent to estimate concentrations. Since flow metrics vary, EPA uses a low flow 30Q5 metric as a health-protective and screening metric for general population assessment because it estimates a higher concentration due to utilizing the lowest flow rate expected occur over a 30-day period once every 5 years. The estimation for general population exposures from drinking water or incidental ingestion via swimming in the receiving waterbody are described in Sections 4.1.3.4.1 and 4.1.3.4.2 below. The low flow 30Q5 metric is intended to overestimate surface water concentrations as a screening assessment for the general population assessment of drinking water ingestion, incidental ingestion from swimming, dermal exposure from swimming, and fish ingestion. Based on risk estimates resulting from the screening assessment, as discussed in Section 4.3.5, no further refinements were needed because no risks to the general population above the benchmarks were identified from the surface water pathway, even with these conservative assumptions.

To model surface water concentrations from the reported facility releases and NHDPlus flow data, EPA used E-FAST modeling to estimate surface water concentrations. This model does not account for the volatilization out of the water compartment. Half-life of ethylene dibromide is as short as 2.6 hours when volatilization at water surface is considered. Concentrations of ethylene dibromide were estimated using this tool, then used to estimate drinking water exposure and dermal and incidental oral exposure from swimming. Not considering volatilization from surface water despite the short half-life of ethylene dibromide is a feature of the screening assessment that overestimates exposures via the surface water pathway. Estimated surface water concentrations at the point of release are presented in Table 4-18. Water concentration estimation methods are further discussed in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

Table 4-18. Surface Water Estimates per OES for Various Flow Metrics

COU	OES	Primary NPDES Permit Number	Release Estimate (kg/day)	Release Days	Harmonic Mean Flow (MLD)	30Q5 Flow (MLD)	7Q10 Flow (MLD)	Harmonic Mean Conc (µg/L)	30Q5 Conc (µg/L)	7Q10 Conc (µg/L)
Processing − Incorporation into formulation, mixture, or reaction product	Incorporation into Formulation, Mixture, or Reaction Product [a]	MSG130178	0.12	256	6	4.9	2.8	21.1	26	44.9
Disposal	Waste Handling, Treatment, and Disposal [a]	AZMS66176	5.6E−03	365	2,990	1,511	1,042	1.9E−03	3.7E−03	5.4E−03
Disposal	Waste Handling, Treatment, and Disposal [a]	AZ0024911	8.0E−04	365	6.5	2.4	1.3	0.22	0.32	0.58
Disposal	Waste Handling, Treatment, and Disposal	KS0098809	1.0E−04	365	0.67	0.80	0.42	0.15	0.13	0.25
Disposal	Waste Handling, Treatment, and Disposal	CAZ197711	1.0E−04	365	0.71	0.27	0.14	8.0E−02	0.22	0.43
Disposal	Waste Handling, Treatment, and Disposal	CA0029947	0	365	6.5E−02	2.4E−02	1.1E−02	0.22	0.60	1.3
Commercial use − Other uses − Laboratory chemical	Laboratory Use [a]	N/A	0	365	101	73	45	1.0E−04	2.0E−04	3.0E−04
Industrial use – Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	IDG911008	0	365	83	55	34	0	0	0
Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	NIACS Code 324110 - Petroleum Refineries (Central Tendency) [b]	1.0E−02	365	4.8E04	4.8E04	4.8E04	2.0E−04	2.0E−04	2.0E−04
Industrial use − Fuel agent in petroleum refineries and/or	Fuels and Related Products	NIACS Code 324110 - Petroleum	2.0E−02	365	4.8E04	4.8E04	4.8E04	4.0E−04	4.0E−04	4.0E−04

COU	OES	Primary NPDES Permit Number	Release Estimate (kg/day)	Release Days	Harmonic Mean Flow (MLD)	30Q5 Flow (MLD)	7Q10 Flow (MLD)	Harmonic Mean Conc (µg/L)	30Q5 Conc (µg/L)	7Q10 Conc (µg/L)
Commercial use − Fuels and related products		Refineries (High-end) [b]								
Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	NAICS Code 21112 - Crude Petroleum Extraction (Central Tendency) [b]	1.0E−02	365	327	332	310	3.0E−02	3.0E−02	3.0E−02
Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	NAICS Code 21112 - Crude Petroleum Extraction (High-end) [b]	2.0E−02	365	327	332	310	5.0E−02	5.0E−02	6.0E−02
Manufacture − Import and/or Processing − Repackaging	Import and Repackaging	NAICS Code 424710 - Repackaging Facilities (Petroleum Bulk Stations and Terminals) (High-End) [b]	6.38	260	1,385	1,335	1,249	4.6	4.8	5.1
Manufacture − Import and/or Processing − Repackaging	Import and Repackaging	NAICS Code 424710 - Repackaging Facilities (Petroleum Bulk Stations and Terminals) (Central Tendency) [b]	6.15	260	1,385	1,335	1,249	4.4	4.6	4.9

30Q5 = lowest 30 consecutive day flow, on average, over the course of 5 years; 7Q10 = lowest 7-day average flow that occurs (on average) once every 10 years; Conc = concentration; COU = condition of use; NAICS = North American Industry Classification System; NPDES = National Pollutant Discharge Elimination System; OES = occupational exposure scenario

[a] Flow lookup failed and flows estimated from nearest water body.

[b] Modeled release. Utilized flows derived from distribution of facilities within presented NAICS codes

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4.1.3.4.1 Drinking Water Exposure

In 1974, Congress passed the Safe Drinking Water Act (SDWA). This law authorizes EPA to set legal limits on the levels of certain contaminants in drinking water. EPA published the current National Primary Drinking Water Regulation (NPDWR) for ethylene dibromide on January 30, 1991 (56 CFR part 3526). The NPDWR established a Maximum Contaminant Level Goal (MCLG; the health goal) of zero. The NPDWR also established a Maximum Contaminant Level (MCL; the enforceable standard) of 0.00005 mg/L, based on analytical feasibility. MCLs are legally enforceable primary standards that apply to public water systems.

As noted above, ethylene dibromide is reported by facilities as released to surface waters from COUs. Ethylene dibromide released to surface water has a relatively short half-life (2.6 hours) and may volatilize (U.S. EPA, 2012d). However, due to its high solubility and high density, a portion may remain in surface water (Rumble, 2018a; O'Neil, 2013). Ethylene dibromide has been shown to be mobile in the subsurface, where biodegradation can take months to years (Section 2.2). Ethylene dibromide is an exceptionally potent carcinogen and toxicant, so even very small amounts could have toxic effects. EPA estimates that there were surface water releases from COUs on 174–365 days each year, and a survey of groundwater (Section 3.3.3) found a small, but non-zero number of samples of groundwater from the Six-Year Review 4 ICR dataset. EPA's Office of Water reported that 44 PWSs (0.110% of PWSs) had detections of ethylene dibromide above the MCL, and these systems serve 1,481,515 people (U.S. EPA, 2024b). To fully quantify any risk that might occur, a chronic oral exposure analysis was performed.

For the analysis, EPA utilized modeled releases from TRI and DMR to surface water to estimate general population exposure to ethylene dibromide. EPA conducted a screening-level analysis using E-FAST modeled surface water concentrations, which assumed no volatilization from surface water, utilized low flow values, estimated concentration at point of discharge, and assumed no drinking water treatment for the general population. EPA expects that the estimation from modeled values of ethylene dibromide in surface water is an overestimation of real-world values. Although these values are an overestimation, no model refinements were needed because risk to the general population was not identified from the drinking water pathway (Section 4.3.5.2). These modeled values are not meant to reflect current drinking water treatment standards and regulations, however data from SYR 4 ICR dataset demonstrates that ethylene dibromide may be found in drinking water at levels above the MCL.

Modeling Approach

To model drinking water concentrations at the point of discharge of facilities reporting releases of ethylene dibromide, EPA started with the upstream TSCA facility surface water concentrations estimated at the facility's point of release. For this screening analysis, EPA assumed no treatment or removal of ethylene dibromide as a part of the drinking water treatment process with the understanding that this approach would overestimate surface water concentrations. Even with these conservative assumptions, the risks from drinking water consumption were estimated to be below the benchmark for all scenarios, as described in Section 4.3.5.2, therefore no further analysis was performed. Modeled surface water concentrations estimation methodology and results are presented in *the Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). EPA estimated drinking water exposures for those facilities that discharge to surface waters that may be potential sources of drinking water. Receiving water bodies with no possibility of downstream drinking water intakes, such as coastal releases, were not assumed to be sources of drinking water, and the corresponding facility releases were not included in the drinking water analysis.

Equations used to estimate acute and chronic exposures can be found in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). In including infant exposures estimates, EPA is considering PESS and protecting these sensitive subpopulations.

Of eight facilities and two modeled OESs reporting releases of ethylene dibromide to surface waters, EPA identified seven facility releases and two modeled OESs that were associated with possible downstream drinking water intakes. Therefore, EPA estimated exposures for those seven facilities and two modeled OESs. Table 4-20 summarizes the drinking water doses for adults and infants from these releases. All exposure estimates are provided in *Draft Surface Water Human Exposure Risk Calculator for General Population for Ethylene Dibromide* (U.S. EPA, 2026af). For the other four COUs, EPA is also presenting the highest exposure estimates within each COU as well as the associated releasing facility that is the source of the corresponding exposures.

EPA also reviewed concentrations of ethylene dibromide reported in the Six-Year Review 4 for finished drinking water and untreated ground water to represent people receiving their water from private drinking water wells. A summary of the SYR 4 data is presented in Table 4-19. In addition to using modeled surface water concentrations, Table 4-20 also presents calculated doses of ethylene dibromide from concentrations presented in the SYR 4. Although that dataset had mostly non-detects for finished drinking water and untreated ground water, the general population may still be exposed via drinking water in the places where ethylene dibromide was detected. The number of non-detects were considered in the screening analysis for the general population drinking water pathway. However, even if most people are exposed to no ethylene dibromide, EPA still considered those individuals that may have a higher exposure in its screening analysis. The median concentrations amongst the detects for finished drinking water and untreated ground water were 0.029 and 0.030 µg/L, respectively (see Table 4-19). If people receive their water from a public water system, that water system would be required to implement measures to reduce this concentration in drinking water. However, people who receive drinking water from private wells may not have these measures implemented.

Table 4-19. Summary of OCSPP's Analysis of Six-Year Review 4 ICR Data for Finished Drinking Water and Untreated Ground Water

Treatment Status	% Non-Detect	Range of Detection Limit (µg/L)	Number of Samples Ethylene Dibromide Detected	Minimum of Detected Values (µg/L)	Median of Detected Values (µg/L)	Maximum Detected Values (µg/L)
Finished Water [a]	99.7	0–50	433	2.7E−03	2.9E−02	1.2
Untreated Ground Water [b]	99.3	0–1.0	238	1.0E−02	3.0E−02	0.7

ICR = information collection request
[a] Finished water is water that is introduced into the distribution system of a public water system and is intended for distribution and consumption without further treatment, except as treatment necessary to maintain water quality in the distribution system (40 CFR 141.2).
[b] Groundwater that has not had drinking water treatment technologies applied.

Table 4-20. Drinking Water Exposures to Ethylene Dibromide

Release Scenario				Adult (21+ years)				Infant (Birth to <1 year)			
				Exposure				Exposure			
OES	Primary NPDES Permit Number	Harmonic Mean Conc (µg/L)	30Q5 Conc (µg/L)	ADR (mg/kg-day)	ADD (mg/kg-day)	LADD (mg/kg-day)	LADC (mg/L)	ADR (mg/kg-day)	ADD (mg/kg-day)	LADD (mg/kg-day)	LADC (mg/L)
Waste Handling, Treatment, and Disposal	CA0029947	0.23	0.60	2.4E−05	2.5E−06	5.0E−09	4.5E−07	8.5E−05	6.3E−06	2.2E−10	7.9E−09
Waste Handling, Treatment, and Disposal	KS0098809	0.16	0.13	5.2E−06	1.7E−06	3.4E−09	3.1E−07	1.8E−05	4.4E−06	1.5E−10	5.5E−09
Waste Handling, Treatment, and Disposal	CAZ197711	8.0E−02	0.22	8.8E−06	9.3E−07	1.9E−09	1.7E−07	3.1E−05	2.4E−06	8.3E−11	3.0E−09
Fuels and Related Products	IDG911008	1.0E−05	2.0E−05	6.1E−10	1.1E−10	2.2E−13	2.0E−11	2.1E−09	2.8E−10	9.9E−15	3.5E−13
Waste Handling, Treatment, and Disposal [a]	AZMS66176	2.0E−03	4.0E−03	1.5E−07	2.1E−08	4.1E−11	3.7E−09	5.2E−07	5.2E−08	1.8E−12	6.6E−11
Waste Handling, Treatment, and Disposal [a]	AZ0024911	0.22	0.32	1.3E−05	2.4E−06	4.8E−09	4.4E−07	4.5E−05	6.2E−06	2.2E−10	7.7E−09
Laboratory Use [a]	N/A	1.3E−04	1.8E−04	7.3E−09	1.5E−09	2.9E−12	2.7E−10	2.6E−08	3.7E−09	1.3E−13	4.7E−12
NIACS Code 324110 - Petroleum Refineries (Central Tendency) [b]	N/A – Modeled Releases	2.2E−04	2.2E−04	8.8E−09	2.4E−09	4.8E−12	4.4E−10	3.1E−08	6.1E−09	2.1E−13	7.6E−12
NIACS Code 324110 - Petroleum Refineries (High-end) [b]	N/A – Modeled Releases	3.7E−04	3.7E−04	1.5E−08	4.1E−09	8.2E−12	7.4E−10	5.2E−08	1.0E−08	3.7E−13	1.3E−11
NAICS Code 21112 - Crude Petroleum Extraction (Central Tendency) [b]	N/A – Modeled Releases	3.2E−02	3.2E−02	1.3E−06	3.5E−07	7.1E−10	6.4E−08	4.5E−06	9.0E−07	3.2E−11	1.1E−09
NAICS Code 21112 - Crude Petroleum Extraction (High-end) [b]	N/A – Modeled Releases	5.5E−02	5.4E−02	2.2E−06	6.0E−07	1.2E−09	1.1E−07	7.6E−06	1.5E−06	5.4E−11	1.9E−09

Release Scenario				Adult (21+ years)				Infant (Birth to <1 year)			
				Exposure				Exposure			
OES	Primary NPDES Permit Number	Harmonic Mean Conc (µg/L)	30Q5 Conc (µg/L)	ADR (mg/kg-day)	ADD (mg/kg-day)	LADD (mg/kg-day)	LADC (mg/L)	ADR (mg/kg-day)	ADD (mg/kg-day)	LADD (mg/kg-day)	LADC (mg/L)
NAICS Code 424710 - Repackaging Facilities (Petroleum Bulk Stations and Terminals) (High-End) [b]	N/A – Modeled Releases	4.61	4.78	1.9E−04	3.6E−05	1.0E−07	9.2E−06	6.8E−04	9.2E−05	4.6E−09	1.6E−07
NAICS Code 424710 - Repackaging Facilities (Petroleum Bulk Stations and Terminals) (Central Tendency) [b]	N/A – Modeled Releases	4.44	4.61	1.9E−04	3.5E−05	9.8E−08	8.9E−06	6.5E−04	8.9E−05	4.4E−09	1.6E−07

30Q5 = lowest 30 consecutive day flow on average over the course of 5 years; ADD = average daily dose; ADR = acute dose rate; Conc = concentration; LADC = lifetime average daily concentration; LADD = lifetime average daily dose; NAICS = North American Industry Classification System; NPDES = National Pollutant Discharge Elimination System; OES = occupational exposure scenario

[a] Flow lookup failed and flows estimated from nearest water body.

[b] Modeled release. Utilized flows derived from distribution of facilities within presented NAICS codes

[c] Finished water is water that is introduced into the distribution system of a public water system and is intended for distribution and consumption without further treatment, except as treatment necessary to maintain water quality in the distribution system (40 CFR 141.2).

[d] Groundwater that has not had drinking water treatment technologies applied.

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4.1.3.4.2 Incidental Ingestion from Swimming

The general population may swim in surface waters (streams and lakes) that could contain ethylene dibromide from facility releases under COUs. EPA used E-FAST to model surface water concentrations with several conservative assumptions as a screening assessment. The highest modeled surface water concentrations per OES included in *Draft Surface Water Human Exposure Risk Calculator for General Population for Ethylene Dibromide* (U.S. EPA, 2026af) were used to estimate doses (ADR and ADD) resulting from incidental ingestion of ethylene dibromide while swimming in the receiving waterbody. Equations found in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d) were used to calculate incidental oral (swimming) doses for adults, youth, and children. The highest modeled concentrations were associated with the Incorporation into Formulation, Mixture, or Reaction Product OES.

Table 4-21 summarizes the incidental ingestion doses derived from the modeled concentration presented in the *Draft Surface Water Human Exposure Risk Calculator for General Population for Ethylene Dibromide* (U.S. EPA, 2026af) and the equations presented in *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

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Facility Information			Rolling Average (254 Days) Release Scenario		Adult (21+ years)		Youth (11–15 years)		Child (6–10 years)	
					Exposure		Exposure		Exposure	
COU	OES	Primary NPDES Permit Number	30Q5 Conc (µg/L)	Harmonic Mean Conc. (µg/L)	ADR (mg/kg-day)	ADD (mg/kg-day)	ADR (mg/kg-day)	ADD (mg/kg-day)	ADR (mg/kg-day)	ADD (mg/kg-day)
Disposal	Waste Handling, Treatment, and Disposal	CA0029947	0.60	0.22	2.1E−06	7.8E−07	3.2E−06	1.2E−06	1.8E−06	6.8E−07
Disposal	Waste Handling, Treatment, and Disposal	KS0098809	0.13	0.16	4.5E−07	5.4E−07	7.0E−07	8.3E−07	3.9E−07	4.7E−07
Disposal	Waste Handling, Treatment, and Disposal	CAZ197711	0.22	8.0E−02	7.6E−07	2.9E−07	1.2E−06	4.5E−07	6.6E−07	2.6E−07
Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	IDG911008	0	0	5.2E−11	3.5E−11	8.1E−11	5.4E−11	4.6E−11	3.0E−11
Disposal	Waste Handling, Treatment, and Disposal [a]	AZMS66176	4.0E−03	2.0E−03	1.3E−08	6.4E−09	2.0E−08	10.0E−09	1.1E−08	5.6E−09
Disposal	Waste Handling, Treatment, and Disposal [a]	AZ0024911	0.32	0.22	1.1E−06	7.6E−07	1.7E−06	1.2E−06	9.6E−07	6.6E−07
Commercial use − Other uses − Laboratory chemical	Laboratory Use [a]	N/A	0	0	6.3E−10	4.6E−10	9.8E−10	7.1E−10	5.5E−10	4.0E−10
Processing – Incorporation into formulation, mixture, or reaction product	Incorporation into Formulation, Mixture, or Reaction Product [a] (Coastal Release)	MSG130178	26	21	9.0E−05	5.0E−05	1.4E−04	7.8E−05	7.8E−05	4.4E−05

Facility Information			Rolling Average (254 Days) Release Scenario		Adult (21+ years)		Youth (11–15 years)		Child (6–10 years)	
					Exposure		Exposure		Exposure	
COU	OES	Primary NPDES Permit Number	30Q5 Conc (µg/L)	Harmonic Mean Conc. (µg/L)	ADR (mg/kg-day)	ADD (mg/kg-day)	ADR (mg/kg-day)	ADD (mg/kg-day)	ADR (mg/kg-day)	ADD (mg/kg-day)
Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	NIACS Code 324110 - Petroleum Refineries (Central Tendency) [b]	0	0	7.5E−10	7.5E−10	1.2E−09	1.2E−09	6.6E−10	6.6E−10
Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	NIACS Code 324110 - Petroleum Refineries (High-end) [b]	0	0	1.3E−09	1.3E−09	2.0E−09	2.0E−09	1.1E−09	1.1E−09
Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	NAICS Code 21112 - Crude Petroleum Extraction (Central Tendency) [b]	0.03	0.03	1.1E−07	1.1E−07	1.7E−07	1.7E−07	9.6E−08	9.7E−08
Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	NAICS Code 21112 - Crude Petroleum Extraction (High-end) [b]	0.05	0.05	1.9E−07	1.9E−07	2.9E−07	2.9E−07	1.6E−07	1.7E−07
Manufacture − Import and/or Processing − Repackaging	Import and Repackaging	NAICS Code 424710 - Repackaging Facilities (Petroleum Bulk Stations and Terminals) (High-End) [b]	4.8	4.6	1.7E−05	1.1E−05	2.6E−05	1.8E−05	1.4E−05	9.9E−06

Facility Information			Rolling Average (254 Days) Release Scenario		Adult (21+ years)		Youth (11–15 years)		Child (6–10 years)	
					Exposure		Exposure		Exposure	
COU	**OES**	**Primary NPDES Permit Number**	**30Q5 Conc (µg/L)**	**Harmonic Mean Conc. (µg/L)**	**ADR (mg/kg-day)**	**ADD (mg/kg-day)**	**ADR (mg/kg-day)**	**ADD (mg/kg-day)**	**ADR (mg/kg-day)**	**ADD (mg/kg-day)**
Manufacture − Import and/or Processing − Repackaging	Import and Repackaging	NAICS Code 424710 - Repackaging Facilities (Petroleum Bulk Stations and Terminals) (Central Tendency) [b]	4.6	4.4	1.6E−05	1.1E−05	2.5E−05	1.7E−05	1.4E−05	9.6E−06

30Q5 = lowest 30 consecutive day flow, on average, over the course of 5 years; ADD = average daily dose; ADR = acute dose rate; Conc = concentration; COU = condition of use; NAICS = North American Industry Classification System; NPDES = National Pollutant Discharge Elimination System; OES = occupational exposure scenario

[a] Flow lookup failed and therefore flows were estimated from nearest water body.

[b] Modeled release. Utilized flows derived from distribution of facilities within presented NAICS codes.

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4.1.3.4.3 Fish Ingestion Exposure

General population exposures can occur from catching fish and ingesting fish tissue where fish may bioaccumulate ethylene dibromide from surface water impacted by facility releases. EPA has no fish tissue data concentration data for ethylene dibromide. Ethylene dibromide is highly mobile within animal systems and can be subject to rapid excretion. The highest BAC observed in carp (*Cyprinus carpio*), by the Chemical Inspection Testing Institute (1977), was 14.9 L/kg. Additionally, trophic level biomagnification factors were modeled to be 5.81, 6.33, and 8.27 for lower, middle, and upper trophic levels (U.S. EPA, 2012d). The Agency recognizes that bioaccumulation factors can vary across and within species based on a number of factors, however, considering that BCF was not observed to be higher than 20 in any measurement, the bioconcentration potential of ethylene dibromide is considered low, and is well below the BCF criteria of 1,000 L/kg, which would be considered moderate bioconcentration potential by The PBT Policy 64 FR 213.1. (Federal Register, 1999).

Ethylene dibromide has a low potential to bioaccumulate and has a short half-life of 2.6 hours in river surface water. Although ethylene dibromide is likely to volatilize out of water and has a relatively short half-life in surface water and low bioaccumulation potential, considering the daily and long term releases of ethylene dibromide into surface water, high water solubility, and presence of ethylene dibromide in surface water from monitoring data (Section 3.3.1), and finished drinking water suggesting that ethylene dibromide is present in the source surface water (Section 3.3.2), EPA conducted a fish ingestion screening assessment to rule out this pathway and to consider the general population, tribal, and subsidences fishers that have the potential to be exposed to ethylene dibromide via fish ingestion. The surface water monitoring data from WQP had 40 non-zero detected values, and from these values only five data point were not from superfund sites. The range of these five monitoring data points were 0.06 to 0.29 µg/L taken from sites in Florida, Illinois, and New Jersey. The detection limits for these values ranged from 0.0024 to 1 µg/L. Because of the low BCF, lack of fish tissue data, and lack of surface water monitoring data for ethylene dibromide, EPA expects this to be a minor pathway for the general population, however EPA conducted a screening analysis to demonstrate this.

In addition, EPA modeled surface water releases of ethylene dibromide to estimate surface water concentrations downstream of releasing facilities, and the fish ingestion exposure pathway is predominantly based on these estimations. EPA based general population exposure estimates from this pathway of exposure on facility release data, the corresponding ethylene dibromide surface water concentrations, and BAF. EPA focused the analysis on the facility releases with the highest surface water concentrations (see *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d)). EPA did not identify any studies presenting ethylene dibromide in fish tissue; therefore, EPA relied on estimated fish tissue concentrations based on estimates using the *Draft Fish Ingestion Risk Calculator for General Population Exposure for Ethylene Dibromide* (U.S. EPA, 2026q). EPA estimated exposure from fish consumption using age-specific ingestion rates as well as ingestion rates associated with specific lifestyles such as subsistence or tribal fishing. The ADR and ADD for chronic non-cancer estimates were calculated using the 90th percentile and central tendency ingestion rate, respectively. EPA used Equation 7-7 from the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d) to calculate fish ingestion doses for adults and toddlers. The inputs to this equation can be found in *Draft Fish Ingestion Risk Calculator for General Population Exposure for Ethylene Dibromide* (U.S. EPA, 2026q). The years within an age group (*i.e.,* 62 years for adults) was used for the exposure duration and averaging time to estimate non-cancer exposure. Table 4-22 presents the exposures calculated using highest estimated ethylene dibromide surface water concentrations resulting from the corresponding facility discharges with BCF 9.55 L/kg.

No facilities were identified that directly discharged ethylene dibromide into water of tribal lands, however, EPA still estimated possible doses of ethylene dibromide from fish ingestion using tribal consumption rates (20.58 g/kg-day) which are estimated as ten times higher than the 95th percentile general population consumption rate. This subset of the general population may be considered representative of PESS and sentinel fish ingestion exposure, which is further discussed in Section 4.3.2.

Table 4-22. General Population Fish Ingestion Doses by Surface Water Concentration

OES	Ethylene Dibromide Surface Water Harmonic Mean Concentrations (µg/L)	Adult ADR (mg/kg-day)	Young Toddler ADR (mg/kg-day)	Adult Sustenance Fisher LADD (mg/kg-day)	Tribal Adult ADR (mg/kg-day)
Incorporation into Formulation, Mixture, or Reaction Product	26	6.9E−05	1.0E−04	3.5E−04	6.7E−04
ADR = acute dose rate ; LADD = lifetime average daily dose; occupational exposure scenario					

4.1.3.5 Weight of Scientific Evidence Conclusions for General Population Exposure

Ambient Air

The weight of scientific evidence for inhalation exposure estimates is determined by several different evidence streams, including evidence supporting the exposure scenarios, release data used as model input data, and agreement between modeled and monitored ambient air concentrations (see *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide)* (U.S. EPA, 2026d). EPA tends to have higher confidence in exposures estimates that are based on facility reported releases than those based on EPA estimated releases from generic facilities/sites.

EPA has robust confidence in the applicability of HEM and IIOAC for the purposes of this risk evaluation. IIOAC is EPA's regulatory model which has been peer reviewed as part of the regulatory model process described in Appendix W to 40 CFR part 51, and HEM conducts dispersion modeling using AERMOD as a compiled executable program. EPA has higher confidence in the physical source specifications used as inputs for modeling of reported releases than those used for modeling of EPA estimated releases from generic facilities/sites (U.S. EPA, 2026d). There are additionally uncertainties when using HEM to characterize populations living near facilities. HEM estimates exposures for the census block centroid, as defined by the U.S. Census Bureau. Values calculated for centroids are not representative of the range of values over the entire block and might not represent where most people reside within a census block. Therefore, estimated exposures using HEM can overestimate or underestimate actual exposures depending on the geographic population distribution within the block. Overall confidence in inhalation exposure estimates resulting from reported ambient air releases and modeled concentrations are robust. The OES with the highest overall predicted lifetime average daily concentrations was Fuels and Related Products.

Surface Water Exposures

EPA considered physical and chemical and fate properties, facility-specific release data and monitoring data (*i.e.,* measured concentrations of ethylene dibromide in drinking water above the MCL) as evidence to both confirm presence of ethylene dibromide in the water column and support the analysis of exposure scenarios resulting from facility-specific surface water releases of ethylene dibromide: oral

exposure estimates from drinking water, incidental oral and dermal from swimming and fish ingestion exposures.

While ethylene dibromide is highly water soluble, it also has a strong tendency to volatilize into the air in aquatic systems. Based on EPA-modeled river systems, approximately half of the dissolved ethyene dibromide would be volatile in 2.6 hours (U.S. EPA, 2012d). NPDES discharge permits require monitoring data to be reported via the DMRs and provide evidence for releases to receiving water bodies. TRI also provides facility-specific water release data. The amount of ethylene dibromide released, as well as receiving water body flow as calculated from NHDPlus flow database at the point of release, are the main factors affecting the concentration in the receiving waterbody and the corresponding levels of exposure.

For exposures via drinking water, releases were considered where there was a possibility of downstream drinking water intakes. Surface water concentrations at the point of discharge were used to estimate drinking water exposures. EPA did not factor in drinking water treatment as a part of their screening assessment, and therefore overestimated concentrations. Authorized by the Safe Drinking Water Act, EPA regulates levels of ethylene dibromide in finished drinking water. The MCL for ethylene dibromide is 0.05 µg/L. In this analysis, OCSPP identified monitoring data from finished drinking water above the MCL from data collected during EPA's SYR 4, which is discussed in Sections 3.3.2 and 4.1.3.4.1.

EPA used several conservative assumptions in the surface water pathway screening analysis of ethylene dibromide. The Agency assumed there was no volatilization of ethylene dibromide from surface water when using the EFAST model, therefore potentially overestimating the concentration in the waterbody. EPA also used estimates in surface water based on 30Q5 flows, increasing the concentration of ethylene dibromide in the water. For all pathways considered, the Agency used concentrations at the point of discharge to estimate exposure to the general population. This was another overestimation used for the screening analysis since it is unlikely that individuals will be swimming and/or fishing or drinking water at the point of discharge. Despite the potential for overestimating exposure via pathways associated with surface water releases, as described in Section 4.3.5.2 and 4.3.5.3 no risk was identified and no further analysis refinements were needed. Because of the use of several conservative assumptions, EPA has robust confidence that the estimated exposures and risk are protective of the general population and PESS.

EPA has robust confidence in the surface water estimates from the reported releases and moderate confidence in the water estimates from modeled releases. The confidence on each OES varies because of the confidence in the release values, the lack of facility location and lack of flow data for some OESs.

4.2 Summary of Human Health Hazard

This section briefly summarizes the human health hazards of ethylene dibromide. Additional information on the human health hazards is provided in Section 2 of the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t).

EPA evaluated non-cancer and cancer hazards via the inhalation, oral, and dermal exposure routes for acute, intermediate, and chronic durations through systematic review of reasonably available evidence. The Agency rated the data quality of each study that met screening criteria as high, medium, low, or uninformative for dose-response and integrated the evidence within and across human, animal, and mechanistic data streams. EPA considered studies that received medium or high overall quality determinations for hazard identification and dose-response analysis. Information from studies of low or

uninformative quality was discussed qualitatively on a case-by-case basis for hazard identification and were considered, but not utilized quantitatively, for dose-response analysis.

4.2.1 Background

EPA reviewed risk assessments published between 2004 and 2022 while considering available data. Of the assessments identified, two report human equivalent values for cancer and chronic non-cancer hazard resulting from inhalation and oral exposures to ethylene dibromide (see Appendix C of the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t)) (ATSDR, 2018; U.S. EPA, 2004b). EPA considered studies with high and medium quality data for dose-response POD selection and also considered lower quality studies and studies that are uninformative for dose-response as needed for weight of scientific evidence and qualitative hazard narratives (U.S. EPA, 2026t). For ethylene dibromide, medium and high-quality animal data were utilized for POD selection because no epidemiology studies were suitable for dose-response assessment. For the dermal route, data were extrapolated from the oral route. Benchmark dose (BMD) analysis was conducted to refine PODs from the no-observed-adverse-effect level (NOAEL) and lowest-observed-adverse-effect level (LOAEL) values as feasible. The CSF calculation for the oral and dermal routes was based on a medium quality animal study by the National Cancer Institute based on dose-responsive tumors in rats in both sexes (NCI, 1978). For the cancer IUR calculation, a high-quality inhalation study by the National Toxicology Program was utilized (NTP, 1982). EPA determined there was adequate and available hazard data to characterize and calculate an acute inhalation, oral and dermal POD based on effects observed in studies that took place over an intermediate exposure duration, as described below in Sections 4.2.3 and 4.2.4.

Due to lack of available dermal absorption data across all relevant species, route-to-route extrapolation was completed based on the oral and inhalation values described below. These extrapolated values are presented in Table 4-24 alongside the HEC/HED values for oral and cancer acute and chronic exposure. There is high confidence in this POD's relevance to dermal exposure, as skin contact can be made in the manufacturing process, when consumers use ethylene dibromide-containing products, or when bathing or swimming in polluted water. When performing route-to-route extrapolation from oral or inhalation endpoints, the suitability of the endpoint was taken into consideration (*e.g.,* portal-of-entry effects were not used for route-to-route extrapolation because these effects are considered route-specific).

EPA utilized systematic review processes to search, screen, evaluate, extract, and integrate reasonably available information to make conclusions about relevant adverse health effects from ethylene dibromide exposure for the oral, inhalation and dermal routes for the acute, intermediate and chronic exposure durations. Following evidence integration, EPA performed dose-response analysis to derive hazard endpoint and POD values for use in risk characterization. The Agency then evaluated the weight of scientific evidence for each aspect of the assessment and determined overall confidence ratings for each critical hazard outcome utilizing the best available science as described in Section 4.2.6. Section 4.2.7 presents the non-cancer PODs, as well as the IUR, oral slope factor (OSF) and CSF values for ethylene dibromide, resulting from oral, inhalation, and dermal exposure.

4.2.2 Absorption, Distribution, Metabolism, Excretion (ADME)

See the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t) for a complete description of pharmacokinetics describing the absorption, distribution, metabolism, and excretion (ADME) of ethylene dibromide.

Absorption

Ethylene dibromide is rapidly absorbed via the oral route of exposure, followed by absorption from the gastrointestinal tract and distribution via the portal system to the liver, where the greater part of metabolism takes place (Hissink et al., 2000). Oral absorption has been found to be extensive (approaching 100%) based on rapid systemic distribution and excretion of metabolites across several species, lending support that animal studies may serve as a reasonable model for human exposure (ATSDR, 2018; U.S. EPA, 2004b). Inhalation studies also found systemic absorption and widespread distribution of ethylene dibromide following exposure, where studies in rats report 50% absorption via the respiratory tract (Stott and Mckenna, 1984). Although dermal absorption has not been quantified, topical application in guinea pigs results in rapid increase of ethylene dibromide concentration in blood (Haldén et al., 1982).

Distribution

Oral exposure studies in male rats indicate that ethylene dibromide is rapidly distributed throughout the body, with the highest retention observed in the kidneys, liver, and spleen (Plotnick et al., 1979). After male Sprague-Dawley rats were fed a diet containing 0.05% disulfiram (a compound known to inhibit cytochrome P 450, specifically CYP2E1 isomer) significant increases in tissue concentrations were found in liver, kidneys, spleen, testes, and brain, with reduced urinary elimination and significant retention noted in the testes, brain, lungs, and erythrocytes (U.S. EPA, 2004b; Plotnick et al., 1979). This indicates that CYP450 inhibition, specifically of CYP2E1, increases the concentration of parent compound systemically. Studies have also examined tissue distribution following intraperitoneal administration. In both male mice and guinea, the kidneys and liver retained the greatest proportion of the administered dose of ethylene dibromide (Plotnick and Conner, 1976; Edwards et al., 1970).

Metabolism

Animal studies have identified that ethylene dibromide metabolism involves two competing pathways: an oxidative route catalyzed by cytochrome P450 (CYP) and a conjugative route mediated by glutathione *S*-transferases (GSTs). The metabolism of ethylene dibromide via oxidation by the CYP pathway yields 2-bromoacetaldehyde (2-BA), a highly reactive electrophile. This intermediate binds to microsomal proteins, causing hepatotoxicity, and contributes to lipid peroxidation, which drives oxidative stress. Conjugation via GST, creating S-(2-bromoethyl)-glutathione. This metabolite spontaneously transforms into a highly reactive episulfonium (thiiranium) ion. These episulfonium ions bind directly to DNA, which is considered to play role in cytotoxic and mutagenic effects (Van Duuren et al., 1985).

These metabolic pathways are consistent across exposure routes, indicating similar metabolism following inhalation and oral exposure after systemic absorption occurs. Conjugation does not require P450 oxidation; these processes occur in parallel not in sequence.

Excretion

Elimination of ethylene dibromide occurs through the production of mercapturic acids via the kidneys. Studies reveal that rodents excrete most of the ethylene dibromide through urinary metabolites and exhaled breath, and feces. In a rat study, oral administration of 15 mg/kg ^{14}C -ethylene dibromide resulted in about 1.65% of the dose being excreted in feces (Plotnick et al., 1979; Plotnick and Conner, 1976). 10 to 12% of the ethylene dibromide dose was excreted via the lung within 72 hours following intraperitoneal injection of 30 mg/kg ^{14}C -ethylene dibromide in guinea pigs. Most of the dose was recovered in the urine (65.9%), with smaller amounts in the liver (2.16%) and feces (3%) (Plotnick and Conner, 1976). Ethylene dibromide as the parent compound is rapidly eliminated from the blood,

primarily through metabolism, with exhaled air serving as a secondary route of elimination (Plotnick et al., 1979).

The data indicates rapid and extensive metabolism and systemic clearance following ethylene dibromide exposure in rats, with little evidence of tissue retention. Accordingly, low-level exposures are not expected to result in the accumulation of ethylene dibromide or its metabolites in tissues. However, at higher exposure levels, saturation of metabolic pathways could occur, potentially allowing ethylene dibromide to persist longer in the body (Hissink et al., 2000).

Physiologically Based Pharmacokinetic (PBPK) Model of Ethylene Dibromide

EPA identified a previously published rat and human PBPK model for ethylene dibromide Hissink *et al*., (2000) and augmented it with a dermal exposure route sub-model as described in Section 2.2.5 of the *Draft Human Health Hazard Assessment for Ethylene Dibromide* and the *Draft PBPK Reporting Document for Ethylene Dibromide* (U.S. EPA, 2026aa). The original Hissink *et al*., (2000) base model was developed using an *in vitro* to *in vivo* extrapolation approach (IVIVE), which translates *in vitro* metabolism parameters to the corresponding *in vivo* parameters and predicts *in vivo* ADME of a compound. The rat IVIVE−PBPK model was evaluated with time-course experimental data in rats and was then extended to humans by using *in vitro* human metabolism parameters and human physiological parameters (Hissink et al., 2000; Ploemen et al., 1997) following a parallelogram framework, which has previously been applied in regulatory settings (Mallick et al., 2020; U.S. EPA, 2019b; Yoon et al., 2015). As discussed in Sections 2.2.5, 2.3.2.5.3, 2.4.7.4.2, and 2.5.2.2 of the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t), PBPK-based route-to-route extrapolation produces refined HEDs by mechanistically translating animal exposures into human internal dose metrics that are relevant to mode of action using dosimetry.

The dermal sub-model added by EPA to the base Hissink *et al*., (2000) human model represents skin permeation and evaporative loss of ethylene dibromide under finite-dose scenarios, for which absorption can be characterized. The in silico dermal model was created with experimental and property-based correlations (*e.g.,* molecular weight, lipophilicity, and volatility informed by human skin penetration rates (Potts and Guy, 1992) and evaporation rates (Deacon et al., 2024)). The dermal- and systemic-integrated PBPK model was then applied to extrapolate human dermal HEDs from rat chronic oral, chronic inhalation, and acute inhalation PODs under specified exposure conditions (*e.g.,* duration and COU) per Sections 5.6.1.4.4, 5.6.2.4.4, 5.6.3.4.4, and 5.6.5.4.4 of the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). The scenario-specific PBPK-yielded dermal doses are also reported as volumes. Dermal absorption is modeled as a time- and dose-varying process; resulting HEDs are expressed as the systemically absorbed dose (*i.e.,* the retained dose, or part of the applied dose that permeates into the skin and is not evaporated or washed, which represents the biologically relevant dose driving systemic exposure). These COUs and exposure-specific HEDs and are reported in Table 4-25 (non-cancer) Table 4-26 (cancer), which are then used for comparison to the retained human dermal exposure estimates described in Section 4.1.1.6. Note that the PBPK model explicitly accounts for dynamic changes in bioavailability for all the routes used in the route-extrapolation assessment including oral, inhalation and dermal, which means that fractional absorption varies over time and with dose. PBPK-estimated dermal HEDs (expressed in mass-based units to compared to the retained doses) reflect chemical-specific absorption (dynamic bioavailability) and systemic exposure (accounting for systemic ADME) under specific dermal exposure conditions.

4.2.3 Non-Cancer

Acute and Intermediate Inhalation Exposure Duration

For acute inhalation, EPA has robust confidence in the reproductive endpoints reported by (Short et al., 1978). Mouse fetal developmental abnormalities and increased late resorptions reported in Short *et al*., (1978) were selected as the basis for the POD used for characterizing risk from exposure to ethylene dibromide due to its sensitive LOAEL of 20 ppm and the severity of outcomes. Female reproductive data are robust in animal studies, slight in mechanistic studies, and indeterminate in epidemiological studies. Developmental data are robust in animal studies, and slight in epidemiological and mechanistic studies. While mechanistic data was considered slight for this endpoint, there is substantial overlap between the genotoxic mode of action for cancer and a genotoxic mode of action for reproductive and developmental toxicity due to modification of cellular macromolecules such as DNA, RNA, proteins, and lipids during critical developmental periods (Godschalk et al., 2025). In Short et al., (1978) , three dose groups were utilized in addition to a control group, but excessive mortality in the highest dose group made BMD modeling infeasible. Ultimately, data for two dose groups in addition to the control was included in the dose-response analysis.

EPA had robust confidence in PESS sensitivity for these findings, as the study observed exposure effects in pregnant females and their resulting pups. Exposure in Short (1978) took place gestational day 6 through 16. As stated in OECD guideline 414, rodent organogenesis occurs between gestational day 5 and 15, and thus the POD is appropriate for examination of both maternal and fetal exposure. There is robust confidence in the relevance of this POD to exposure, as inhalation exposure is relevant to occupational, consumer, and general population scenarios, in which ethylene dibromide is released into air. The significant effects on reproductive endpoints reported in Short (1978) are complimented by additional studies (Short et al., 1979), (NTP, 1982), and (NCI, 1978), which focus primarily on reproductive endpoints and show significant effects at doses ranging from 10 to 89 ppm. The lack of an identified NOAEC and the limited number of exposure groups in the critical study led to an overall confidence in the intermediate inhalation POD of moderate. Because this POD was also applied to acute exposure scenarios, the confidence in the acute inhalation POD is slight (reduced 1 level due to applying it to a shorter duration exposure).

The PODs for acute and intermediate inhalation exposures were also applied to acute and intermediate dermal exposures by route-to-route extrapolation. These were the only PODs that could be extrapolated to dermal exposures. The effects seen via inhalation are expected to be relevant to dermal exposures (after adjusting for the lower bioavailability via the skin) because they are systemic effects and there is no first-pass metabolism via either inhalation or dermal routes. The confidence in the acute dermal POD is slight and the confidence in the intermediate dermal POD is moderate.

Acute and Intermediate Oral Exposure Duration

For acute oral exposure, EPA has moderate confidence in the gastrointestinal endpoints reported by (Ghanayem et al., 1986). This reference assessed exposure to ethylene dibromide in male rats, evaluating histopathological changes to organs. Forestomach epithelial cell proliferation and hyperkeratosis was selected as the basis for the POD used for characterizing risk from exposure to ethylene dibromide due to its sensitive LOAEL of 80 mg/kg/day and the severity of outcomes. This study was designed and intended to measure precursor events in the pathway for alkylating agents. Evidence for adverse gastrointestinal outcomes was found to be slight in epidemiological studies, with relatively few animal toxicology references identified. While there were no mechanistic studies flagged for gastrointestinal outcomes related to ethylene dibromide exposure per se, alkylating agents as a class are known to cause gastrointestinal effects via multiple mechanisms: hematogenesis through a pathway mediated by the chemoreceptor trigger zone (O'Brien, 2008) as well as breakdown of the gastrointestinal

mucosa due to differential cytotoxicity of alkylating agents on rapidly dividing cells, such as those lining the intestinal tract (Mustian et al., 2008). EPA has moderate confidence in PESS sensitivity for these findings, as testing occurred in adult animals only with no specific PESS-related considerations, though the endpoints observed are thought to be applicable to all populations. There is moderate confidence in this POD's relevance to exposure, as oral exposure is relevant to general population scenarios related to consumption through polluted water and fish from polluted waterways. However, the POD utilizes gavage experimentally rather than food or drink to expose animals. Effects are expected to be similar but may not directly capture all factors associated with oral exposure. Although relatively few animal studies were available for gastrointestinal outcomes, (NCI, 1978) supports the findings described in (Ghanayem et al., 1986) at a chronic exposure duration. Additionally, adverse gastrointestinal outcomes have been reported in several cases of acute oral and inhalation exposure in humans (Singh et al., 2007; Saraswat et al., 1986; Peoples et al., 1978).

This POD was not suitable for route-to-route extrapolation because it is a portal of entry effect. As such, the oral POD was not used to extrapolate to dermal exposures.

Chronic Oral Exposure Duration

For chronic oral exposure, EPA has robust confidence in the critical liver effects and co-critical reproductive and adrenal endpoints reported by (NCI, 1978). At 38 mg/kg/day, peliosis hepatis and focal necrosis of the liver, along with adrenal cortex degenerative lesions, and testicular atrophy, were identified in rats. For adverse liver outcomes, evidence was found to be robust in animal studies, slight in epidemiological studies, and slight in mechanistic studies. For male reproductive outcomes, evidence was found to be robust in animal studies, moderate in epidemiological studies, and slight in mechanistic studies. Although not specific to ethylene dibromide, there is strong mechanistic evidence linking alkylating agents as a class with male reproductive effects including testicular atrophy (Sriram et al., 2024; Lazowski et al., 1982). Finally, EPA found slight animal evidence of adrenal effects in animal studies. EPA has moderate confidence in PESS sensitivity for these findings, as testing occurred in adult animals only with no specific PESS-related considerations, though the endpoints observed are thought to be applicable to all populations. There is moderate confidence in the relevance of this POD to exposure, as oral exposure is relevant to general population scenarios related to consumption through polluted water and fish from polluted waterways. However, the POD was based on dosing the animals via gavage rather than via diet or drinking water, which would have been more relevant than gavage. Effects are expected to be similar but may not directly capture all factors associated with oral exposure.

This POD was considered for route-to-route extrapolation from oral-to-dermal. However, the weight of scientific evidence and the best available science was to use the POD extrapolated from the chronic inhalation study (see Sections 2.3.2.5.2 and 2.3.2.7 in the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t)).

Chronic Inhalation Exposure Duration

For chronic inhalation exposure, EPA has robust confidence in the liver endpoints reported by (NTP, 1982), describing similar hazards to those observed with chronic oral exposure. At 10 ppm exposure in rats, a critical outcome of liver necrosis was identified. Additionally, adrenal cortex degradation and testicular degradation are significant, as well as retinal atrophy, nasal cavity inflammation, and splenic hematopoiesis. In EPA's evaluation of adverse liver outcome data following exposure to ethylene dibromide, evidence was found to be robust in animal studies, slight in epidemiological studies, and slight in mechanistic studies. Although there is limited mechanistic evidence for liver effects for ethylene dibromide directly, the fact that the liver bioactivates ethylene dibromide to an alkylating agent supports the liver being a target, as alkylating agents are also cytotoxic (NIDDK, 2015). EPA has

moderate confidence in PESS sensitivity for these findings, because testing occurred in adult animals only with no specific PESS-related considerations, though the endpoints observed are thought to be applicable to all populations. There is high confidence in the relevance of this POD to exposure, as inhalation exposure is relevant to occupational, consumer, and general population scenarios, in which ethylene dibromide is released into air.

The POD for chronic inhalation exposure was also applied to chronic dermal exposure by route-to-route extrapolation. This decision was supported by the weight of scientific evidence and the best available science (see Sections 2.3.2.5.2 and 2.3.2.7 in the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t)). The effects seen via inhalation are expected to be relevant to dermal exposures (after adjusting for the lower bioavailability via the skin) because they are systemic effects and there is no first-pass metabolism via either inhalation or dermal routes. The confidence in the chronic dermal POD is robust.

4.2.4 Cancer

EPA identified carcinogenic effects at multiple-sites associated with chronic oral, inhalation, and dermal exposure to ethylene dibromide based on evidence from experimental animal studies. Existing assessments of ethylene dibromide also identified carcinogenic effects following oral, inhalation and dermal chronic exposure to ethylene dibromide, including the development of tumors such as squamous cell carcinoma in the stomach and hemangiosarcoma in the cardiovascular system (NCI, 1978). Additional tumor types observed across studies include adenomas and carcinomas in the nasal cavity, adenomas in the pituitary gland, hemangiosarcoma in the spleen, and fibroadenomas in the mammary gland (Adkins et al., 1986; NTP, 1982), and skin papillomas and papillary adenomas of the lung after dermal exposure (Van Duuren et al., 1979). EPA has preliminarily determined that ethylene dibromide "is likely carcinogenic to humans", with robust animal evidence for cancer at multiple sites, and the weight of scientific evidence supports a mutagenic mode of action. The most biologically relevant PODs for cancer effects for ethylene dibromide are described below. The corresponding CSF, dermal slope factor, and inhalation unit factor are listed in Table 4-24.

The carcinogenicity of ethylene dibromide is supported by robust evidence integrating multiple chronic inhalation (NTP, 1982) and oral (NCI, 1978) studies. Tumor formation was observed across species including F344 rats and B6C3F1 mice, and in both sexes. Following inhalation exposure, increased incidences of tumors were observed in respiratory tract (*e.g.,* adenoma and carcinoma of nasal cavity) and circulatory system (*e.g.,* hemangiosarcoma's of the spleen). Following oral exposure, tumorigenesis was observed in the gastrointestinal tract (*e.g.,* forestomach squamous cell carcinomas). These findings demonstrate multi-organ carcinogenic effects across exposure routes. The studies utilized for non-cancer chronic inhalation and oral HEC/HED calculation are the same that were used to calculate the IUR and CSF, with tumorigenesis observed across several organ systems at 10 ppm and 38 mg/kg/day, respectively. The routes (inhalation and oral) and study durations were sufficient to capture carcinogenic outcomes and are considered relevant for human exposure scenario, particularly in the context of understanding the ethylene dibromide's MOA. The relationship varies across organ systems and species, indicating variability in tumor response. For example, adenomas and adenocarcinomas of the nasal cavity were observed in low-dose rats of both sexes, while additional tumors including combined alveolar/bronchiolar adenomas and carcinomas, were increased in high-dose female rats. The extrapolation to humans assumes that humans fall within this range of sensitivity. Confidence in PESS is considered moderate for our toxicity values because as testing occurred in adult animals only with no specific PESS-related considerations, though the endpoints observed are thought to be applicable to all populations. There is high confidence in this toxicity value's relevance to exposure. Overall, despite these moderate considerations, the weight of evidence for ethylene dibromide's carcinogenicity is

robust. This was supported by cross-species, sex, and duration exposure relevance clearly evidence of tumor formation. The selection of animal toxicity values, routes, and durations provide a basis for assessing human cancer risk.

The OSF was considered for route-to-route extrapolation from oral-to-dermal. However, the weight of scientific evidence and the best available science was to use a slope factor extrapolated from the chronic inhalation study (see Sections 2.4.7.4.1 and 2.4.7.5 in the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t)). The effects seen via inhalation are expected to be relevant to dermal exposures (after adjusting for the lower bioavailability via the skin) because they are systemic effects and there is no first-pass metabolism via either inhalation or dermal routes. The confidence in the dermal CSF is robust.

4.2.5 Dermal Route-to-Route Estimation Approaches

EPA assessed dermal exposure to ethylene dibromide using a tiered route-to-route extrapolation to derive human equivalent dermal exposure doses (HEDs) for non-cancer and cancer endpoints. The route-to-route extrapolation approach assumes that, once absorbed, systemic PK (distribution, metabolism, and excretion) is route-independent and systemic toxicity is driven by the absorbed internal dose and equivalent internal doses produce comparable effects. In the present evaluation, non-dermal to dermal extrapolation converted oral or inhalation PODs from animal studies to equivalent dermal doses. The consistent evidence of observed toxicological effects resulting from both oral and inhalation routes of exposure and systemic toxicity provides confidence in performing route-to-route extrapolation of available oral and inhalation data using a PBPK model to derive dermal PODs for non-cancer.

Default Dermal Route-to-Route Extrapolation

At the screening tier, the default approach translated animal toxicity values from oral and inhalation toxicity studies to HEDs using allometric scaling, which assumes that many physiological processes scale with body size. This approach has been widely used in risk evaluations when chemical-specific data are limited. However, it primarily relies on addressing interspecies differences through body size relationships. The default approach, discussed more in Sections 2.3.2.5.1, 2.4.7.4.1 and 2.5.2.1 of the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t), requires scaling by fixed constants of proportionality. The important parameters include route-specific absorption (bioavailability), body weights of experimental animals versus adult humans, breathing rates of adult humans, and the regional gas dose ratio, which is set at a value of one for category three gases. Route-to-route extrapolation from oral-to-dermal consistently yielded similar results as route-to-route extrapolation from inhalation-to-dermal; however, inhalation was determined to be a more appropriate basis for dermal extrapolation since inhalation and dermal exposure lack the first pass effect. Additionally, because some oral studies were based on portal-of-entry effects that are unsuitable for route-to-route extrapolation, only the inhalation-to-dermal extrapolations were used for risk calculation.

The benefits of this approach include reliance on existing EPA guidance, a long history of application in risk assessments by various governmental authorities worldwide, and a body of literature supporting these practices as health-protective but not overly conservative. Challenges include a lack of scenario dependence, a lack of consideration of metabolism or bioactivation, and gaps related to potential dose-limiting portal of entry effects for the untested portal of entry. Although inhalation-to-dermal exposure might provide a reasonable estimate of the dermal dose expected to lead to the same systemic effects as inhalation, such as an increase in birth defects, but a true dermal study may have found more sensitive effects on the skin and surrounding tissue that might occur at lower doses that cannot be extrapolated from other routes of exposure.

Overall EPA's confidence in the default approach reflects the confidence of the inhalation and dermal PODs that the dermal PODs are based off, which range from slight (acute non-cancer) to moderate (intermediate non-cancer) and robust (chronic non-cancer and cancer). It has multiple precedents in the operation of the TSCA Existing Chemicals Program, other EPA programs, and other U.S. government risk assessments of chemical substances. However, improvements can be made by incorporating additional data on ethylene dibromide specifically and exposure to chemicals in general, including ADME of these substances, for which PBPK modeling can be used for refinement.

PBPK Dermal Route-to-Route Extrapolation

At the refinement tier, PBPK modeling was used to perform interspecies and route-to-route extrapolation, converting oral and inhalation PODs to dermal HEDs based on the internal dose metric associated with toxicity. This was done because the incorporation of time-course kinetics for both systemic and specific routes furnishes additional tiered support and confidence in extrapolation than the sole reliance of body weight scaling. The Hissink et al., (2000) ethylene dibromide PBPK model was used for route-to-route extrapolation. This model is explained more in Section 4.2.2 of the current document and in Sections 2.2.5, 2.3.2.5.3, 2.4.7.4.2, and 2.5.2.2 of the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t). A thorough evaluation and uncertainty analysis of the model is in *Draft PBPK Reporting Document for Ethylene Dibromide* (U.S. EPA, 2026aa). The refined PBPK-based dermal route-to-route extrapolation simulates dynamics of dermal exposure, hence time-dependent changes in the systemically absorbed dose under defined exposure conditions, which can be compared with retained dose estimates from the exposure assessment. Specifically, dermal absorption is simulated as a function of chemical-specific physiochemical properties and scenario-specific exposure parameters. This permits explicit characterization of the relation between applied and internal dose. Thus, retained dose for a given exposure scenario can be directly estimated and compared with internal dose metrics derived from oral and inhalation animal studies. By integrating systemic PK processes with scenario-specific exposure assumptions, the PBPK model incorporates both systemic exposure (which informs effect magnitude) and exposure dynamics into hazard estimates.

Summary and Comparison of Default and PBPK-Based Route-to-Route Methods

Both default and PBPK-based route-to-route extrapolation include three elements in converting animal PODs to HEDs: (1) interspecies dosimetry, (2) exposure-regimen differences (duration and frequency), and (3) route-specific bioavailability. Default dermal route-to-route extrapolation methods are used when chemical-specific dermal absorption data are unavailable. In these approaches, an internal dose metric (lower confidence limit of the BMD [BMDL] or POD) derived from an oral or inhalation toxicity study is converted to an equivalent dermal dose by applying simplifying assumptions regarding absorption. In the case of this assessment, complete (100%) gastrointestinal absorption or inhaled uptake from the toxicity studies is assumed and a fractional dermal absorption term is applied to estimate a retained dermal dose corresponding to each BMDL or POD. Under this framework, the resulting dermal toxicity value is expressed as a retained, or systemically absorbed, dose, and exposure is compared directly to this retained dose metric without explicit adjustment for exposure-condition-specific determinants. See Table 4-23 for a comparison table of default and PBPK approaches.

Table 4-23. Comparison of Default and PBPK Dermal Route-to-Route Approaches

Attribute	Default Dermal Route-to-Route Approach	PBPK Dermal Route-to-Route Approach
POD Basis	Derived BMDL from chronic oral and chronic inhalation study and POD from acute inhalation study	BMDL (chronic oral and inhalation) and POD (acute inhalation) to derive internal dose metric (amount metabolized in the liver via GST pathway)
Dermal Absorption Bioavailability	Applied as fixed fraction	Estimated dynamically by model, is dose- and time-dependent
Exposure Conditions (COU-specific details)	Not explicitly considered	Incorporated into model
Volatilization	Not explicitly considered	Incorporated into model
Applied Dose Estimation	Not generated	Generated from exposure inputs
Retained Systemic Dose	Estimated via default fraction	Generated from exposure inputs
Dose Metric Compared to POD	Retained dose	Retained dose
Relationship Between Applied and Retained Dose	Assumed constant	Scenario-dependent
BMDL = benchmark dose limit; GST = glutathione S-transferase; PBPK = physiologically based pharmacokinetic modeling		

4.2.6 Weight of Scientific Evidence Conclusions for Human Health Hazards

EPA evaluated the confidence for human health hazard conclusions based on evidence integration conclusions, selection of the most critical endpoint and study, relevance to exposure scenarios, dose-response considerations, and incorporation of PESS. More details on how EPA evaluated these factors are provided in Sections 2.5.1 and 2.6 of the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t). EPA has robust overall confidence for the evidence integration, study/endpoint selection, exposure scenario applicability, dose-response, and PESS sensitivity of the conclusions and PODs for hepatic toxicity, reproductive/developmental effects, gastrointestinal effects, and carcinogenicity, which are used for the risk estimates. These hazard outcome categories received moderate and robust evidence integration conclusions, and biologically relevant health effects were identified for these hazard outcomes.

Non-Cancer

Evidence Integration Conclusions: Considering acute, intermediate, and chronic exposure, EPA concluded that ethylene dibromide likely causes effects on liver, lung, and reproductive function in humans under relevant exposure circumstances based primarily on animal data. EPA also concluded that ethylene dibromide likely causes effects on mortality. The Agency has moderate-to-robust overall confidence in the evidence integration, study/endpoint selection, exposure scenario applicability, dose-response analysis, PESS sensitivity, and PBPK modeling supporting derivation of PODs for ethylene dibromide based on the endpoints described below. The selection of references for PODs is consistent with prior risk evaluations for ethylene dibromide published by (ATSDR, 2018) and (U.S. EPA, 2004b).

Selection of the Most Critical Endpoint and Study: EPA identified liver, gastrointestinal, mortality, and reproductive/developmental effects as the most sensitive non-cancer outcomes supported by the strongest evidence. Available studies consistently show similar effects on related endpoints.

For acute and intermediate inhalation, EPA selected (Short et al., 1978) as the basis for the PODs because it evaluated a range of doses and a comprehensive set of sensitive reproductive and developmental endpoints. This reference follows exposure to ethylene dibromide in pregnant mice and rats, evaluating a variety of maternal and fetal effects. Mouse fetal developmental abnormalities and increased late resorptions were selected as the basis for the POD used for characterizing risk from exposure to ethylene dibromide due to the severity of outcomes. Because exposure took place over several days during gestation, this dosing regimen falls under the "intermediate" duration for toxicity studies. However, without highly specialized studies to probe the "window of susceptibility" of the developing fetus to the toxic effect, it cannot be ruled out that a single dose (*i.e.,* a single, acute exposure) would have been sufficient for the adverse effects seen in the study. Because of this uncertainty, the same value is used for both acute and intermediate exposures for inhalation. The significant effects on reproductive endpoints reported in (Short et al., 1978) are supported by additional studies (Short et al., 1979), (NTP, 1982), and (NCI, 1978), which reported significant reproductive effects at doses ranging from 10 to 89 ppm.

For the acute and intermediate oral PODs, EPA selected (Ghanayem et al., 1986), which allows for dose-response analysis. This reference follows exposure to ethylene dibromide in male rats, evaluating histopathological changes to organs. Hyperkeratosis of the forestomach was selected as the basis for the POD used for characterizing risk from exposure to ethylene dibromide; this was the only available dose-response data suitable for POD derivation, the endpoint was considered adverse, and the critical effect is directly linked to histopathological changes seen in longer duration studies. This experiment involved exposing test animals to ethylene dibromide 5 times per week, for 10 total exposures. For oral studies, the available study for dose-response had multiple oral exposures. This dosing regimen falls under the "intermediate" duration for toxicity studies because there was more than one exposure to the same dosing groups. Because of the low number of exposures (10 exposures over 2 weeks) and because there were no high-quality single exposure studies for dose-response, this study was used to derive an acute/intermediate POD for oral exposures. Importantly, the POD for intermediate effects should be protective for acute effects as well (U.S. EPA, 2002a).

Existing reports of human acute exposures confirms that nausea, vomiting, and other signs of gastrointestinal distress are the most common findings following oral exposure to ethylene dibromide (see Section 2.3.2.4 and Table_Apx A-9 in the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t)). Because the Ghanayem et al. (1986) study dosed 10 times, the effects observed in this study are inclusive of single dose effects (*e.g.,* any effects from the first dose will also be reported). While effects on the forestomach are generally considered to be specific to rodents and of questionable human relevance, in this case it was being examined specifically for early key events in a chain of events that could lead to DNA damage and cancer outcomes. The HED from BMD modeling was calculated to be 2.7 mg/kg/day. The forestomach is a rodent-specific structure lined with squamous epithelium and is not present in humans, rodents also possess a glandular stomach, which is more closely comparable to the human stomach due to its specialized mucosal epithelium involved in secretion of gastric enzymes and acid. The changes seen in (Ghanayem et al., 1986) are indicative of non-cancer outcomes that precede and do not inevitably progress to tumorigenesis but are relevant to chronic and cancer outcomes from ethylene dibromide exposure.

For characterizing risk for acute and intermediate dermal exposures to ethylene dibromide, route-to-route extrapolation was applied to the acute and intermediate inhalation PODs. However, the above-described acute and intermediate inhalation PODs based on (Short et al., 1978) were not considered appropriate for PBPK route-to-route extrapolation, because they were measured in a species for which EPA lacks a PBPK model. Instead, for route-to-route extrapolation, the Agency selected (Short et al.,

1979), a rat study that evaluated the effects of ethylene dibromide exposure on male and female reproductive endpoints including implantations and resorptions. Male or female rats were exposed, then mated with non-exposed controls. A female LOAEL of 80 ppm was determined for uterine epithelium degeneration and effects on the estrous cycle. A male LOAEL of 89 ppm was determined for lowered fertility and testicular atrophy. The study durations were different among sexes; female rats were exposed to 80 ppm for shorter durations than the male rats exposed to 89 ppm. This resulted in a lower internal dose from the 89 ppm exposures. Thus, the 89-ppm LOAEL was chosen for route-to-route extrapolation because it would be protective across sexes.

For chronic inhalation, EPA selected (NTP, 1982) as the basis for POD determination because it evaluates sensitive dose levels and the endpoints reported reflect patterns seen in both inhalation and oral exposure studies at various durations. At 38 mg/kg/day, co-critical effects of liver peliosis, adrenal cortex degenerative lesions, and testicular atrophy were identified in rats. The oral chronic study utilized for POD determination for noncancer endpoints (NTP, 1982) describes similar hazards. At 10 ppm exposure in rats, a critical outcome of liver necrosis is identified. Additionally, adrenal cortex degradation and testicular degradation are significant, as well as retinal atrophy, nasal cavity inflammation, and splenic hematopoiesis.

For characterizing non-cancer hazard from chronic dermal exposure to ethylene dibromide, route-to-route extrapolation was applied to the chronic inhalation POD and chronic oral POD described in the previous paragraph. Both references are appropriate for route-to-route extrapolation because they both study exposure in rats, and they both describe endpoints that are systemic rather than being localized to portal of entry.

Relevance to Exposure Scenarios: The inhalation POD is based on effects in a developmental study in mice and rats (Short et al., 1978) that EPA determined to be relevant for acute/intermediate exposures in humans. Although there were 10 total exposures in this study, fetal development can be impacted differently depending on gestational day of exposure. Based on the available evidence, even brief exposure to ethylene dibromide during pregnancy has potential for fetal toxicity in humans and it therefore cannot be ruled out that the effects described in (Short et al., 1978) could not also be seen in a single exposure during a sensitive period of gestational development. Similarly, the oral POD selected is based on a short-term study, in which exposure takes place over 10 total days (Ghanayem et al., 1986). The toxicity associated with ethylene dibromide exposure is found in the same organ systems with acute, intermediate, and chronic exposure, where the effects with chronic exposure display increased severity.

The inhalation and oral chronic PODs are based on effects found in cancer studies by the National Cancer Institute and the National Toxicology Program. Both institutions apply standardized protocols based on the best available science for appropriate testing of chemicals for carcinogenicity, while also reporting non-cancer effects. EPA considers the resulting non-cancer chronic effects described in both studies to be relevant for chronic exposures in humans.

Dose-Response Considerations: EPA analyzed all reasonably available references for potential use in dose-response assessment. The selected oral study was sufficient for BMDL modeling. Although the selected inhalation study was the best-fit in the reasonably available data pool to be utilized for dose-response, the study was ultimately not amenable to BMD modeling. No principal study was selected for acute dermal exposure to ethylene dibromide due to lack of data availability. The acute and intermediate dermal PODs were calculated by the default and PBPK route-to-route extrapolation methods in a tiered manner.

Chronic inhalation and chronic oral PODs were identified in references that described sensitive endpoints. No critical study was selected for chronic dermal exposure to ethylene dibromide due to lack of data availability. A PBPK model was built for route-to-route extrapolation to determine a chronic dermal value. Furthermore, EPA completed default route-to-route calculations to identify a chronic dermal POD based on oral chronic data to compare to the resulting PBPK-derived value.

Consideration of PESS: Extrapolation from the inhalation POD is expected to be protective of sex-specific effects across most life stages. It is based on the best available science in a short-term reproductive study and is therefore expected to be protective of effects resulting from in-utero exposure. Although the POD is based on a female reproductive endpoint most relevant to adult females and fetal development, extrapolation from this POD is protective of other endpoints that may be affected by ethylene dibromide, including male reproductive outcomes, and respiratory and liver effects relevant to other groups and life stages. Other factors that may contribute to biological susceptibility were considered qualitatively but not quantitatively incorporated into the POD. A 10 UF_H factor was applied to account for human toxicokinetic and toxicodynamic variability, which is expected to account for differences in dose-response and toxicokinetics due to factors such as limited coverage of infants and children's exposure as well as interindividual variability. For example, considerations such as existing disease states and genetic polymorphisms in metabolizing enzymes or transporters can result in variation in chemical clearance and distribution within subpopulations. Moreover, disease states (such as inflammatory bowel diseases) that result in variations in gastrointestinal tract composition may affect absorption and overall distribution—especially for first-pass metabolism in the gut wall—of the test chemical. Hepatic diseases can change the liver volume and metabolic processes, potentially changing internal kinetics.

Cancer

Evidence Integration Conclusions: EPA concluded that ethylene dibromide likely causes carcinogenic effects on the gastrointestinal tract, cardiovascular system, lungs, hematopoietic system, skin, nasal cavity, pituitary, spleen, liver, kidney, pancreas, mammary gland, testes, lymphatic system, and subcutaneous tissue in humans under relevant exposure circumstances based primarily on animal data. The Agency has robust overall confidence in the evidence integration, study/endpoint selection, and exposure scenario applicability for ethylene dibromide based on the respective endpoints described below.

Selection of the Most Critical Endpoint and Study: The references that EPA identified for chronic non-cancer POD calculation were also used for identification of potential cancer PODs. Studies of cancer endpoints demonstrate systemic toxicities of ethylene dibromide exposure with tumors spread across many organ systems regardless of exposure type. The selected inhalation study (NTP, 1982) is determined to be the best available science identified with a positive cancer identification at 10 ppm in rats. Although the POD is based on carcinomas and adenocarcinomas of the nasal cavity, the authors report tumors in a wide variety of organ systems.

The selected oral exposure study (NCI, 1978) is the best available science from EPA's literature review, with the lowest cancer-causing dose at 38 mg/kg/day, resulting in forestomach squamous-cell carcinomas and hemangiosarcomas in rats. Hepatocellular carcinomas were also observed at the higher experimental dose (*i.e.* 39 mg/kg/day). Several references utilizing drinking water as a mode of exposure (Van Duuren et al., 1986; Van Duuren et al., 1985) were ultimately not selected for POD determination due to uncertainty concerning the palatability of the mixture significantly and chronically decreasing the volume of water ingested by test animals, leading to chronic dehydration and chemical uncertainties as a result of reactivity between ethylene dibromide and water. The average dosing in Van Duuren et al.

(1985) (*i.e.,* 103 or 116 mg/kg/day) is approximately double that was utilized by (NCI, 1978) and exposure was in mice rather than rats. Despite these differences, similarly increased mortality and consistent tumorigenesis was observed in these studies, with (Van Duuren et al., 1985) reporting forestomach stomach, liver, and esophageal tumors. The presence of esophageal tumors is reflective of the drinking water dosing method, where (NCI, 1978) instead utilized gavage to pass the test material directly to the stomach. Van Duuren (1986) exposed mice to a much lower average dose (*i.e.,* 1.2 or 1.4 mg/kg/day) via drinking water and authors still reported observing forestomach and esophageal tumors, though mortality is not clearly reported. National Cancer Institute (1978) also exposed mice to ethylene dibromide via gavage, but these animals underwent a more complex dosing paradigm during which exposure levels were changed several times over the course of the experiment, making the experiment inappropriate for use in dose-response calculations. In this experiment, mice were exposed to 62 or 107 mg/kg/day, so the high-dose group approximately matches the dosing in Van Duuren (1985). The National Cancer Institute (1978) mice also developed forestomach tumors. Together, this consistent evidence of gastrointestinal tumorigenesis in mice and rats following ethylene dibromide exposure strengthens our confidence in the selected POD reference.

Relevance to Exposure Scenarios: EPA considers the resulting cancer effects described in both studies to be relevant for chronic exposures in humans.

Dose-Response Considerations: EPA analyzed all reasonably identified references for potential use in dose-response assessment. The National Cancer Institute study (male rats) and the National Toxicology Study (male and female rats) were used as inputs to BMD modeling using a multi-stage cancer model to estimate the slope factor (oral) or IUR (inhalation). No key study was selected for dermal exposure to ethylene dibromide due to lack of data availability. Instead, route-to-route extrapolation was performed from the oral and inhalation cancer studies.

The dose-response analysis resulted in CSFs that are in line with those derived as part of other assessments on ethylene dibromide and also a close analogue, 1,2-dichloroethane, which differ in that the two bromine atoms have been replaced with chlorine atoms. Ethylene dibromide and 1,2-dichloroethane share substantial similarities in chemical structure, genotoxicity, mode of action, and toxic effects. Both are alkylating agents. Ethylene dibromide is expected to be a more potent alkylator due to bromide being a better leaving group than chloride. This is supported by the CSFs for these two chemicals. According to EPA's analysis, ethylene dibromide is approximately 3.2 times more potent than 1,2-dichloroethane via oral exposure, 15 times more potent via inhalation exposure, and 7.7 times more potent via dermal exposure. This roughly half-log to one-log difference in potency is consistent with the kinetics of bimolecular nucleophilic substitution reactions (S_N2) of the brominated vs. chlorinated ethane (U.S. EPA, 2026ai).

The U.S. EPA 2004 assessment *Toxicological Review of 1,2-Dibromoethane (CAS no. 106-93-4)* reported an oral CSF of 2.0 $(mg/kg/day)^{-1}$ and IUR of 6.0×10^{-4} $(\mu g/m^3)^{-1}$ (U.S. EPA, 2004b). Although the numerical values presented in this document differ from those reported in and other agencies, the proposed oral CSF and IUR as described below in Table 4-24 are 0.24 $(mg/kg/day)^{-1}$ and 8.9×10^{-5} $(\mu g/m^3)^{-1}$, respectively; these remain with the same order of magnitude of carcinogenic potency.

This analysis enhances the Agency's confidence in the CSF calculations for ethylene dibromide. The numbers are consistent with other assessments and show greater potency than 1,2-dichloroethane (which would be expected) but the values are not extremely disparate (less than approximately 1-log; *i.e.,* <10 times).

Consideration of PESS: As discussed in Section 2.5.1.3, Section 2.6.2, and Section A.7.1 of the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t), though there are several factors that may influence susceptibility to cancer in general, such as sociodemographic factors and lifestyle activities (*e.g.,* smoking, nutrition), few studies have assessed susceptibility specifically in combination with ethylene dibromide exposure. There is some indication that specific genetic polymorphisms (Hölzer et al., 2008; Ploemen et al., 1995), co-exposures (Niehoff et al., 2019), and age (Niehoff et al., 2019) are potential susceptibility factors that may interact with ethylene dibromide exposure. EPA incorporated age-based susceptibility to mutagenic carcinogens through the inclusion of an ADAF for general population exposures. Due to insufficient data, EPA was unable to quantitatively incorporate other potential susceptibility factors.

Dermal Route-to-Route Extrapolation Tiered Approach

EPA conducted route-to-route extrapolation in a tiered manner and estimated dermal HEDs, as described in Section 4.2.5. The traditional (default) method provided an initial, screening-level tier. Default and PBPK-based dosimetry approaches for cross-species and route-to-route extrapolation differ in how they use scientific evidence to address uncertainty. In the default approach, external exposure levels (*e.g.,* administered dose) were the basis for assessing dermal hazard. Because the relationship between external exposure and the biologically relevant dose is not explicitly characterized in the dermal approach, uncertainties such as those pertaining to species, exposure variability, and human variability remain. To account for these uncertainties, a PBPK model was applied in the refinement tier. The PBPK model approach relies on kinetics of the internal dose metric (*e.g.,* amount of ethylene dibromide metabolized in the liver through the GST pathway), that can be directly linked to toxic effects. Because it is a mechanistic model, intra-species differences and exposure regimens (duration, frequency, and COU) are incorporated directly into the model, reducing the overall uncertainty that default extrapolations address with default factors. As such, uncertainty in PBPK extrapolations from animal to human is limited to model error. The weight of scientific evidence is therefore strong because the model is well-validated and biologically credible, internal dose metrics are likely relevant to toxicity MOA and parameters are well-characterized.

PBPK Model Uncertainty Analysis

A complete uncertainty analysis and assessment of the PBPK model performance can be found in *Draft PBPK Reporting Document for Ethylene Dibromide* (U.S. EPA, 2026aa) and in Section 2.5.2.2 of the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t). For the application of route-to-route extrapolation, model confidence depends on uncertainties arising from both systemic and exposure components of the PBPK model. The ethylene dibromide PBPK model described in Hissink et al., (2000) was developed to describe pharmacokinetics of ethylene dibromide after inhalation, oral, and intravenous dosing, including pulmonary exchange, first pass metabolism, and competing metabolic pathways for ethylene dibromide. The systemic PBPK model structure is based on the widely-accepted PBPK model for VOCs, which has been applied to other relevant VOCs (Sweeney and Gargas, 2016; Andersen et al., 1987; Ramsey and Andersen, 1984). Note that EPA identified some uncertainties and errors in the Hissink et al., (2000) publication, which included a lack of published code and inadequate written model description. EPA had to attempt to recreate the model in R (version 4.4.0) by making various assumptions about the model equations that may introduce uncertainty. The Hissink et al., (2000) publication also included mislabeled figures and data. EPA addressed these uncertainties in the *Draft PBPK Reporting Document for Ethylene Dibromide* (U.S. EPA, 2026aa).

Due to a lack of *in vitro* or *in vivo* data to inform dermal kinetics, an *in silico* model was used to predict evaporation from skin and permeation into the skin. The absorption of ethylene dibromide was characterized with physical-chemical properties via the *in silico* dermal model. The *in silico* dermal

model was not validated with experimental data since neither *in vitro* nor *in vivo* data that evaluated evaporation or dermal permeation of ethylene dibromide were found. However, ethylene dibromide falls within the domain of applicability for the permeation model (Potts and Guy, 1992) and the evaporation model (Deacon et al., 2024)—both of which were developed using *in vitro* skin data and evaluated for chemicals with similar physico-chemical properties as ethylene dibromide. Despite a lack of ethylene dibromide-specific validation data, the support of these predictions have been accepted regulatorily; for example, exposure estimates already make use of *in silico* models to predict dermal bioavailability via IH SkinPerm (AIHA, 2024).

Uncertainties may arise from the use of these *in silico* models, the parameters that govern evaporation and skin permeation absorption, and exposure assumptions. This uncertainty was mitigated by estimating the retained HED, which is driven more by systemic model assumptions and parameters.

Sensitivity analysis was conducted to measure the proportional (unitless) change in the dose metric (amount metabolized in the liver by GST) produced by proportional changes in the parameter value. A complete analysis can be found in the *Draft PBPK Reporting Document for Ethylene Dibromide* (U.S. EPA, 2026aa). For both the acute and chronic human dermal exposure model for both low (1%) and high (100%) ethylene dibromide formulations, the parameters most influential to the dose metric included body weight, liver and muscle volume, the first order GST-mediated metabolic rate constant in the liver, the maximum metabolic rate for CYP pathway, skin permeability, and ethylene dibromide evaporation flux. For the lowest molar fraction chemical concentrations (*i.e.,* 1% ethylene dibromide), exposed surface area of skin, the enzyme's binding affinity, and solvent density were considerably more influential for the chronic endpoints. Body weight, tissue volumes, liver metabolism parameters, respiration rate, and blood-to-air partitioning were influential for the rat model. Variability in these parameters could account for inter-individual differences in dermal absorption and systemic exposure.

High confidence in parameterization of body composition (from *in vivo* data) and metabolism parameters (*in vitro* experiments) strengthen confidence in quantifying results for applicable dose metrics. Because physiological parameters are known with a high degree of confidence (Brown et al., 1997), the route-to-route extrapolation results that rely solely on these influential parameters have correspondingly high levels of confidence. However, model uncertainty can increase for dose metric for which dermal evaporation and permeation are most influential if the parameters used in the evaporation and permeation QSARs (quantitative structure-activity relationships) are not well characterized. Due to a lack of *in vivo* or *in vitro* dermal exposure data, dermal parameters were not validated against experimental data and could mischaracterize dermal absorption.

4.2.7 Human Health Hazard Values

The HECs and HEDs and corresponding uncertainty factors (UFs) that EPA derived for evaluating risks from acute, intermediate, and chronic inhalation, oral, and dermal exposures are presented in Table 4-24. The HEDs are expressed as daily doses and the HECs are based on daily, continuous concentrations (24 hours/day) assuming a breathing rate for individuals at rest. Any adjustments needed to exposure durations and frequencies and breathing rates are made in the exposure estimates used to calculate risks for individual exposure scenarios. As discussed in Section 4.2.5, EPA used a tiered route-to-route extrapolation to derive HEDs for non-cancer and cancer endpoints. Table 4-25 summarizes PBPK-derived dermal non-cancer HEDs (retained dose) based on acute, intermediate, and chronic inhalation empirical data for both worker and consumer COUs. Table 4-26 summarizes PBPK-derived dermal cancer HEDs and CSFs based on inhalation empirical data for worker and consumer COUs. Sections

2.2.5.2, 2.3.2.5.3, and 2.4.7.2.4 of the *Draft Human Health Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t) describes the data and approaches used to derive these hazard values.

Route-to-route extrapolation from oral-to-dermal consistently yielded similar results to route-to-route extrapolation from inhalation-to-dermal and are reported in Table 7-3 of the *Draft Human Health Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t); however, inhalation-to-dermal extrapolation values were ultimately selected for risk characterization. Using inhalation as the basis for extrapolation is supported because the inhalation and dermal routes of exposure have more similar systemic effects than those resulting from oral exposure; since both inhalation and dermal exposures bypass the "first-pass effect" in the liver, they result in similar liver exposures. Given the centrality of metabolism to the bioactivation of ethylene dibromide as well as the choice of liver effects as the critical effect for both oral and inhalation PODs support the decision to estimate PODs extrapolation from inhalation studies, which also provide more health protective values. Oral exposures will lead to different liver concentrations due to the first pass effect. The PBPK approach represents a refinement over the default approach. The high-end scenarios were used for the POD because there was not much difference between high-end and central tendency, and these scenarios match those for the risk calculations. Additionally, some oral studies were based on portal-of-entry effects that are not suitable for route-to-route extrapolation, only the inhalation-to-dermal extrapolations were used for risk calculation.

EPA used an overall interspecies uncertainty factor (UF_A) of three to account for any toxicodynamic differences across species. To account for both toxicokinetic and toxicodynamic variation in sensitivity within human populations (which was not accounted for by the PBPK model), EPA used a default UF_H of 10 due to limited information regarding the degree to which human toxicokinetic and toxicodynamic variability may impact the disposition of or response to ethylene dibromide. A lowest-observed-adverse-effect concentration (LOAEC) to no-observed-adverse-effect concentration (NOAEC) uncertainty factor (UF_L) of three was used when BMDL/lower confidence limit of the BMC (BMCL) values were not available, requiring use of a LOAEC instead.

For dermal risk evaluation, the PBPK model extrapolated from rodent PODs to human equivalent dermal exposures for ethylene dibromide accounted for interspecies toxicokinetics. Thus, EPA used an overall interspecies uncertainty factor (UF_A) of 3 to account for any toxicodynamic differences across species. Due to limited information regarding the degree to which human toxicokinetic and toxicodynamic variability may impact the disposition of or response to ethylene dibromide, the PBPK model calculated human dermal loadings for an average human (*i.e.,* the parameters used in the PBPK model were for the average adult human, which means that resulting HEDs are for the average human as well). Because toxicokinetic and toxicodynamic variation within human populations (such as sensitive populations and children) was not accounted for by the PBPK model, EPA used a default UF_H of 10. Combining these two uncertainty factors, the total UF used as the basis for the benchmark MOE was 30.

3222 **Table 4-24. HECs and HEDs and Critical Endpoint Used for Risk Estimates for Each Exposure Pathway**

Target Organ System	Species	Duration	POD	Effect	HEC/HED [a]	Benchmark MOE [b]	Reference	Overall Quality Determination [c]	POD Selection Confidence [d]
Acute and intermediate inhalation POD									
Reproductive/ Developmental	Mouse	24 hours/day, 10 days (starting GD=6)	LOAEC = 20 ppm/day	Fetal developmental abnormalities and increased late resorptions	HEC = 150 mg/m^3 (20 ppm)	100 [UF_A = 3, UF_H = 10, UF_L = 3]	Short et al. (1978)	High	Slight (acute duration) Moderate (intermediate duration)
Acute and intermediate oral POD									
Gastrointestinal	Rat	5 days/week, 2 weeks	LOAEL = 80 mg/kg/day	Forestomach epithelial cell proliferation and hyperkeratosis	HED = 2.7 mg/kg-bw/day	30 [UF_A = 3, UF_H = 10]	Ghanayem et al. (1986)	High	Slight (acute duration) Moderate (intermediate duration)
Acute and intermediate dermal POD									
Reproductive/ Developmental	Mouse	24 hours/day, 10 days (starting GD=6)	LOAEC = 20 ppm/day	Fetal developmental abnormalities and increased late resorptions	HED = 28 mg/kg/day (this is the default route-to-route extrapolation from the acute and intermediate inhalation PODs)	100 [UF_A = 3, UF_H = 10, UF_L = 3]	Short et al. (1978)	High	Slight (acute duration) Moderate (intermediate duration)
Reproductive/ Developmental	Rat	7 hours/day, 5 days/week, 10 weeks	LOAEC = 89 ppm/day	Testicular atrophy, lowered fertility	HE = 38–40 mg/kg/d (9–33 mL) CT = 43–45 mg/kg/d (24–100 mL) (This is a PBPK route-to-route extrapolation from the acute and intermediate inhalation PODs)	100 [UF_A = 3, UF_H = 10, UF_L = 3]	Short et al. (1979)	High	Slight (acute duration) Moderate (intermediate duration)

Target Organ System	Species	Duration	POD	Effect	HEC/HED [a]	Benchmark MOE [b]	Reference	Overall Quality Determination [c]	POD Selection Confidence [d]
Chronic inhalation POD									
Liver	Rat	6 hours/day, 5 days/week, 2 years	LOAEC = 10 ppm	Liver necrosis	HEC = 11 mg/m^3 (1.5 ppm)	30 [UF_A = 3, UF_H = 10]	NTP (1982)	High	Robust
Chronic oral POD									
Liver, Adrenal, Reproductive	Rat	5 days/week, 49 weeks	LOAEL = 38 mg/kg/day	Liver peliosis, adrenal cortex degenerative lesions, and testicular atrophy	HED = 3.3 mg/kg-bw/day	30 [UF_A = 3, UF_H = 10]	NCI (1978)	Medium	Robust
Chronic dermal POD									
Liver	Rat	6 hours/day, 5 days/week, 2 years	LOAEC = 10 ppm	Liver necrosis	BMDL = 2.2 mg/kg/day (This is the default route-to-route extrapolation from the chronic inhalation POD)	30 [UF_A = 3, UF_H = 10]	NTP (1982)	Medium	Robust
Liver	Rat	6 hours/day, 5 days/week, 2 years	BMDL= 9 ppm from LOEC = 10 ppm	Liver necrosis	HE = 3.3–3.8 (1–3 mL) CT = 3.4–3.6 mg/kg/d (3–8mL) (This is a PBPK route-to-route extrapolation from the chronic inhalation POD)	30 [UF_A = 3, UF_H = 10]	NTP (1982)	Medium	Robust
Liver, Adrenal, Reproductive	Rat	5 days/week, 49 weeks	LOAEL = 38 mg/kg/day	Liver peliosis, adrenal cortex degenerative lesions, and testicular atrophy	BMDL = 3.3 mg/kg/day (This is the default route-to-route extrapolation from	30 [UF_A = 3, UF_H = 10]	NCI (1978)	Medium	Robust

Target Organ System	Species	Duration	POD	Effect	HEC/HED [a]	Benchmark MOE [b]	Reference	Overall Quality Determination [c]	POD Selection Confidence [d]
					the chronic oral POD)				
Liver, Adrenal, Reproductive	Rat	5 days/week, 49 weeks	BMDL = 11 mg/kg/day From LOAEL = 11 mg/kg/d	Liver peliosis, adrenal cortex degenerative lesions, and testicular atrophy	HE = 5.5-5.7 mg/kg/d (1-5mL) CT = 5.6-6 mg/kg/d (1–7 mL) (This is the PBPK route-to-route extrapolation from the chronic oral POD)	30 [UF_A = 3, UF_H = 10]	NCI (1978)	Medium	Robust
Cancer inhalation IUR [e]									
Cancer Inhalation IUR	Rat	Low-dose animals: 5 days/week, 103 weeks High dose males: 5 days/week, 88 weeks High dose females: 5 days/week, 91 weeks	10 ppm	Carcinomas, adenocarcinomas, adenomas of the nasal cavity	IUR = 8.9E−05 $(\mu g/m^3)^{-1}$ $(0.68(ppm)^{-1})$ IUR (adult) = 5.6E−05 $(\mu g/m^3)^{-1}$ $(0.43(ppm)^{-1})$	N/A	NTP (1982)	High	Robust
Cancer oral OSF [f]									
Cancer	Rat	5 days/week, 49 weeks	38 mg/kg/day	Incidence of all primary tumors	OSF = 0.24 $(mg/kg/day)^{-1}$ OSF (adult) = 0.15 $(mg/kg/day)^{-1}$	N/A	NCI (1978)	Medium	Robust
Dermal CSF-route-to-route extrapolation [g]									
Cancer	Rat	Low-dose animals: 5	10 ppm	Carcinomas, adenocarcinomas,	IUR = 8.9E−05 $(\mu g/m^3)^{-1}$ $(0.68(ppm)^{-1})$	N/A	NTP (1982)	Medium	Robust

Target Organ System	Species	Duration	POD	Effect	HEC/HED [a]	Benchmark MOE [b]	Reference	Overall Quality Determination [c]	POD Selection Confidence [d]
		days/week, 103 weeks High dose males: 5 days/week, 88 weeks High dose females: 5 days/week, 91 weeks		adenomas of the nasal cavity	IUR (adult) = 5.6E−05 $(\mu g/m^3)^{-1}$ $(0.43(ppm)^{-1})$				

BMDL = lower confidence limit of the BMD; CT = central tendency; CSF = cancer slope factor; HE = high-end estimate; HEC = human equivalent concentration; HED = human equivalent dose; IUR = inhalation unit risk; LOAEC = lowest observable adverse effect concentration; LOAEL = lowest observable adverse effect level; MOE = margin of exposure; NOAEL = no observed adverse effect level; OSF = oral slope factor; PBPK = physiologically-based pharmacokinetic; POD = point of departure; ppm = parts per million; UF = uncertainty factor BMD = benchmark dose; BMDL = lower confidence limit of the BMD; CSF = cancer slope factor; CT = central tendency estimate; HE = high-end estimate; HEC = human equivalent concentration; HED = human equivalent dose; IUR = inhalation unit risk; LOAEC = lowest observable adverse effect concentration; LOAEL = lowest observable adverse effect level; MOE = margin of exposure; NOAEL = no observed adverse effect level; OSF = oral slope factor; PBPK = physiologically-based pharmacokinetic; POD = point of departure; ppm = parts per million; UF = uncertainty factor

[a] HED/HEC values were derived in accordance with the appropriate guidance (HED (U.S. EPA, 2011b), HEC (U.S. EPA, 1994b)). Exposure values used in the critical study were converted to HED/HEC values and benchmark dose modeling (BMD) was performed for all endpoints except for acute and intermediate inhalation, where BMD modeling was not possible. More details on non-cancer HEC/HED derivation and BMD modeling (Section 2.3.2.4) and cancer HEC/HED derivation and BMD modeling (Section 2.4.7.2) are provided in the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t).

[b] UF = uncertainty factor; UF_A = extrapolation from animal to human (interspecies); UF_H = potential variation in sensitivity among members of the human population (intraspecies); UF_L = extrapolation from LOAEC to NOAEC; UF_S = subchronic-to-chronic duration extrapolation

[c] Overall Quality Determination (OQD) is a rating that is reported for each health outcome per study that undergoes data quality evaluation. Section 2.1.2 of the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t) provides a brief overview and lists the data quality evaluation and extraction supplemental files relevant for studies identified for the characterization of environmental and human health hazard. Full details regarding the systematic review process for all the identified studies are described in the *Draft Systematic Review Protocol for Ethylene Dibromide* (U.S. EPA, 2026ag).

[d] POD selection confidence is based on an evaluation of the identified POD and the confidence in the alignment of this POD with the assigned route/duration and any uncertainties associated with the POD being used for risk estimates (*e.g.,* route-to-route extrapolation, duration adjustment, etc.). These considerations are summarized in Section 2.5.1 of the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t).

[e] Cancer inhalation unit risk for ethylene dibromide based on nasal tumors in male and female rats from (NTP, 1982).

[f] Cancer oral slope factor for ethylene dibromide was based on incidence of primary tumors in male rats from (NCI, 1978).

[g] Dermal cancer slope factor was derived from the calculated IUR from (NTP, 1982) and extrapolated to the dermal route to derive the corresponding dermal slope factor.

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Table 4-25. PBPK Route-to-Route Extrapolated Dermal Non-Cancer Human Health Hazard PODs for Workers and Consumers

Route-to-Route Route of Exposure and POD_{rat} Duration	COU	Concentration of Ethylene Dibromide Used (CT–HE)	OES or Consumer Scenario	HE Dermal COU				CT Dermal COU			
				Mass %	Exposed skin surface area (cm^2)	Volume (L)	HED (Retained, mg/kg/d)	Mass %	Exposed skin surface area (cm^2)	Volume (L)	HED (Retained, mg/kg/d)
Non-cancer chronic inhalation-to-dermal, BMCL, 9 ppm, Male F344 Rat	Manufacture − Import	45–60 wt%	Import and Repackaging	60	1,070	2.7E−03	3.4	45	535	4.5E−03	3.5
	Processing − Repackaging	50–100 wt%		100	1,070	8.3E−04	3.3	50	535	3.8E−03	3.5
	Processing − Incorporation into formulation, mixture, or reaction product	30–60 wt%	Incorporation into Formulation, Mixture, or Reaction Product	60	1,070	2.7E−03	3.4	30	535	7.9E−03	3.6
	Processing − As a reactant; Industrial use – Other use; Processing aid not otherwise specified; Pigment and dye manufacturing	55–100 wt%		100	1,070	8.3E−04	3.3	55	535	3.3E−03	3.4
	Industrial use − Fuel agent in petroleum refineries; Commercial use − Fuels and related products (2-hands)	0.085–0.1 wt%	Fuels and Related Products (avgas)	0.1	1,070	N/A (cannot reach internal dose)		0.085	1,070	N/A (cannot reach internal dose)	
	Commercial use – Other use − Laboratory chemical (2-hands)	50–100 wt%	Laboratory Use	100	1,070	8.3E−04	3.3	50	535	3.8E−03	3.5
	Disposal	50–100 wt%	Waste Handling, Treatment, and Disposal	100	1,070	8.3E−04	3.3	50	535	3.8E−03	3.5
	Commercial use − Other uses − Laboratory chemical (1-hands)	50–100 wt%	Laboratory Use	100	535	8.3E−04	3.3	50	267.5	3.8E−03	3.5

Route-to-Route Route of Exposure and POD_{rat} Duration	COU	Concentration of Ethylene Dibromide Used (CT–HE)	OES or Consumer Scenario	HE Dermal COU				CT Dermal COU			
				Mass %	Exposed skin surface area (cm^2)	Volume (L)	HED (Retained, mg/kg/d)	Mass %	Exposed skin surface area (cm^2)	Volume (L)	HED (Retained, mg/kg/d)
Non-cancer chronic inhalation-to-dermal, BMCL, 9 ppm, Male F344 Rat	Industrial use − Fuel agent in petroleum refineries; Commercial use − Fuels and related products (1-hand)	0.085–0.1 wt%	Fuels and Related Products (avgas)	0.1	535	N/A (cannot reach internal dose)		0.085	267.5	N/A (cannot reach internal dose)	
	Consumer use − Fuels and related products (avgas) (2 hands)	0.085–0.1 wt%	Consumer	0.1	1,070	N/A (cannot reach internal dose)		0.085	535	N/A (cannot reach internal dose)	
	Consumer use − Fuels and related products (avgas) (1 hand)	0.085–0.1 wt%	Consumer	0.1	535	N/A (cannot reach internal dose)		0.085	267.5	N/A (cannot reach internal dose)	
Acute inhalation-to-dermal, LOEC, 89 ppm, combined Sex CD Rats and CD-1 Mice	Manufacture − Import	45–60 wt%	Import and Repackaging	60	1,070	3.2E−02	40	45	535	6.1E−02	44
	Processing − Repackaging	50–100 wt%		100	1,070	9.4E−03	38	50	535	4.9E−02	43
	Processing − Incorporation into formulation, mixture, or reaction product	30–60 wt%	Incorporation into Formulation, Mixture, or Reaction Product	60	1,070	3.2E−02	40	30	535	0.23	45
	Processing − As a reactant; Industrial use – Other use; Processing aid not otherwise specified; Pigment and dye manufacturing	55–100 wt%		100	1,070	9.4E−03	38	55	535	4.1E−02	42
	Industrial use − Fuel agent in petroleum refineries; Commercial use − Fuels and related products (2-hands)	0.085–0.1 wt%	Fuels and Related Products (avgas)	0.1	1,070	N/A (cannot reach internal dose)		0.085	535	N/A (cannot reach internal dose)	
	Commercial use – Other use − Laboratory chemical (2-hands)	50–100 wt%	Laboratory Use	100	1,070	9.4E−03	38	50	535	4.9E−02	43

Route-to-Route Route of Exposure and POD_{rat} Duration	COU	Concentration of Ethylene Dibromide Used (CT–HE)	OES or Consumer Scenario	HE Dermal COU				CT Dermal COU			
				Mass %	Exposed skin surface area (cm^2)	Volume (L)	HED (Retained, mg/kg/d)	Mass %	Exposed skin surface area (cm^2)	Volume (L)	HED (Retained, mg/kg/d)
Acute inhalation-to-dermal, LOEC, 89 ppm, combined Sex CD Rats and CD-1 Mice	Disposal	50–100 wt%	Waste Handling, Treatment, and Disposal	100	1,070	9.4E−03	38	50	535	4.9E−02	43
	Commercial use – Other use − Laboratory chemical (1-hands)	50–100 wt%	Laboratory Use	100	535	9.6E−03	38	50	267.5	0.10	45
	Industrial use − Fuel agent in petroleum refineries; Commercial use − Fuels and related products (1-hand)	0.085–0.1 wt%	Fuels and Related Products (avgas)	0.1	535	N/A (cannot reach internal dose)		0.085	267.5	N/A (cannot reach internal dose)	
	Consumer use − Fuels and related products (avgas) (2 hands)	0.085–0.1 wt%	Consumer	0.1	1,070	N/A (cannot reach internal dose)		0.085	535	N/A (cannot reach internal dose)	
	Consumer use − Fuels and related products (avgas) (1 hand)	0.085–0.1 wt%	Consumer	0.1	535	N/A (cannot reach internal dose)		0.085	267.5	N/A (cannot reach internal dose)	

BMCL = lower confidence limit of the BMC; COU = condition of use; CT = central tendency; HE = high-end; HED = human equivalent dose; LOEC = lowest observed effect concentration; OES = occupational exposure scenario; POD_{rat} = rat point of departure; wt% = weight percent

"HE Dermal COUs" describes HE mass % formulation for applicable COU for each exposed surface area of skin, and predicted volume of media and predicted HED. "CT Dermal COUs" describes CT mass % formulation for applicable COU, for each exposed surface area of skin, and predicted volume of media and predicted HED.

"N/A (cannot reach internal dose)" means that under the given exposure scenario, no HED and volume of media large enough could be calculated to reach maximum internal dose threshold. The retained dose, or part of the applied dose that permeates into the skin and is not evaporated or washed, represents the biologically relevant dose driving systemic exposure.

* HE concentrations were simulated for 1,070 cm^2 (2 hands) and 535 cm^2 (1 hand) exposed skin; CT concentrations were simulated with 535 cm2 (2 hands) and 267.5 cm^2 (1 hand) exposed skin.

Reported HED (mg/kg/d) is retained dermal human equivalent dose over specified surface area of skin (cm^2) and in specified volume of liquid (L). COU describes condition of use, which can include 1 or 2 hands. Rows that indicate "1 hand or 1 palm" or "2-hand" indicate that COUs that are distinct by surface area of skin. The simulated skin surface area can be found under the "Exposed skin surface area (cm^2)" column.

Table 4-26. PBPK Route-to-Route Extrapolated Dermal Cancer Human Health Hazard HEDs and CSFs (Inhalation-to-Dermal) for Workers and Consumers

Route-to-Route Route of Exposure and POD_{BMDL}	COU	Concentration of Ethylene Dibromide Used (CT–HE)	OES or Consumer Scenario	HE Dermal COU				CT Dermal COU			
				Mass %	Exposed Skin Surface Area (cm^2)	Volume (L)	CSF $(mg/kg/d)^{-1}$	Mass %	Exposed Skin Surface Area (cm^2)	Volume (L)	CSF $(mg/kg/d)^{-1}$
PBPK, 0.231 ppm	Manufacture − Import	45–60 wt%	Import and Repackaging	60	1,070	3.9E−04	0.21	45	535	6.2E−04	0.21
	Processing − Repackaging	50–100 wt%		100	1,070	1.2E−04	0.21	50	535	5.2E−04	0.21
	Processing − Incorporation into formulation, mixture, or reaction product	30–60 wt%	Incorporation into Formulation, Mixture, or Reaction Product	60	1,070	3.9E−04	0.21	30	535	1.1E−03	0.21
	Processing − As a reactant; Industrial use – Other use; Processing aid not otherwise specified; Pigment and dye manufacturing	55–100 wt%		100	1,070	1.2E−04	0.21	55	535	4.5E−4	0.21
	Industrial use − Fuel agent in petroleum refineries; Commercial use – Fuels and related products (2-hands)	0.085–0.1 wt%	Fuels and Related Products (avgas)	0.1	1,070	N/A (cannot reach internal dose)		0.085	535	N/A (cannot reach internal dose)	
	Commercial use – Other use – Laboratory chemical (2-hands)	50–100 wt%	Laboratory Use	100	1,070	1.2E−04	0.21	50	535	5.2E−04	0.21
	Disposal	50–100 wt%	Waste Handling, Treatment, and Disposal	100	1,070	1.2E−04	0.21	50	535	5.2E−04	0.21

Route-to-Route Route of Exposure and POD_{BMDL}	COU	Concentration of Ethylene Dibromide Used (CT–HE)	OES or Consumer Scenario	HE Dermal COU				CT Dermal COU			
				Mass %	Exposed Skin Surface Area (cm^2)	Volume (L)	CSF $(mg/kg/d)^{-1}$	Mass %	Exposed Skin Surface Area (cm^2)	Volume (L)	CSF $(mg/kg/d)^{-1}$
PBPK, 0.231 ppm	Commercial use – Other use − Laboratory chemical (1-hands)	50–100 wt%	Laboratory Use	100	535	5.2E−04	0.21	50	267.5	5.2E−04	0.21
	Industrial use − Fuel agent in petroleum refineries; Commercial use − Fuels and related products (1-hand)	0.085–0.1 wt%	Fuels and Related Products (avgas)	0.1	535	N/A (cannot reach internal dose)		0.085	267.5	N/A (cannot reach internal dose)	
	Consumer use − Fuels and related products (avgas) (2 hands)	0.085–0.1 wt%	Consumer	0.1	1,070	N/A (cannot reach internal dose)		0.085	535	N/A (cannot reach internal dose)	
	Consumer use − Fuels and related products (avgas) (1 hand)	0.085–0.1 wt%	Consumer	0.1	535	N/A (cannot reach internal dose)		0.085	267.5	N/A (cannot reach internal dose)	
Default 0.231 ppm	Unspecified			CSF = 0.33 $(mg/kg/d)^{-1}$ HED = 0.30 mg/kg/d							

COU = condition of use; CSF = cancer slope factor; CT = central tendency; HE = high-end; HED = human equivalent dose; IUR = inhalation risk; OES = occupational exposure scenario; POD_{rat} = rat point of departure; wt% = weight percent

"N/A (cannot reach internal dose)" means that under the given exposure scenario, no HED and volume of media large enough could be calculated to reach maximum internal dose threshold. The retained dose, or part of the applied dose that permeates into the skin and is not evaporated or washed, represents the biologically relevant dose driving systemic exposure.

CSF $(mg/kg/d)^{-1}$ = BMR/HED; BMR = 0.1. All HE and CT HEDs from inhalation-to-dermal route-to-route extrapolation = 0.47–0.48 mg/kg/d. HED (mg/kg/d) is retained dermal human equivalent dose over specified surface area of skin (cm^2) and in specified volume of liquid (L).

HE dermal exposures were simulated for HE COU formulation and HE skin surface area (1,070 cm^2 for 2 hands or 535 cm^2 for 1 hand); CT dermal exposures were CT simulated for COU formulation and CT skin surface area (535 cm^2 for 2 hands or 267.5 cm^2 for 1 hand)). Benchmark MOE = 1.0E−04; Consumer Benchmark MOE = 1.0E−06.

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4.3 Human Health Risk Characterization

4.3.1 Risk Characterization Approach

The exposure scenarios, populations of interest, and hazard values (including toxicological endpoints) used for evaluating risks from acute, intermediate, and chronic/lifetime exposures are summarized in Table 4-27.

Ethylene Dibromide – Human Health Risk Characterization: Key Points

EPA evaluated all reasonably available information to support the human health risk assessment of ethylene dibromide. The following bullets summarize the results of the draft human health risk characterization:

- Risks to workers from inhalation and dermal exposure are above the cancer threshold (1×10^{-4}) for most OESs at both the central tendency and high-end of worker exposures, including OESs related to Import and Repackaging, Incorporation into Formulation, Mixture or Reaction Product, Laboratory Use, and Waste Handling, Treatment, and Disposal.
  - These same OESs showed non-cancer risks at the high-end but not at the central tendency.
  - Of the OESs considered, only Fuels and Related Products did not have cancer or non-cancer risks for any duration at the central tendency or the high-end.
- Risks to consumers from inhalation exposure are within the cancer risk range (1×10^{-6} to 1×10^{-4}) for low-, medium-, and high-intensity scenarios.
- Risks to consumers from dermal exposure are within the cancer risk range for medium- and high-intensity scenarios
  - None of the consumer scenarios showed non-cancer risks (*i.e.,* all MOEs > benchmark).
- No risks to the general population from exposures through drinking water, surface water, and fish ingestion were found for non-cancer or cancer effects.
- Risks to the general population from ambient air inhalation are within the cancer risk range (1×10^{-6} to 1×10^{-4}) for three OESs:
  - Incorporation into Formulation, Mixture, or Reaction Product; Fuels and Related Products, and Waste Handling, Treatment, and Disposal
  - None of these OESs showed corresponding non-cancer risks.

Table 4-27. Exposure Scenarios, Populations of Interest, and Hazard Values

Population of Interest and Exposure Scenario	***Workers*** [a] Average adult workers (≥16 years old) including both male and female (including pregnant women) directly working with ethylene dibromide under light activity (breathing rate of 1.25 m^3/h) including high-end and central tendency exposure assumptions (for further details see Sections 4.1.1.5 and 4.1.1.6 of this documents, and the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). Exposure Durations and Frequencies *For all OESs,* • *Acute* – 8 hours for a single workday • *Intermediate* – 8 hours per workday for up to 22 days per 30-day period • *Chronic, non-cancer* – 8 hours per workday for up to 250 days per year for 31 or 40 working years • *Chronic, cancer* – 8 hours per workday for up to 250 days per year for lifetime of 78 years *For Fuels and Related Products – Refueling OES,* • *Acute* – 5.3 to 42.4 minutes for a single workday

Population of Interest and Exposure Scenario *(continued)*	• *Intermediate* – 5.3 to 42.4 minutes per workday for up to 22 days per 30-day period • *Chronic, non-cancer* – 5.3 to 42.4 minutes per day for up to 250 days per year • *Chronic, cancer* – 5.3 to 42.4 minutes per workday for up to 250 days per year for 31 to 40 years of working years Exposure Routes Inhalation exposure to ethylene dibromide vapor, and Dermal exposure to ethylene dibromide liquid
	Occupational Non-Users Average adult workers (≥16 years old) indirectly exposed to ethylene dibromide within the same work area as workers (breathing rate of 1.25 m^3/h) (for further details see (U.S. EPA, 2026d)) Exposure Durations and Frequencies • *Acute, Intermediate, and Chronic* – same as workers Exposure Routes Inhalation exposure to ethylene dibromide vapor
	Consumers Youth (16–20 years) and adults (21+ years) exposed to ethylene dibromide throughout avgas refueling activity based on low-end, central tendency and high-end intensity use scenarios (for further details see Section 4.1.2 and (U.S. EPA, 2026d) Exposure Durations • *Acute* – 1 day exposure • *Intermediate* – 12/26/52 days per year • *Chronic Cancer* – 14/32/56 years Exposure Routes – Inhalation and dermal
	General Population Exposed to Environmental Releases Male and female infants, children, youth, and adults exposed to ethylene dibromide through ambient air, drinking water, surface water, and fish ingestion (for further details see Section 4.1.3 (U.S. EPA, 2025a)) Exposure Durations • *Acute* – Exposed to ethylene dibromide for a short non-continuous period • *Chronic* – Exposed to ethylene dibromide continuously up to the number of years within an age group/life stage Exposure Routes – Inhalation, dermal, and oral (depending on exposure scenario)
Health Effects, Concentration, and Time Duration	***Non-Cancer*** The **acute and intermediate oral endpoint** is increased forestomach epithelial cell proliferation and hyperkeratosis in rats via oral gavage 5 days/week, for 2 weeks (Ghanayem et al., 1986). • HED = 2.7 mg/kg-bw/day • Uncertainty factors (benchmark MOE) = 30 [UF_A = 3, UF_H = 10] The **chronic oral endpoint** is liver peliosis, adrenal cortex degenerative lesions, and testicular atrophy in rats via oral gavage for 5 days/week or 49 weeks (NCI, 1978). • HED = 3.3 mg/kg-bw/day • Uncertainty factors (benchmark MOE) = 30 [UF_A = 3, UF_H = 10] The **acute and intermediate inhalation endpoint** is increased fetal developmental abnormalities and increased late resorptions in mice after exposure for 24 hours/day, for 10 days (Short et al., 1978). • HEC = 150 mg/m^3 or 20 ppm • Uncertainty factors (benchmark MOE) = 100 [UF_A = 3, UF_H = 10, UF_L = 3] The **chronic inhalation endpoint** is liver necrosis in rats after exposure for 6 hours/day, 5 days/week, for 2 years (NTP, 1982). • HEC = 11 mg/m^3 or 1.5 ppm • Uncertainty factors (benchmark MOE) = 30 [UF_A = 3, UF_H = 10]

Health Effects, Concentration, and Time Duration *(continued)*	The **acute and intermediate dermal endpoint** is extrapolated via route-to-route, through default and PBPK methods. The **default route-to-route extrapolation from inhalation** is based on fetal developmental abnormalities and increased late resorptions in mice after exposure for 24 hours/day, for 10 days (Short et al., 1978). • HED = 28 mg/kg/day • Uncertainty factors (benchmark MOE) = 100 [UF_A = 3, UF_H = 10, UF_L = 3] The **PBPK route-to-route extrapolation from inhalation** is based on testicular atrophy and lowered fertility in rats after exposure for 7 hours/day, 5 days/week, for 10 weeks Short et al. (1979). • HE = 38–40 mg/kg/d (9–33 mL) • CT = 43–45 mg/kg/d (24–100 mL) • Uncertainty factors (benchmark MOE) = 100 [UF_A = 3, UF_H = 10, UF_L = 3] The **chronic dermal endpoint** is extrapolated via route-to-route, through default and PBPK methods. The **default route-to-route extrapolation from oral** is based on liver peliosis, adrenal cortex degenerative lesions, and testicular atrophy in rats via oral gavage for 5 days/week or 49 weeks (NCI, 1978). • BMDL = 3.3 mg/kg/day • Uncertainty factors (benchmark MOE) = 30 [UF_A = 3, UF_H = 10] The **PBPK route-to-route extrapolation from oral** is based on liver peliosis, adrenal cortex degenerative lesions, and testicular atrophy in rats via oral gavage for 5 days/week or 49 weeks (NCI, 1978). • HE = 5.5–5.7 mg/kg/d (1–5 mL) • CT = 5.6–6 mg/kg/d (1–7 mL) • Uncertainty factors (benchmark MOE) = 30 [UF_A = 3, UF_H = 10] The **default route-to-route extrapolation from inhalation** is based on liver necrosis in rats after exposure for 6 hours/day, 5 days/week, for 2 years (NTP, 1982). • BMDL = 2.2 mg/kg/day ED = 28 mg/kg/day • Uncertainty factors (benchmark MOE) = 30 [UF_A = 3, UF_H = 10] The **PBPK route-to-route extrapolation from inhalation** is based on liver necrosis in rats after exposure for 6 hours/day, 5 days/week, for 2 years (NTP, 1982). • HE = 3.3–3.8 (1–3 mL) • CT = 3.4–3.6 mg/kg/d (3–8 mL) • Uncertainty factors (benchmark MOE) = 30 [UF_A = 3, UF_H = 10] ***Cancer*** The **cancer inhalation endpoint** is carcinomas, adenocarcinomas, and adenomas of the nasal cavity in rats after exposure for 5 days/week, for 88 to 103 weeks (NTP, 1982). • IUR (all ages) = 8.9E−05 $(\mu g/m^3)^{-1}$ or $0.68(ppm)^{-1}$ • IUR (adult) = 5.6E−05 $(\mu g/m^3)^{-1}$ or $0.43(ppm)^{-1}$ The **cancer oral endpoint** is squamous cell carcinoma of the stomach in rats via oral gavage 5 days/week, for 1 year (NCI, 1978). • OSF (all ages) = 0.24 $(mg/kg/day)^{-1}$ • OSF (adult) = 0.15 $(mg/kg/day)^{-1}$ The **cancer dermal endpoint** is extrapolated based on the oral cancer endpoint of squamous cell carcinoma of the stomach in rats via oral gavage 5 days/week, for 1 year (NCI, 1978). • CSF = 0.48 $(mg/kg/day)^{-1}$ • CSF (adult) = 0.30 $(mg/kg/day)^{-1}$

BMDL = lower confidence limit of the BMD; CT = central tendency; CSF = cancer slope factor; HE = high-end estimate; HEC = human equivalent concentration; HED = human equivalent dose; IUR = inhalation unit risk; MOE = margin of exposure; OES = occupational exposure scenario; OSF = oral slope factor; PBPK = physiologically-based pharmacokinetic; POD = point of departure; ppm = parts per million; UF = uncertainty factor

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4.3.1.1 Estimation of Non-Cancer Risks

EPA used an MOE approach to identify potential non-cancer risks. The MOE is the ratio of the non-cancer hazard value POD divided by a human exposure dose. The chronic MOEs for non-cancer inhalation risks were calculated using the equation below:

Equation 4-2.

$$MOE = \frac{Non-cancer\ Hazard\ Value\ (POD)}{Human\ Exposure}$$

Where:

MOE	=	Margin of exposure for acute, short-term, or chronic risk comparison (unitless)
Non-cancer Hazard Value (POD)	=	Human equivalent concentration (HEC, µg/m^3)
Human Exposure	=	Exposure estimate (µg/m^3)

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

4.3.1.2 Estimation of Cancer Risks

Extra cancer risks for repeated exposures to a chemical were estimated using the following equations:

Equation 4-3.

$$Lifetime\ Cancer\ Risk = Human\ Exposure \times IUR$$

or

$$Dermal\ or\ Oral\ Cancer\ Risk = Human\ Exposure \times CSF$$

Where:

Human Exposure	=	Exposure estimate (LADC in ppm or µg/m^3; LADD in mg/kg-day)
IUR	=	Inhalation Unit Risk (risk per unit of exposure (ppm or µg/m^3)
CSF	=	Cancer slope factor (risk per mg/kg-day)

Estimates of extra cancer risks are interpreted as the incremental probability of an individual developing cancer over a lifetime following exposure (*i.e.,* incremental or extra individual lifetime cancer risk). EPA considers a range of extra cancer risk from 1.0×10^{-4} to 1.0×10^{-6} to be relevant benchmarks for risk assessment (U.S. EPA, 2017). Consistent with NIOSH guidance (Whittaker et al., 2016), under TSCA EPA typically applies a 1.0×10^{-4} benchmark for occupational scenarios in industrial and commercial work environments subject to OSHA requirements. EPA typically considers the general population and consumer benchmark for cancer risk to be within the range of 1.0×10^{-4} to 1.0×10^{-6}. Again, it is important to note that these benchmarks are not bright-lines and EPA uses discretion to find unreasonable risks based on other risk-related considerations. Exposure-related considerations (*e.g.,* duration, magnitude, population exposed) can affect EPA's estimates of the excess lifetime cancer risk (ELCR).

4.3.2 Aggregate and Sentinel Exposure and Risk Approach

Section 2605(b)(4)(F)(ii) of TSCA requires EPA, as a part of the risk evaluation, to describe whether aggregate or sentinel exposures under the conditions of use were considered and the basis for their consideration. The Agency considered aggregate exposure considerations (Appendix F.1) and aggregate risk (Appendix F.3) across all routes of exposure for each individual occupational, consumer and general population COU evaluated for acute, intermediate, and chronic exposure durations. Hazard considerations for the applicability of aggregate exposure and risk are discussed further in Appendix F.2).

EPA did not consider aggregate exposure scenarios across COUs because the Agency did not find any evidence to support such an aggregate analysis based on the reasonably available information, such as workers performing tasks across COUs. However, EPA did consider aggregate exposures and risks across exposure routes (*i.e.,* inhalation, oral, and/or dermal), as applicable to specific exposure scenarios, as discussed in Appendix F. Aggregate non-cancer and cancer risk was quantified for workers but not for consumers and workers due to various exposure and hazard considerations pertaining to that exposure pathway, duration and scenario as described in Appendices F.1 and F.3. Ultimately, due to the uncertainties further described in Appendix F, aggregate non-cancer and cancer risk identified for workers do not preliminarily drive the unreasonable risk determination as described in Section 6.

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)."

EPA considered sentinel exposures by considering risks to populations who may have upper-bound exposures; for example, workers 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) (U.S. EPA, 2011a, 1994a). 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 occasionally characterized sentinel exposure through a "high-intensity use" category based on elevated consumption rates, breathing rates, or user-specific factors.

For general population assessment, EPA considered sentinel exposures to tribal communities when considering fish ingestion to the general population. EPA performed a screening analysis for fish ingestion where they evaluated the highest estimated surface water concentrations of ethylene dibromide with the higher level of fish consumption that is associated with some tribal communities. This approach is described in Section 4.1.3.4.3. EPA did not find unreasonable risk using this screening approach.

4.3.3 Risk Estimates for Workers and ONUs

This section provides discussion and characterization of risk estimates for workers and ONUs from exposures to ethylene dibromide across all routes (*i.e.,* inhalation, and dermal).

4.3.3.1 Occupational Inhalation Exposure Risk Characterization

This section provides a summary table of inhalation risk estimates (Table 4-28), as well as a discussion of the risk characterization per OES. Table 4-28 provides occupational inhalation MOEs with and without PPE, as well as the minimum assigned protection factor (APF) needed (depending on the expected workplace activity, represented in the risk evaluation by the various SEGs) for an MOE above the non-cancer benchmark or below the cancer benchmark, for the OES and worker categories assessed for ethylene dibromide. 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. General information on PPE and respiratory protection is available in Section 5.4.5 of the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d), and more specific information is included in each OES specific sub-sections below. Detailed calculations on inhalation risk estimates for each COU are presented in the *Draft Default Risk Calculator for Occupational and Consumer Exposures for Ethylene Dibromide* (U.S. EPA, 2026d).

3344 **Table 4-28. Occupational Inhalation Risk Summary Table**

COU	OES	Population	Exposure Level	Acute Non-Cancer (Benchmark MOE = 100)		Intermediate Non-Cancer (Benchmark MOE = 100)		Chronic Non-Cancer [h] (Benchmark MOE = 30)		Cancer (Benchmark = 1.0E−04)	
				MOE – No PPE [f]	MOE – APF [g]	MOE – No PPE [f]	MOE – APF [g]	MOE – No PPE [f]	MOE – APF [g]	MOE – No PPE [f]	MOE – APF [g]
Manufacture – Import [a] Processing – Repackaging [a]	Import and Repackaging [a]	Worker	CT	1,106	–	1,508	–	129	–	**2.1E−03**	8.3E−05 (APF 25)
			HE	**41**	408 (APF 10)	**56**	557 (APF 10)	**4.8**	480 (APF 10)	**7.2E−02**	7.2E−05 (APF 1,000)
		ONU	CT	6,375	–	8,693	–	745	–	**3.6E−04**	3.6E−05 (APF 10)
			HE	**45**	454 (APF 10)	**62**	620 (APF 10)	**5.3**	53 (APF 10)	**6.5E−02**	6.5E−05 (APF 1,000)
Processing – Incorporation into formulation, mixture, or reaction product Processing – As a reactant Industrial use – Other use – Processing aid not otherwise specified	Incorporation into Formulation, Mixture or Reaction Product [a]	Worker	CT	5,219	–	7,117	–	610	–	**4.4E−04**	4.4E−05 (APF 10)
			HE	796	–	1,085	–	93	–	**3.7E−03**	7.4E−05 (APF 50)
		ONU	CT	7.1E04	–	9.8E04	–	8,389	–	3.2E−05	–
			HE	3,585	–	4,889	–	419	–	**8.2E−04**	1.6E−05 (APF 50)
Industrial use – Fuel agents in petroleum refineries	Fuels and Related Products – Bulk Terminals [c]	Worker	CT	6,482	–	8,839	–	757	–	**3.5E−04**	3.5E−05 (APF 10)
			HE	2,168	–	2,957	–	253	–	**1.4E−03**	5.4E−05 (APF 25)
		ONU	CT	6,482	–	8,839	–	757	–	**3.5E−04**	3.5E−05 (APF 10)

COU	OES	Population	Exposure Level	Acute Non-Cancer (Benchmark MOE = 100)		Intermediate Non-Cancer (Benchmark MOE = 100)		Chronic Non-Cancer [h] (Benchmark MOE = 30)		Cancer (Benchmark = 1.0E−04)	
				MOE – No PPE [f]	MOE – APF [g]	MOE – No PPE [f]	MOE – APF [g]	MOE – No PPE [f]	MOE – APF [g]	MOE – No PPE [f]	MOE – APF [g]
Commercial use – Fuels and related products	Fuels and Related Products – Refueling [d i]	Worker (Low Exposure)	LE	3.2E04	–	4.3E04	–	3,702	–	7.2E−05	–
			HE	3,962	–	5,403	–	463	–	**7.5E−04**	7.5E−05 (APF 10)
		ONU (Low Exposure)	LE	3.2E04	–	4.3E04	–	3,702	–	7.2E−05	–
		Worker (Medium Exposure)	LE	2.1E04	–	2.9E04	–	2,481	–	**1.1E−04**	1.1E−05 (APF 10)
			HE	2,656	–	3,621	–	310	–	**1.1E−03**	4.4E−05 (APF 25)
		ONU (Medium Exposure)	LE	2.1E04	–	2.9E04	–	2,481	–	**1.1E−04**	1.1E−05 (APF 10)
		Worker (High Exposure)	LE	1.3E04	–	1.7E04	–	1,486	–	**1.8E−04**	1.8E−05 (APF 10)
			HE	1,590	–	2,168	–	186	–	**1.9E−03**	7.4E−05 (APF 25)
		ONU (High Exposure)	LE	1.3E04	–	1.7E04	–	1,486	–	**1.8E−04**	1.8E−05 (APF 10)
Commercial use – Other use – Laboratory chemical	Laboratory Use [a]	Worker	CT	4,099	–	5,589	–	479	–	**5.6E−04**	5.6E−05 (APF 10)
			HE	131	–	178	–	**15**	152 (APF 10)	**2.3E−02**	2.3E−05 (APF 1,000)
		ONU	CT	4,098	–	5,589	–	479	–	**5.6E−04**	5.6E−05 (APF 10)
Disposal	Waste Handling, Treatment, and Disposal – Landfill [e]	Worker	CT	2.6E05	–	3.5E05	–	3.0E04	–	8.8E−06	–
			HE	7.3E04	–	9.9E04	–	8,495	–	4.1E−05	–
		ONU	CT	2.6E05	–	3.5E05	–	3.0E04	–	8.8E−06	–

COU	OES	Population	Exposure Level	Acute Non-Cancer (Benchmark MOE = 100)		Intermediate Non-Cancer (Benchmark MOE = 100)		Chronic Non-Cancer [h] (Benchmark MOE = 30)		Cancer (Benchmark = 1.0E−04)	
				MOE – No PPE [f]	MOE – APF [g]	MOE – No PPE [f]	MOE – APF [g]	MOE – No PPE [f]	MOE – APF [g]	MOE – No PPE [f]	MOE – APF [g]
Disposal	Waste Handling, Treatment, and Disposal – Wastewater [a b]	Worker	CT	2.5E04	–	3.5E04	–	2,985	–	8.9E−05	–
			HE	7,941	–	10,828	–	927	–	**3.7E−04**	3.7E−05 (APF 10)
		ONU	CT	2.6E04	–	3.5E04	–	2,985	–	8.9E−05	–
Distribution in commerce	Distribution in Commerce	No quantitative risk assessment was performed for this OES as occupational exposures covered are not reasonably expected to occur									

APF = assigned protection factor; COU = condition of use; CT = central tendency; HE = high-end; LE = low-end; MOE = margin of exposure; OES = occupational exposure scenario; PPE = personal protective equipment; "–" = inhalation APF not needed as the MOE is greater than benchmark MOE, or the cancer risk is lower than the benchmark of cancer without any PPE

Bolded/shaded cells indicate MOEs lower than the benchmark MOE or cancer risks higher than the benchmark for cancer

BLS estimates based on working year data from the Bureau of Labor Statistics (U.S. Census Bureau, 2019; U.S. BLS, 2014)

[a] Based on exposure estimates derived from chemical-specific PBZ monitoring data from literature

[b] Based on exposure estimates derived from PBZ surrogate monitoring data from risk evaluation of 1,2-dichloroethane

[c] Based on exposure estimates derived from surrogate data from generic scenario

[d] Based on exposure estimates derived from modeled concentrations using CEM

[e] Based on exposure estimates derived from chemical-specific or surrogate area monitoring data from risk evaluation of 1,2-dichloroethane

[f] Risk estimates that exceed the benchmark (*i.e.,* non-cancer risks less than the risk benchmark and cancer risks exceeding the cancer risk benchmark) are bolded and shaded.

[g] APF listed in parentheses is the minimum level of protection needed for estimated MOEs to be above benchmark.

[h] For chronic, non-cancer exposure estimates, exposure dose over the working years is averaged over the working years. Therefore, different values of working years do not affect these estimates, and EPA has presented one chronic, non-cancer estimate.

[i] For refueling scenario, EPA assessed low-end (LE) instead of CT using the lower end value of exposure frequency with an assumption of one refueling or exposure event per day. EPA did not identify sufficient information to accurately characterize the statistical distribution of exposure frequencies in a day; and therefore, based inhalation exposure assessment on the lower bound (*i.e.,* one event/day) and upper bound (*i.e.,* eight events/day) values of exposure frequencies

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4.3.3.1.1 Import and Repackaging OES

The inhalation exposure and risk estimates presented in Table 4-4 for the Import and Repackaging OES covers two COUs: Manufacture – Import COU; and Processing – Repackaging COU.

As described in Table 4-4, for the Import and Repackaging OES, EPA estimated worker inhalation exposures to ethylene dibromide using PBZ monitoring data published between 1977 to 1980 comprising both full-shift and short-term samples and collected from U.S. facilities engaged in manufacturing, blending, and anti-knock product processing of ethylene dibromide where worker activities are aligned with this OES. The assessment incorporated a total of 47 PBZ datapoints for workers and 8 datapoints for ONUs, with LOD ranging from 4.0×10^{-5} to 0.03 mg/m³. CT of TWA exposure concentrations for workers were 0.19 mg/m³, while HE exposures were calculated as 5.4 mg/m³; for ONUs, CT and HE exposures were 0.035 mg/m³ and 4.85 mg/m³, respectively. These data, though collected in the late-1970s, are considered relevant due to the similarity of tasks and concentration ranges to current operations, but EPA acknowledges uncertainties regarding their representativeness for present-day exposures—particularly given potential improvements in engineering controls and PPE.

There is uncertainty about how well these data gathered from older facilities represent the true distribution of inhalation concentrations in currently operated facilities for this OES.

EPA rated the weight of scientific evidence as moderate for this OES. The primary strengths include the use of PBZ samples directly applicable to this OES.

EPA acknowledges that there is a lack of sufficient information to accurately characterize the exposure scenario based on how industry practices (*e.g.,* operation, engineering controls to reduce exposure) may have changed since these data were collected. This scenario represents a worker with 8 exposure hours per day and 250 exposure days per year with continuous ethylene dibromide exposure each working day. The representativeness of this scenario is influenced by the variability in worker activities, schedules, and facility operations across the full distribution of facilities covered by this OES. Because the assessment assumes 8-hour work shifts and 250 exposure days per year, and in the absence of more recent facility-specific data, central tendency values are considered more representative of typical exposures, whereas high-end values are included to bound plausible upper-bound exposure scenarios. EPA also acknowledges that the actual maximum number of exposures days for an individual worker depending on the import and repackaging site may be less than 8 hours per day, or less than 250 days per year, and not all tasks with high exposure potential are performed with a daily frequency during the working year. The assumption of 250 days/year exposure could result in upper-bound exposure and risk estimates since the average operating days for a chemical repackaging facility ranges from 174 to 260 days/year per the generic scenario document from which EPA based its assumption.

In calculating cancer risks for this OES, EPA utilized estimates of working years provided by BLS (central tendency) value of 31 years and high-end value of 40 years.

The Agency considers that high-end exposure and risk estimates are most appropriate for consideration of shorter (*i.e.,* acute, intermediate) duration without consideration of existing respiratory protections. EPA has lower-confidence that high-end inhalation exposures are representative for chronic non-cancer and cancer inhalation exposure estimates, because the likeliness of a worker being exposed to the 95th percentile concentration of ethylene dibromide on a daily basis consistently over a year is low, and the monitoring data were collected from facilities where ethylene dibromide was used at a much higher

concentrations (up to 100 wt%) than the majority of current use (TEL-B import containing 30–60 wt% ethylene dibromide) under this OES. Although some of the ethylene dibromide imports are at 100 wt% concentration (*e.g.,* for laboratory use), the majority of current import occur at 30 to 60 wt% ethylene dibromide. Because most of the imported ethylene dibromide is used for fuel use, and comes to the United States as a TEL-B blend containing 30 to 60 wt% ethylene dibromide, whereas some of the exposure monitoring data that was used for this assessment from previous ethylene dibromide manufacturing facilities where ethylene dibromide was produced at neat concentration, the high-end risk estimates are less representative of workers exposure at long-term based on majority of current use concentrations under this OES. Also, there are uncertainties with the exposure levels at currently operated facilities under this OES compared to exposure levels measured 50 years ago at reported facilities since engineering controls and exposure controls may have changed over time.

Whether to select central tendency or high-end estimates is chemical and OES-specific. In this case, EPA expects the HE estimates to be more appropriate for intermediate exposures on the basis of several considerations. Although the majority of ethylene dibromide is imported at 30 to 60 wt% concentrations, the Agency identified SDSs reporting up to 100 wt% of ethylene dibromide and identified market information showing bulk ethylene dibromide imports at higher concentrations (*e.g.,* 98 wt%) in recent years. Therefore, EPA expects that ethylene dibromide is still imported and repackaged at a much higher concentration than TEL-B imports. The Agency identified a total of 47 sites that reported environmental releases of ethylene dibromide under this OES, and EPA only identified information from 2 TEL-B importer sites that reported in CDR. Although the Agency gathered some information about the process descriptions, worker activities and operational practices (*e.g.,* outdoor) from two TEL-B importers reported in CDR, EPA did not identify any information from the facilities which import and repackage ethylene dibromide at higher concentrations (*e.g.,* 98 wt%). Because the exposure monitoring dataset EPA used for this assessment was gathered from different types of facilities (*i.e.,* manufacturing, processing) that were using ethylene dibromide at various concentrations (*i.e.,* 100 wt% for manufacturing and 18–35 wt% for processing), the Agency used the 95th percentile value of the exposure distribution from this dataset.

When applying the process description, worker activities, and operational practices of the two CDR reporters to the other sites that did not report to CDR, primarily because of the differences in product concentrations and uncertainties around frequency of exposure, EPA believes that the high-end estimates would be more appropriate for intermediate exposure at facilities that use ethylene dibromide at neat or near neat concentrations under this OES. Due to the age of the monitoring data, and lack of current information about facilities that use ethylene dibromide at neat or near neat concentration under this OES, EPA is seeking further information from relevant facilities that use ethylene dibromide at concentrations greater than 60 wt% to accurately characterize risk for this OES.

Central tendency estimates of inhalation exposure are expected to be representative and appropriate exposure estimate for a frequent, repeated inhalation exposure (*i.e.,* chronic) for the workers, without consideration of existing respiratory protections. This is because the central tendency values are more representative based on the ongoing primary ethylene dibromide use concentrations (*i.e.,* 30–60 wt%) under Manufacture – Import COU. Although TEL-B containing ethylene dibromide is no longer imported or widely used for automotive fuel use (except limited use for racing cars), the concentrations ranges used in previous anti-knock products containing ethylene dibromide processing facilities were in a similar range (*i.e.,* 18–35 wt%) to the concentration of ethylene dibromide in TEL-B (*i.e.,* 30–60 wt%) that is currently imported for avgas use. Although ethylene dibromide is also imported at higher concentration (*i.e.,* 100 wt%) for other uses (*e.g.,* laboratory use, processing as a reactant), the majority of the imported ethylene dibromide is for avgas use, and EPA characterized inhalation exposure risk

from this OES based on the relevance of TEL-B Import and Repackaging. Because the exposure monitoring data used for this inhalation exposure assessment was gathered from both ethylene dibromide manufacturing and processing facilities that were using ethylene dibromide at a wider concentration range (*i.e.,* 18–100 wt%), (1) the high-end exposure estimates from this monitoring dataset may likely overestimate chronic exposure potential at facilities that use ethylene dibromide at lower concentrations (*e.g.,* 30–60 wt%); and (2) subsequently may overestimate risks for majority worker activities that fall under this OES. EPA acknowledges that there is uncertainty whether the use of central tendency estimates for chronic durations underestimate exposure potential for workers and ONUs at facilities that import and repackage ethylene dibromide at neat or closer to neat concentrations. The Agency seeks more information on the use, and current practices related to import and repackaging of ethylene dibromide at neat concentration.

For ONUs, high-end estimates may be more representative of short term (*i.e.,* acute and intermediate) and central tendency estimates are more representative of chronic exposure potential for the same reasons (*e.g.,* age of monitoring data, use concentration of ethylene dibromide) that are applicable to workers.

An important uncertainty with this assessment is that the monitoring data EPA used for this assessment are more than 40 years old (*i.e.,* from 1977) and there is lack of evidence on how the practices have changed and therefore, exposure potential may have changed over the past 4 decades. Inhalation monitoring data was available for various worker groups based on activities or roles and indicate that workers in an exposure group experience a range of potential exposure concentrations.

Reported Use of Respiratory Protection by Workers

Estimates of occupational inhalation risks are presented in Table 4-28. Where the estimated MOE is below the benchmark value, an indication of the respirator APF needed to mitigate risk is also provided. Some information on PPE was available from the literature and stakeholders. A 1977 industrial hygiene study reported that in an antiknock blend operation facility using ethylene dibromide at 18 to 35 wt% concentrations, (1) workers handling raw materials or sampling tank cars wore half-mask respirators with organic vapor cartridges; (2) organic vapor cartridge respirators were used during unloading/loading of tank cars, collection of quality-control samples from tank cars, dipping of storage tanks, drum washing/loading, and activity-specific short-term durations of workers wearing PPE; and (3) it was not specified in the report whether workers would wear PPE during the entire work day (NIOSH, 1977b). Similarly, in other closed-system blending and production operations, respiratory protection was used during tasks with potential liquid exposure (*e.g.,* quality-control sampling and some tank-car loading), but the type and wear time was not reported (NIOSH, 1977c, d). An ethylene dibromide importer, Innospec reported that workers use A2/P3 gas-filter respirators in well-ventilated outdoor settings, positive-pressure air-supplied respirators in low-ventilation or high-vapor situations, and self-contained breathing apparatus during spills, fires, or emergency interventions (Innospec, 2025). The Chemical Repackaging GS indicated limited PPE details and did not report respiratory protection practices (U.S. EPA, 2022a). Due to a lack of specific information (*e.g.,* respirator type utilized during specific tasks, duration of PPE use), it is uncertain how usage of respiratory protection may influence the exposures estimated for this OES, and EPA is unable to further refine these risk estimates. Where proper respiratory protection is utilized, the Agency expects that worker exposures will be reduced.

4.3.3.1.2 Incorporation into Formulation, Mixture or Reaction Product OES

The inhalation exposure and risk estimates presented in Table 4-4 for the Incorporation into Formulation, Mixture or Reaction Product OES covers three COU: Processing – Incorporation into

formulation, mixture, or reaction product COU, Processing – As a reactant COU, and Industrial use – Other use – Processing aid not otherwise specified COU.

EPA estimated worker inhalation exposures to ethylene dibromide using PBZ monitoring data collected between 1977 and 1980 from U.S. facilities engaged in blending, processing, and anti-knock product manufacturing, where worker activities are aligned with this OES. The assessment incorporated 38 PBZ datapoints for workers and five for ONUs, with LODs ranging from 4.0×10^{-5} to 0.03 mg/m^3. Central tendency TWA exposure concentrations for workers were 0.042 mg/m³, while high-end exposures were 0.28 mg/m³; for ONUs, CT and HE exposures were 0.003 and 0.062 mg/m^3, respectively. Although these data were collected in the late 1970s, they are considered relevant due to the similarity of tasks and concentration ranges to current operations, but EPA acknowledges uncertainties regarding their representativeness for present-day exposures, particularly given potential improvements in engineering controls and PPE.

EPA rated the weight of scientific evidence as moderate for this OES, citing the direct applicability of PBZ samples, the number of samples available, and the medium or high data overall quality determination from the systematic review process. However, there is a lack of sufficient information to accurately characterize how industry practices (*e.g.,* operation, engineering controls) may have changed since these data were collected.

There is uncertainty about how well the inhalation exposure monitoring data used for this assessment represent the true distribution of inhalation exposure concentrations for ongoing worker activities under this OES. For this assessment, EPA assumed 8-hour work shifts and 250 exposure days per year, but actual exposure days may be lower, as the average operating days for ethylene dibromide processing facilities may vary. This scenario represents a worker with 8 exposure hours per day and 250 exposure days per year with continuous ethylene dibromide exposure each working day. The representativeness of this scenario is influenced by the variability in worker activities, schedules, and facility operations across the full distribution of facilities covered by this OES. EPA recognizes that the actual maximum number of exposure days and the frequency of high-exposure tasks may be lower than what assumed, and that improvements in workplace controls may further reduce exposures in current settings.

Another uncertainty with this assessment is that the monitoring data EPA used for this assessment are more than 40 years old (*i.e.,* published in 1977), and there is a lack of information on how industry practices (*e.g.,* engineering controls to reduce exposure) may have changed since these data were collected. This older monitoring dataset may not accurately reflect present-day conditions, as facility operations, engineering controls, and PPE practices have likely evolved, potentially reducing exposures compared to those measured decades ago. Additionally, historical monitoring often targets facilities or tasks with higher expected exposures, which may not represent the broader industry or typical worker experiences today. The limited size and scope of these job, role or worker activity-specific datasets further constrain their statistical robustness. Worker exposures at the 95th percentile of ethylene dibromide exposure concentration from this assessment are not expected on a daily basis, but rather infrequently as suggested by the statistically high percentile value workers involved in processing of ethylene dibromide. The central tendency value from this assessment is more representative and appropriate exposure estimate for a frequent, repeated inhalation exposure (*i.e.,* chronic) for the workers than high-end for the assessment of cancer risks. For ONUs, the estimates are more representative due to the same reasons that are applicable to workers.

For risk characterization, EPA used BLS estimates of working years (31 years for central tendency, 40 years for high-end) in cancer risk calculations.

High-end values are considered more representative of acute and intermediate exposure than central tendency values, without consideration of existing respiratory protections, as a one time exposure to a high concentration (*i.e.,* 95th percentile) of ethylene dibromide is plausible. Although a majority of ethylene dibromide used under this OES are expected to be related to the avgas use which comprises ethylene dibromide concentrations ranging from 30 to 60 wt% as a process feed, and 0.07 to 0.1 wt% in the fuel product, EPA identified other processing-related uses (*i.e.,* pigment and dye manufacturing) that may comprise 100 wt% ethylene dibromide in the process feed as a reactant. The central tendency exposure estimates in that case may not reflect the actual potential of exposure in those processing facilities where ethylene dibromide is used as a reactant as the central tendency exposure estimates are based on the monitoring dataset that was originally gathered from facilities that handled ethylene dibromide at a much lower concentration than neat ethylene dibromide. Therefore, high-end estimates are considered representative of intermediate exposure durations. EPA seeks facility-specific information from currently operated facilities that process ethylene dibromide for other uses (*e.g.,* pigment and dye manufacturing) beyond fuel use.

However, EPA considers that high-end estimates are less representative for chronic, non-cancer and cancer risk determination due to their likely overestimation of current exposure potential. This is because the monitoring data were collected from facilities where ethylene dibromide was used at higher concentrations than the majority of current use, which is typically in the range of 30 to 60 wt% for TEL-B blends. Although ethylene dibromide is also used at higher concentrations for other purposes, the majority of current use is for avgas, and the assessment is based on the relevance of TEL-B blending and processing. Because the majority of ethylene dibromide imported to the United States are used for fuel, primarily in avgas, EPA expects that majority of ethylene dibromide processing facilities are for processing TEL-B in avgas. The concentration of ethylene dibromide in TEL-B mixtures is reported to be between 30 to 60 wt% of TEL-B and therefore, the concentration of ethylene dibromide is expected to be 30 to 60 wt% (before processing) or significantly below (after processing) in majority of the avgas processing facilities. Although there are other ethylene dibromide processing facilities for other uses (*e.g.,* Processing – As a reactant – *E.g.* in Pigment and dye manufacturing), where ethylene dibromide is expected to be used at higher concentrations, there is uncertainty about what percentage of the total ethylene dibromide processing facilities use ethylene dibromide at neat or concentrations above 60 wt% in mixtures. Therefore, the high-end estimates are not applicable for assessing chronic, non-cancer and cancer risks across all facilities within this OES. Consequently, central tendency estimates are considered more appropriate for both (*i.e.,* non-cancer and cancer) exposures, without consideration of existing respiratory protections. High-end values are included to bound plausible upper scenarios; worker exposures at the 95th percentile are not expected daily on a chronic level (*i.e.,* over a year), but rather infrequently, as suggested by the statistically high percentile value.

Reported Use of Respiratory Protection by Workers

Estimates of occupational inhalation risks are presented in Table 4-28. Where the estimated MOE is below the benchmark value, an indication of the respirator APF needed to mitigate risk is also provided. Some information on PPE was available from the literature and stakeholders. Respiratory PPE for ethylene dibromide included half-mask respirators with organic vapor cartridges worn by workers handling raw materials and during tasks such as unloading/loading ethylene dibromide tank cars, taking quality-control samples from ethylene dibromide tank cars, and drum washing/loading (NIOSH, 1977b). At another site, respiratory protection (type not specified) was used during quality-control sample collection and some tank car loading activities whenever there was potential for liquid exposure (NIOSH, 1977c). Innospec reported using an A2/P3 respirator for ethylene dibromide transfer and maintenance tasks that may involve contact with liquid or vapor, with escalation to an air-supplied respirator when ventilation cannot be assured, implemented under trained respiratory protection

programs to guide selection, use, and maintenance (Innospec, 2025). Another reported that although operations were largely closed-system and controls kept airborne ethylene dibromide within previously satisfactory limits (no areas with average concentrations above ≈1 ppm), respirators were still required for tasks with higher exposure potential (NIOSH, 1977c). One report described policies for eye/face and dermal protection but did not provide any respirator specifics for handling ethylene dibromide (Velsicol Chem Corp, 1978). However, all of these reports lack details on specific respirator models, cartridge change-out schedules, and duration or full-shift use to accurately characterize the impact of PPE on exposure (Innospec, 2025; NIOSH, 1977b, c). Due to a lack of specific information (*e.g.,* respirator type utilized during specific tasks, duration of PPE use), it is uncertain how usage of respiratory protection may influence the exposures estimated for this OES, and EPA is unable to further refine these risk estimates. Where proper respiratory protection is utilized, EPA expects that worker exposures will be reduced.

4.3.3.1.3 Fuels and Related Products OES – Bulk Terminals

The inhalation exposure and risk estimates presented in Table 4-4 for the Fuels and Related Products – Bulk Terminals OES covers one COU: Industrial use – Fuel agents in petroleum refineries COU.
For exposure at bulk terminals, EPA estimated worker inhalation exposures using a modeling approach, as no chemical-specific PBZ monitoring data were available for this OES. Exposure concentrations were estimated by applying the fraction of ethylene dibromide present in 100LL avgas vapor to measured VOC concentrations reported at petroleum bulk terminals, as described in the Fuels and Related Products Generic Scenario (U.S. EPA, 2021b). This approach allowed the assessment to approximate ethylene dibromide exposures for workers engaged in activities such as fuel transfer, storage, and handling at bulk terminals, using petroleum VOC data as a surrogate for modeling. Central tendency TWA exposure concentrations for workers at bulk terminals were estimated at 0.034 mg/m^3 with high-end exposures at 0.102 mg/m^3.

For the bulk terminals, the assessment assumes 8-hour work shifts and 250 exposure days per year, but actual exposure days may be lower, as the average operating days for such facilities may differ. Central tendency values are considered more representative of typical exposures, while high-end values are included to bound plausible upper scenarios; worker exposures at the 95th percentile are not expected daily, but rather infrequently, as suggested by the statistically high percentile value. EPA seeks input on what the actual operating days and hours may be.

EPA rated the weight of scientific evidence as moderate for this OES, citing the use of surrogate data from the GS, the modeling approach, and the alignment of modeled scenarios with current operational practices. However, there is a lack of sufficient information to accurately characterize how industry practices (*e.g.,* operation, engineering controls, vapor recovery systems) may have changed since the surrogate data were published between 1986 to 2002 (see Table 5-5 and Table 5-6 of (U.S. EPA, 2021b)).

High-end estimates are more representative of short-term exposure scenarios (*i.e.,* acute and intermediate), without consideration of existing respiratory protections. However, high-end estimates are less representative of workers exposure for chronic, non-cancer and cancer risk determination due to their likely overestimation of current exposure potential. This is because the high-end scenario assumes no vapor recovery (VR) and the highest plausible ethylene dibromide concentrations in avgas which may occur at some facilities and workers may get infrequently exposed to high ethylene dibromide vapor concentrations. Worker exposures at the 95th percentile of ethylene dibromide exposure concentration are not expected on a daily basis for a long-term, but rather infrequently as suggested by the statistically high percentile value. The high-end estimates assume that ethylene dibromide

concentration in avgas is 0.1 wt% whereas the central tendency estimates assume that ethylene dibromide concentration in avgas is 0.085 wt%, which is more representative of majority of the avgas. The exposure estimates of this assessment are based on exposure monitoring data collected from both types of bulk terminals or facilities including facilities that store petroleum products in the presence of VR technologies and facilities that store petroleum products without VR technologies.

The high-end exposure estimates represent 95th percentile of exposure concentrations measured at bulk terminals or storage facilities where exposure control technologies like VR systems may or may not be present. Higher exposure concentrations were monitored at facilities where VR systems were lacking. For such facilities, it is plausible that a worker is exposed to the high-end exposure concentration repeatedly for an intermediate duration, and therefore, EPA considers high-end intermediate exposure estimates to be representative for intermediate exposure scenarios under this OES. EPA acknowledges that there are uncertainties regarding the extent to which avgas storage facilities implement VR technologies. Therefore, the Agency seeks more information on the engineering controls of the existing bulk terminals that currently store ethylene dibromide containing fuel (*e.g.,* avgas).

The central tendency exposure estimates have higher confidence than the high-end estimates for chronic exposure durations, without consideration of existing respiratory protections. As stated earlier, this assessment assumes that bulk terminals may or may not have VR systems. The central tendency estimates represent the 50th percentile exposure concentration monitored at these various petroleum product bulk terminals where some of the facilities had VR systems and others did not corresponding to typical (with VR) and worst-case (no VR) monitoring data used from Table 5-5 of the Fuels and Related Products GS (U.S. EPA, 2021b). Because there is uncertainty on the presence of VR technology in avgas bulk terminals, the central tendency of the distribution of exposure monitoring data is more representative of bulk terminals where VR may or may not be present, whereas the high-end of the distribution of exposure monitoring data is more representative of bulk terminals where it is certain that there is no VR system in place. The high-end estimates based on this dataset may overestimate exposure potential for chronic durations in facilities where ethylene dibromide is handled at 0.085 wt% concentration in presence of VR systems and working days are less than 250 days per year. In contrast, the central tendency estimates based on this dataset may underestimate exposure potential for chronic durations in facilities where ethylene dibromide is handled at 0.1 wt% concentration, stored without any VR system, and working days are greater than 250 days/year. While there are uncertainties with the determination, EPA expects that central tendency estimates are most appropriate for both chronic, non-cancer and cancer exposures—without consideration of existing respiratory protections as the central tendency scenario reflects a mix of VR or no VR system consideration and ethylene dibromide concentrations stored at bulk terminals.

For ONUs, the exposure and risk estimates are assumed to be the same as workers central tendency estimates.

There is uncertainty about how well the various input parameters used in modeling the exposure estimates in capturing the true distribution of inhalation concentrations for this OES. This scenario represents a worker with 8 exposure hours per day and 250 exposure days per year with continuous ethylene dibromide exposure each working day. The representativeness of this scenario is influenced by

the variability in worker activities, schedules, and facility operations across the full distribution of facilities covered by this OES.

Reported Use of Respiratory Protection by Workers

Estimates of occupational inhalation risks are presented in Table 4-28. Where the estimated MOE is below the benchmark value, an indication of the respirator APF needed to mitigate risk is also provided. For this OES, EPA did not identify any evidence that PPE are generally worn. Where proper respiratory protection is utilized, EPA expects that worker exposures will be reduced.

4.3.3.1.4 Fuels and Related Products OES – Refueling

The inhalation exposure and risk estimates presented in Table 4-4 for the Fuels and Related Products OES – Refueling covers one COU: Commercial use – Fuels and related products COU.

For exposure from the refueling scenario, EPA modeled inhalation exposure for both workers and ONUs by first estimating the total avgas emissions into the ambient air due to the transfer of fuel from the airport's fuel storage tank into the airplane fuel tank during one refueling event and then using the CEM to model dispersion of the ethylene dibromide "loading loss" emissions within the of the worker or consumer refueling the airplane. For refueling scenarios, modeled exposures ranged from 0.63 mg/m^3 (low exposure scenario, high windspeed) to 1.6 mg/m^3 (high exposure scenario, low windspeed). ONUs were assumed to have exposures similar to the central tendency of workers, as no ONU-specific data were available.

There is uncertainty about how well the various input parameters used in modeling the exposure estimates in capturing the true distribution of inhalation concentrations for this OES. This scenario represents a worker with 8 exposure hours per day and 250 exposure days per year with continuous ethylene dibromide exposure each working day. The representativeness of this scenario is influenced by the variability in worker activities, schedules, and facility operations across the full distribution of facilities covered by this OES.

While the low-end and high-end estimates from low exposure scenario (high windspeed, 95th percentile of windspeed in the United States) or the high exposure scenario (low windspeed, 5th percentile of windspeed) are plausible depending on the geographic location, or time of the year, EPA generally expects that the low-end and high-end estimates from medium exposure scenario (medium windspeed, 50th percentile windspeed) are more representative of typical exposure pattern and more appropriate to be used for risk determination.

The low-end estimates for this scenario are based on assumptions that a worker refuels one aircraft per day, with 53 gallons of avgas which can be interpreted as 5.3 min of exposure to ethylene dibromide vapor during an 8-hour work shift per day, and the worker works for 31 years. The high-end estimates are based on assumptions that a worker refuels eight aircraft per day, each refueling 53 gallons of avgas (therefore, totaling 424 gallons of avgas per day) which can be interpreted as 42.4 min of exposure to ethylene dibromide vapor during an 8 hour work shift per day, and the worker works for 40 years.

Both low-end and high-end exposure estimates are plausible since there is a large variation of number of exposure events per day depending on location, demand and season. For ONUs, the estimates from low exposure scenario (high windspeed) is expected to be more representative for risk determination since they are further away from refueling or exposure source, and the exposure is expected to be significantly

lower than a worker in ambient conditions (due to distance and dilution of ethylene dibromide concentration from dispersion) under medium exposure scenario.

Reported Use of Respiratory Protection by Workers

Estimates of occupational inhalation risks are presented in Table 4-28. Where the estimated MOE is below the benchmark value, an indication of the respirator APF needed to mitigate risk is also provided. For this OES, EPA did not identify any evidence that PPE are generally worn. Where proper respiratory protection is utilized, the Agency expects that worker exposures will be reduced.

4.3.3.1.5 Laboratory Use OES

The inhalation exposure and risk estimates presented in Table 4-4 for the Laboratory Use OES covers one COU: Commercial use – Laboratory chemical COU.

EPA estimated worker inhalation exposures using PBZ monitoring data collected between 1977 and 1984 from laboratory technicians at ethylene dibromide manufacturing, processing, and blending sites, assuming exposures would be similar at sites using ethylene dibromide as a laboratory reagent. The assessment incorporated 21 PBZ datapoints for workers, with LODs ranging from 2.0×10^{-5} to 0.05 mg/m³. Central tendency TWA exposure concentrations for workers were 0.054 mg/m³, while high-end exposures were 1.69 mg/m³. EPA did not identify ONU monitoring data for this OES and estimated ONU exposure based on central tendency estimates of workers' exposure. Although these data were collected several decades ago, they are considered relevant due to the similarity of laboratory tasks and concentration ranges to current operations, but EPA acknowledges uncertainties regarding their representativeness for present-day exposures, particularly given potential improvements in engineering controls and PPE.

The representativeness of this scenario is influenced by the variability in worker activities, schedules, and facility operations across the full distribution of facilities covered by this OES. However, the worker exposure was based on medium to high quality data published between 1977 to 1984 comprising samples collected from areas where activities that fall under this COU were conducted in ethylene dibromide manufacturing and processing plants which included both full-shift and short-term sampling data. However, EPA found no exposure monitoring data from a laboratory facility with no other ethylene dibromide-related activities occurring on or near the site. Therefore, there is uncertainty regarding the representation of ethylene dibromide concentrations (*i.e.,* PBZ or area) from monitoring data that were used in exposure assessment for this COU.

For risk characterization, EPA used BLS estimates of working years (31 years for central tendency, 40 years for high-end) in cancer risk calculations.

There is uncertainty about how well these data represent the monitoring data in capturing the true distribution of inhalation concentrations for this OES. Due to lack of ONU-specific exposure monitoring data, EPA used central tendency of workers exposure monitoring data as surrogate for estimating ONUs exposure which resulted in lower confidence in the ONUs exposure estimates.

EPA rated the weight of scientific evidence as moderate for this OES, citing the direct applicability of PBZ samples, the number of samples available, all samples measured above the LOD, and the medium or high data overall quality determination from the systematic review process. However, there is a lack of sufficient information to accurately characterize how industry practices (*e.g.,* operation, engineering controls) may have changed since these data were collected. This scenario represents a worker with 8 exposure hours per day and 250 exposure days per year with continuous ethylene dibromide exposure

each working day. However, actual exposure days may be lower, as laboratory use may not occur daily or for full-shifts.

High-end estimates are considered more appropriate for acute duration resulting from exposure to ethylene dibromide compared to the central tendency estimates, without consideration of existing respiratory protections. This is because central tendency estimates may underestimate the exposure and risk potential from current worker activities and use concentration of ethylene dibromide (*i.e.,* upper bound 100 wt%) under this OES as the use concentration of ethylene dibromide in laboratory facilities from where the monitoring data were gathered are unknown. This assessment is based on the relevance of laboratory use in quality control laboratories, research and analytical settings. However, the monitoring data were collected from laboratory facilities which may not encompass all types of laboratories and worker activities that currently use ethylene dibromide.

EPA considers the central tendency estimates to be more appropriate for the representation of intermediate exposure for laboratory facilities where ethylene dibromide is used frequently on a short-term basis (*e.g.,* 22 working days for a month). The Agency acknowledges that high-end estimates from this assessment may overestimate exposure at facilities where ethylene dibromide is used at a much lower concentration (*e.g.,* 0.07 wt% for avgas quality testing), at a lower frequency, and the relevant worker activities, therefore exposure is not continuous throughout an 8-hour work shift per day. EPA also acknowledges that the central tendency estimates may underestimate exposure at facilities where highly concentrated ethylene dibromide is frequently used on a large scale. However, based on the limited information EPA identified for this OES, the Agency did not find any evidence that such facilities exist. There are uncertainties with the extensive use of concentrated ethylene dibromide in laboratory facilities, and seeks further information on the use, worker activities and engineering controls in the currently operated laboratory facilities to accurately characterize the exposure scenario and refine the assessment.

Central tendency values are considered more representative of typical exposures for chronic durations (*i.e.,* chronic, non-cancer and chronic, cancer), without consideration of existing respiratory protections. High-end estimates are less representative for chronic (*i.e.,* non-cancer and cancer) risk determination due to their likely overestimation of current exposure potential. As high-end estimates are based on the 95th percentile of ethylene dibromide concentration and exposure duration, worker exposures at the 95th percentile are not expected daily, but rather infrequently, as suggested by the statistically high percentile value. High-end estimates, therefore, may result in overestimation of current, frequent exposure range for workers. This is mainly because the monitoring data were collected from facilities where ethylene dibromide was used at higher concentrations than the majority of current laboratory use, which is typically in the range of 0.07 to 100 wt%. Also because when a laboratory facility is located within or in close proximity of a manufacturing or processing facility of ethylene dibromide, there is potential to secondary exposure in the laboratory from the nearby manufacturing or processing facilities due to the large volume use of ethylene dibromide in manufacturing or processing facilities compared to laboratory use. For isolated laboratory facilities, ethylene dibromide exposure is expected to be solely from the use of ethylene dibromide as a laboratory chemical.

EPA gathered information related to the National Aeronautics and Space Administration'S (NASA) use of ethylene dibromide in laboratories; NASA noted that the use of ethylene dibromide is infrequent in one currently operating facility. In the single NASA facility with active use, ethylene dibromide is typically kept in 1 mL vials, and about 5 mL of ethylene dibromide are stored on site at any one time. Activities requiring ethylene dibromide occur with varying frequency, from weekly to less than 10 times per year. NASA indicated that ONUs may be located approximately 20 to 30 feet from the workers

activity (U.S. EPA, 2026a). While this information suggests that the laboratory use of ethylene dibromide is very limited, and infrequent, unlike the assumptions made for the inhalation exposure assessment (*e.g.,* 8 hours exposure per day, 250 days exposure per year), EPA acknowledges that there are other facilities that currently use ethylene dibromide under this OES and there are uncertainties regarding the exposure scenarios in those facilities. The use and exposure potential of ethylene dibromide in a federal research laboratory may be significantly different from the use and exposure potential of ethylene dibromide in a laboratory facility that operates on an industrial scale for quality control purposes. EPA seeks further information on exposures in federal and non-federal laboratories.

Reported Use of Respiratory Protection by Workers

Estimates of occupational inhalation risks are presented in Table 4-28. Where the estimated MOE is below the benchmark value, an indication of the respirator APF needed to mitigate risk is also provided. Some information on PPE was available from the literature and stakeholders. An industrial hygiene report reported that laboratory samples were handled in ventilated hoods, but the report did not specify what PPE laboratory technicians wore (NIOSH, 1977e). Another report noted that, although airborne ethylene dibromide was generally below about 1 ppm, respiratory protection and gloves were used for activities with potential for liquid exposure (*e.g.,* quality-control sampling), with exposures controlled by half-mask respirators with organic vapor cartridges alongside chemical goggles; however, it did not clarify whether all workers used PPE or how long it was worn (NIOSH, 1977c). A stakeholder, NASA noted that all standard preparation and analytical procedures are performed using appropriate PPE and are conducted within a chemical fume hood (U.S. EPA, 2026a).

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 Chemical Hygiene Plan (CHP) and the CHP must include criteria for the use of PPE and engineering controls, and the CHP must include criteria for the use of PPE and engineering controls. Examples of respiratory PPE include respirators and face shields (U.S. EPA, 2023c). However, due to a lack of specific information (*e.g.,* respirator type utilized during specific tasks, duration of PPE use), it is uncertain how usage of respiratory protection may influence the exposures estimated for this OES, and EPA is unable to further refine these risk estimates. Where proper respiratory protection is utilized, EPA expects that worker exposures will be reduced. EPA seeks further information on PPE used during worker activities that fall under this OES.

4.3.3.1.6 Waste Handling, Treatment, and Disposal OES

The inhalation exposure and risk estimates presented in Table 4-4 for the Waste Handling, Treatment, and Disposal OES – Landfill covers exposure and risk at the landfill facilities, and the Waste Handling, Treatment, and Disposal OES – Wastewater covers exposure and risk at wastewater treatment facilities under one COU: Disposal COU.

EPA did not identify any monitoring data from the United States that would provide any ethylene dibromide concentration data that could provide a reliable range of exposure concentrations that a worker may experience during activities related to Disposal COU. Therefore, the concentrations of ethylene dibromide in the disposal facilities (*i.e.,* landfills and wastewater treatment plants) are uncertain. The exposure and risk estimates represent an air composition where the concentration of ethylene dibromide in these facilities is equivalent to the maximum concentration of ethylene dibromide.

For landfill disposal facilities, EPA used 12 area monitoring data points from international studies of 1,2-dichloroethane, adjusted for the physical and chemical properties of ethylene dibromide. Because no ONU-specific data were identified, ONU exposures were estimated based on central tendency worker

exposures. Central tendency TWA exposure concentrations for workers in landfill scenarios were 0.001 mg/m³, with high-end exposures at 0.003 mg/m³.

For wastewater treatment, EPA identified two PBZ monitoring data points from a waste treatment (incineration) facility for ethylene dibromide and supplemented these with three PBZ surrogate data points from 1,2-dichloroethane risk assessments, due to the limited availability of direct monitoring data for this OES. Although EPA did not identify sufficient information on how ethylene dibromide is disposed; the Agency assumes that any off-site transfer of ethylene dibromide would be to wastewater treatment or incineration similar to 1,2-dichloroethane. From EPA's programmatic databases (*i.e.,* CDR, NEI, TRI), for ethylene dibromide, the Agency identified total 801 facilities mapped to this OES, whereas for 1,2-dichloroethane, EPA had identified total 1,026 facilities mapped to this OES. Furthermore, both ethylene dibromide and 1,2-dichloroethane are structurally similar halogenated ethanes with comparable environmental fate and transport properties, such as volatility and solubility. The surrogate data from 1,2-dichloroethane landfill and waste treatment studies were adjusted to account for differences in vapor pressure and molecular weight between the two chemicals, allowing EPA to estimate ethylene dibromide exposures in the absence of direct measurements (see Appendix C.1.12 of *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d) for conversion of surrogate data). No ONU-specific data were identified, so ONU exposures were estimated based on central tendency worker exposures. For wastewater treatment, central tendency exposures were 0.009 mg/m³ and high-end exposures were 0.028 mg/m³.

Additionally, EPA assumed 250 exposure days/year based on 5 working days/week for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures to ethylene dibromide. The actual exposure days may be lower as the average operating days for such facilities may differ.

EPA rated the weight of scientific evidence as slight-to-moderate for this OES, citing the use of chemical-specific and surrogate monitoring data, and the adjustment for relevant physical and chemical properties. Because the surrogate exposure monitoring data are from a landfill for 1,2-dichloroethane, an ethylene dibromide wastewater treatment plant, and a wastewater treatment plan for 1,2-dichloroethane, the dataset may not be representative of all landfills and wastewater treatment plants as pollutant concentrations surrounding a landfill and in wastewater can vary depending on the composition and structure of the landfill and wastewater. Furthermore, there is a lack of sufficient information to accurately characterize how industry practices (*e.g.,* operation, engineering controls) may have changed since these data were collected, and the representativeness of surrogate data for U.S. facilities is uncertain.

The data sources used for the exposure monitoring data do not explicitly report the liquid ethylene dibromide concentrations in the landfill and waste treatment facilities and lack significant metadata to accurately characterize whether the exposure monitoring data is more relevant for scenarios where disposed ethylene dibromide is neat (*i.e.,* 100 wt%) or for scenarios when very diluted (*e.g.,* 0.07 wt% from avgas disposal). Furthermore, ethylene dibromide is a volatile chemical which can also contribute to variations in exposure concentrations in air depending on multiple factors (*e.g.,* presence of other chemicals in the disposed mixture, ambient temperature, disposal process). Therefore, for ethylene dibromide, in this particular case, EPA expects that the high-end estimates are more appropriate to represent short-term exposure potential as ethylene dibromide can be disposed at a wide range of concentrations, including the upper bound concentration of 100 wt% from some use (*e.g.,* laboratory use). However, the Agency acknowledges that there are several uncertainties associated with this conclusion and seeks more information (*e.g.,* worker activities, frequency of exposure, disposed

ethylene dibromide concentrations, process descriptions) about disposal facilities that currently handle ethylene dibromide disposal in the United States.

High-end estimates are considered less representative for chronic level exposure due to their likeliness of overestimation of long-term exposure potential. Central tendency values are considered more representative of a frequent, repeated inhalation exposure (*i.e.,* chronic, non-cancer and chronic, cancer) to workers involved in the disposal of ethylene dibromide, without consideration of existing respiratory protections. EPA recognizes that the actual maximum number of exposure days and the frequency of high-exposure tasks may be lower than assumed, and the lack of information on the landfills and wastewater treatment facilities that handle ethylene dibromide in the United States increases uncertainties in this assessment.

Reported Use of Respiratory Protection by Workers

Estimates of occupational inhalation risks are presented in Table 4-28. Where the estimated MOE is below the benchmark value, an indication of the respirator APF needed to mitigate risk is also provided. For this OES, EPA did not identify any information on PPE use. Where proper respiratory protection is utilized, EPA expects that worker exposures will be reduced.

4.3.3.1.7 Distribution in Commerce OES

Distribution in commerce consists of the activities associated with the transportation of ethylene dibromide or ethylene-dibromide containing products and/or articles between sites that import, process, and use ethylene dibromide. Additionally, this OES includes the transportation of ethylene dibromide-containing wastes to recycling sites or for final disposal. EPA expects all the ethylene dibromide or ethylene dibromide-containing products and/or articles to be transported in a closed system or otherwise to be transported in a form (*e.g.,* articles containing ethylene dibromide) such that there is negligible potential for releases except during an incident. It is possible that ethylene dibromide may go through a third party for temporary storage/warehouse before distribution to use. If repackaging takes place at these facilities involving transfer from larger to smaller containers, EPA assessed this scenario under the OES of import and repackaging. Transport containers are not expected to be opened during transport between producing and receiving sites. Speculative exposures may result from irregular and unpredictable accidental spills during transport are not assessed by TSCA Risk Evaluations. Therefore, occupational exposures covered under TSCA Risk Evaluations are not reasonably expected to occur, and no quantitative assessment was performed for estimating occupational exposures from the COU covered under the Distribution in Commerce OES (*i.e.,* Distribution in commerce COU). EPA considers the activities of loading and unloading of chemical product part of distribution in commerce; however, these activities were assessed as part of each use's OES. EPA's current approach for quantitatively assessing exposures for the remaining aspects of distribution in commerce consists of searching U.S. Department of Transportation (DOT) and National Response Center (NRC) data for incident reports pertaining to ethylene dibromide distribution. EPA did not use any information from these incident reports because the Agency did not perform any quantitative risk assessment for this OES.

4.3.3.2 Occupational Dermal Exposure Risk Characterization

This section provides summary tables and dermal risks, as well as a discussion of the risk characterization for dermal exposures. For all COUs, EPA used DEVL Model to estimate dermal exposure to ethylene dibromide liquid from various workers activities, as described in Section 5.4.4 of the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). The Agency used a tiered route-to-route extrapolation approach to derive HEDs for non-cancer and cancer hazard endpoints, screening HEDs with the "default" approach, and then refining the analysis by calculating HEDs with a PBPK model. Default dermal route-to-route extrapolation methods are used

when chemical-specific dermal absorption data are unavailable. In this approach, PODs or BMDLs from rat oral or inhalation toxicity studies are translated into HEDs using allometric scaling, which assumes that many physiological processes scale with species-specific body size.

To account for the route differences in this assessment, complete (*i.e.,* 100%) gastrointestinal absorption or inhaled uptake from the toxicity studies is assumed and a fractional dermal absorption term is applied to estimate a retained dermal dose corresponding to each BMDL or POD. Under this framework, the resulting dermal toxicity value is expressed as a retained, or systemically absorbed, dose, and exposure is compared directly to this retained dose metric without explicit adjustment for exposure-condition-specific determinants. PBPK-based route-to-route extrapolation uses a mechanistic model to simulate the same exposure scenarios for each rat POD or BMDL and resulting internal kinetics (associated with a hazard). The model is then used by reverse dosimetry to determine the retained dermal dose and vehicle volume that produces the internal dose metric of hazard, under defined exposure conditions. Specifically, the model simulates dermal uptake as a function of chemical-specific physiochemical properties and scenario-specific exposure parameters. This permits explicit characterization of the relation between applied and internal dose, such that the retained dose associated with a given exposure scenario can be directly estimated and compared to internal dose metrics derived from the oral and inhalation animal toxicity studies. These approaches are further described in Section 2.2.5 of the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t) and Section 4.2.5 of the current document.

For risk estimates, EPA compared the retained exposure doses to retained human equivalent hazard doses to calculate MOEs using both approaches. Table 4-30 presents dermal risk estimates in derived from both approaches in this section. Although the numerical risk values differ between the default and PBPK methods for a given COU, both approaches lead to the same overall risk conclusions, and these conclusions are consistent across all COUs.

The dermal loading values (mg/cm^2) used for the DEVL Model are based on experimental studies and EPA is applying these loading values for exposure scenarios that are encountered in the industrial and commercial settings for the COU/OES identified for ethylene dibromide. The experimental study used oils as substances to measure the applied amount on skin as opposed to solvents which are less viscous. The modeling approach includes a weight fraction parameter that accounts for differences in the weight fraction of ethylene dibromide between OESs. However, it does not account for other differences that may exist among the OESs that impact dermal exposure such as differences in dermal loading, and frequency of contact. EPA considered different skin surface area for two OESs (*i.e.,* Laboratory Use and Fuels and Related Products – Refueling) based on the information EPA identified (*e.g.,* small volume liquid used in lab; refueling avgas with one hand). The weight of scientific evidence was rated as moderate for the dermal modeling method used to assess dermal exposure for the COU/OES of ethylene dibromide. In executing the DEVL Model, EPA used a deterministic modeling approach. This calculation included variation in fraction absorbed for different wt% of ethylene dibromide among the various OES. The model estimates the acute potential dose rate. The Agency did not identify any data on dermal exposure in industrial and commercial settings to compare the model results.

EPA assessed dermal exposures for each COU under central tendency and high-end assumptions. Dermal exposure estimates incorporate weight fractions of ethylene dibromide in formulations, mixtures, reaction products, or products; the amount of ethylene dibromide used; and the surface area of potentially exposed skin. For central tendency estimates, EPA assumed exposure to the 50th percentile concentration of ethylene dibromide for a given OES, with exposed skin surface area equivalent to 267 to 535 cm^2 (representing the 50th percentile of 1–2 hands), a loading rate of 1.4 mg/cm^2, and exposure

once per day, 5 days per week, 250 days per year, for 31 years. EPA used the mean of the concentration range for the central tendency calculations. For high-end estimates, EPA assumed exposure to the 95th percentile concentration, exposed skin surface area equivalent to 535 to 1,070 cm² (95th percentile of 1–2 hands), a loading rate of 2.1 mg/cm², and exposure once per day, 5 days per week, 250 days per year, for 40 years. The highest value in the concentration range was used for the high-end exposure estimates. Default risk estimates applied a single hazard endpoint for each exposure duration (*i.e.,* acute, intermediate, chronic non-cancer, and chronic cancer) across all COUs, whereas PBPK risk estimates applied COU-specific central tendency and high-end PBPK hazard endpoints relevant to each scenario and exposure duration. Table 3-3 of this document presents description of the function of ethylene dibromide for each OES, and references used for assumptions on the concentration ranges used in the dermal risk assessment.

The summary of COU-specific assumptions for dermal exposure assessments is presented in the Table 4-29 below.

Table 4-29. COU-Specific Assumptions for Dermal Risk Assessment

Condition of Use	Scenario Assumption	Skin Surface Area		Conc. Range of Ethylene Dibromide Used	Conc. of Ethylene Dibromide in Assessment		Exposure Frequency
		Central Tendency	High-End		Central Tendency	High-End	
Manufacture – Import	2-Hands Exposure	535 cm^2	1,070 cm^2	30–60 wt%	45 wt%	60 wt%	1 event/day, 5 days/week, 250 days/year
Processing – Repackaging	2-Hands Exposure	535 cm^2	1,070 cm^2	0.07–100 wt%	50 wt%	100 wt%	1 event/day, 5 days/week, 250 days/year
Processing – Incorporation into formulation, mixture, or reaction product	2-Hands Exposure	535 cm^2	1,070 cm^2	0.07–60 wt%	30 wt%	60 wt%	1 event/day, 5 days/week, 250 days/year
Processing – As a reactant	2-Hands Exposure	535 cm^2	1,070 cm^2	10–100 wt%	55 wt%	100 wt%	1 event/day, 5 days/week, 250 days/year
Industrial use – Other use – Processing aid not otherwise specified; Pigment and dye manufacturing	2-Hands Exposure	535 cm^2	1,070 cm^2	10–100 wt%	55 wt%	100 wt%	1 event/day, 5 days/week, 250 days/year

Condition of Use	Scenario Assumption	Skin Surface Area		Conc. Range of Ethylene Dibromide Used	Conc. of Ethylene Dibromide in Assessment		Exposure Frequency
		Central Tendency	High-End		Central Tendency	High-End	
Industrial use – Fuel agents in petroleum refineries; Commercial use – Fuels and related products	2-Hands Exposure	535 cm^2	1,070 cm^2	0.07–0.1 wt%	0.085 wt%	0.1 wt%	1 event/day, 5 days/week, 250 days/year
	1-Hand Exposure (Refueling) [a]	267.5 cm^2	535 cm^2	0.07–0.1 wt%	0.085 wt%	0.1 wt%	1 event/day, 5 days/week, 250 days/year
Commercial use – Other use – Laboratory chemical	2-Hands Exposure	535 cm^2	1,070 cm^2	0.07–100 wt%	50 wt%	100 wt%	1 event/day, 5 days/week, 250 days/year
	1-Hand Exposure (Small liquid vol) [b]	267.5 cm^2	535 cm^2	0.07–100 wt%	50 wt%	100 wt%	1 event/day, 5 days/week, 250 days/year
Disposal	2-Hands Exposure	535 cm^2	1,070 cm^2	0.07–100 wt%	50 wt%	100 wt%	1 event/day, 5 days/week, 250 days/year

Conc. = concentration; CT = central tendency; HE = high-end; wt% = weight percentage
[a] EPA assumed that during refueling an aircraft, a worker holds an avgas pump nozzle with 1 hand; therefore, the potentially exposed skin surface area is equivalent to 1 palm (CT) or 1 hand (HE).
[b] EPA identified several products containing ethylene dibromide that are sold in small quantities (*e.g.,* 1, 5, 10 mL). When using such small volumes of ethylene dibromide, EPA assumes that the potentially exposed skin surface area is equivalent to 1 palm (CT) or 1 hand (HE).

Using the default approach, EPA conducted route-to-route extrapolation as described in Section 2.3.2.5.1 of the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t). For non-cancer effects, duration-specific PODs were derived from inhalation studies. The acute and intermediate dermal POD of 28 mg/kg/day is based on skeletal malformations and resorptions in mice (Short et al., 1978). The chronic dermal POD of 2.2 mg/kg/day is based on liver effects in male rats (NTP, 1982). EPA derived an adult dermal CSF (0.30 per mg/kg/day) using the default approach for occupational exposures, excluding age-dependent adjustment factors.

In parallel, EPA derived dermal hazard values using a PBPK model (U.S. EPA, 2026aa) as described in Section 2.3.2.5.3 of the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t) and *Draft PBPK Reporting Document for Ethylene Dibromide* (U.S. EPA, 2026aa). Although PBPK models contain inherent uncertainties, those uncertainties are well characterized, and EPA determined that they do not limit application of the model within its domain of applicability. EPA has robust confidence in these PBPK-based hazard values, which are used as refined estimates following the default screening level approach, consistent with the uncertainty analysis in *Draft PBPK Reporting Document for Ethylene Dibromide* (U.S. EPA, 2026aa). The PBPK model predicts retained dose and pharmacokinetic behavior under defined dermal exposure conditions. Unlike a fixed fraction absorption approach, the PBPK model estimates bioavailability as a function of ethylene dibromide concentration (*e.g.,* neat or diluted), exposed skin surface area, and duration and frequency of exposure. PBPK outputs are expressed as retained dose (mg/kg-day) and volume of the applied vehicle.

Exposure duration-specific (*i.e.,* acute, intermediate, chronic, non-cancer and chronic, cancer) default hazard endpoints used for the default dermal risk estimates are presented in Table 4-24 of this document. COU-specific, exposure duration-specific (*i.e.,* acute, intermediate, chronic, non-cancer and chronic, cancer), and scenario specific PBPK hazard endpoint values used for the PBPK risk estimates are presented in Table 4-25.

For all COUs, using default approaches, MOEs calculated for central tendency of acute, and intermediate dermal exposures are above the benchmark MOE of 100, and MOEs calculated for central tendency of chronic, non-cancer dermal exposures are above the benchmark MOE of 30, as presented in Table 4-30 below. For some COUs (*i.e.,* Manufacture – Import; Processing – Incorporation into formulation, mixture, or reaction product; Industrial use – Fuel agent in petroleum refineries; and Commercial use – Fuels and related products), using default approaches, MOEs calculated for high-end of acute dermal exposures are above the benchmark MOE of 100. For all COU except for two COUs (*i.e.,* Industrial use – Fuel agent in petroleum refineries; and Commercial use – Fuels and related products), using default approaches, chronic, non-cancer MOEs for high-end exposure scenarios are below the benchmarks in the absence of PPE use. For all COUs except for two COUs (*i.e.,* Industrial use – Fuel agent in petroleum refineries; and Commercial use – Fuels and related products), using default approaches, chronic, cancer risks for both central tendency and high-end exposure scenarios are above the benchmark cancer risk of 1.0×10^{-4} in the absence of PPE use. Although the risk estimates are not exactly the same between default approach and PBPK approach for a given COU, the risk conclusions are same between these two approaches and are consistent. More detailed risk estimates are available in the *Draft Default Risk Calculator for Occupational and Consumer Exposures for Ethylene Dibromide* (U.S. EPA, 2026d), and *Draft PBPK Risk Calculator for Occupational Exposures for Ethylene Dibromide* (U.S. EPA, 2026ab).

EPA has moderate confidence in the resulting risk estimates from both the default and PBPK approaches. The primary differences between central tendency and high-end dermal exposure and risk estimates are the higher use concentrations of ethylene dibromide, the quantity of ethylene dibromide remaining on the skin, and the surface area of skin exposed, which may be expected to vary across tasks and across individuals. Central tendency and high-end dermal risk estimates are presented for exposure scenarios without glove use. Potential for evaporation is reflected in final risk estimates because the fractional absorption of ethylene dibromide was modeled using IH SkinPerm with ethylene dibromide-specific empirical data points, and the fractional absorption parameter was used to estimate the retained dose of ethylene dibromide in the epidermis layer of skin. Exposure estimates assume that ethylene dibromide is not removed by handwashing; however, the frequency of handwashing is not expected to substantially impact exposure estimates given that the evaporation accounted for in modeling the fractional absorption parameter using IH SkinPerm reflects that about 98% of ethylene dibromide evaporation occurs from skin in about an hour, and over 98% of ethylene dibromide evaporation occurs from skin in less than 2 hours, suggesting that ethylene dibromide transportation to or from the dermis of the skin stops after 2 hours of a brief, single exposure to ethylene dibromide liquid.

The DEVL Model estimates dermal retained dose using a fixed fractional absorption derived from the IH SkinPerm tool. IH SkinPerm provides the fractional absorption value using a one compartment, uptake-limited skin model that describes absorption into the stratum corneum via diffusivity and stratum corneum thickness, where the driving force is stratum corneum storage capacity and not vehicle concentration. Evaporation is a loss term independent of the stratum corneum and competes with absorption, resulting in a single, default value that describes bioavailability but is not dose-dependent. Alternatively, the PBPK model is flux-based and accounts for volume, which means the vehicle concentration changes as the vehicle volume shrinks due to loss by evaporation or permeation, which in

turn changes skin flux. Additionally, dermal exposure modeled with PBPK dynamically connects the skin to the systemic body compartments, enabling time-dependent simulation of dermal absorption, and whole-body distribution and clearance. This results in dose-dependent bioavailability based on both dermal and systemic pharmacokinetics.

Discussion on Use of Dermal PPE

The DEVL Model estimates the AAD rate and does not take into account the protection provided by gloves when workers perform their tasks. Because there are no dermal exposure measurements available, EPA is unable to evaluate the usage of gloves in the context of specific exposure measurements or concentrations. Additionally, there are no established quantitative protection factors for gloves. Nonetheless, the occupational risk estimates, which do not include or assume the use of gloves, may be an over-estimate of dermal exposures. There is limited information on use of dermal PPE for all OESs. For the OES where EPA identified information on the use of gloves by workers, EPA has further reviewed this information to understand how this may affect the risk estimates. OES-specific dermal PPE-related information are presented in OES-specific subsections below. While EPA recognizes that workers may wear PPE, there is a lack of specific information available to further refine or discuss how the potential use of such PPE may inform interpretation of the risk estimates. Therefore, the dermal risk estimates presented in this document do not consider dermal protection factors that may reduce risk. Because there are no dermal exposure measurements available, EPA is unable to evaluate the reported usage of gloves in the context of specific dermal exposure measurements or concentrations. The Agency does not have specific information on how chemical gloves are selected for each task where required, or standard operating procedures for proper glove use by workers in the facilities monitored (*e.g.,* glove change out schedules). The occupational dermal risk estimates, which do not assume the use of gloves or other types of controls, may be an overestimate of dermal exposures, as there is evidence that workers in these facilities utilize dermal PPE. EPA provided additional discussion of the available information on dermal PPE usage and existing controls for each OES in the risk determination sections. The Agency welcomes additional information on how dermal protection is selected, applied, and utilized for each OES.

Table 4-30 provides occupational dermal MOEs for the OES and worker categories assessed for ethylene dibromide. Working years is a parameter that impacts the estimates of chronic cancer risks. EPA did not identify any OES-specific data on working years, and therefore, assumed a central tendency of 31 working years and high-end of 40 working years based on BLS data for estimating chronic cancer risks for all OESs. General information on PPE, including dermal protection is available in Appendix C.3.8 of *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d), and more specific information is included in this subsection.

4138 **Table 4-30. Occupational Dermal Risk Summary Table**

COU	OES	Population	Exposure Level	Default Dermal Risk Estimates [a d]				PBPK Dermal Risk Estimates [a d]			
				Acute (Benchmark MOE = 100) MOE – No Gloves	Interm. (Benchmark MOE = 100) MOE – No Gloves	Chronic, Non-Cancer [b c] (Benchmark MOE = 30) MOE – No Gloves	Chronic, Cancer [b] (Benchmark = E−04) Risk – No Gloves	Acute (Benchmark MOE = 100) MOE – No Gloves	Interm. (Benchmark MOE = 100) MOE- No Gloves	Chronic, Non-Cancer [b c] (Benchmark MOE = 30) MOE – No Gloves	Chronic, Cancer [b] (Benchmark = E−04) Risk – No Gloves
Manufacture – Import	Import and Repackaging (2-Hands, 45−60 wt%)	Worker	CT	415	566	48	**5.5E−03**	654	892	75	**5.9E−03**
			HE	104	142	**12**	**2.8E−02**	148	202	**18**	**9.2E−02**
Processing – Repackaging	Import and Repackaging (2-Hands, 50−100 wt%)	Worker	CT	374	509	43	**6.1E−03**	581	792	67	**4.3E−03**
			HE	**62**	**85**	**7.1**	**4.7E−02**	**84**	115	**11**	**3.3E−02**
Processing – Incorporation into formulation, mixture, or reaction product	Incorporation into Formulation, Mixture or Reaction Product (2-Hands, 30−60 wt%)	Worker	CT	622	849	107	**3.7E−03**	1,005	1,370	115	**2.6E−03**
			HE	104	142	**12**	**2.8E−02**	148	202	**18**	**2.0E−02**
Processing – As a reactant Industrial use – Other use – Processing aid not otherwise specified; Pigment and dye manufacturing	Incorporation into Formulation, Mixture or Reaction Product (2-Hands, 55−100 wt%)	Worker	CT	340	463	39	**6.7E−03**	521	711	61	**4.7E−03**
			HE	**62**	**85**	**7.1**	**4.7E−02**	**84**	115	**11**	**3.3E−02**

COU	OES	Population	Exposure Level	Default Dermal Risk Estimates [a d]				PBPK Dermal Risk Estimates [a d]			
				Acute (Benchmark MOE = 100) MOE – No Gloves	Interm. (Benchmark MOE = 100) MOE – No Gloves	Chronic, Non-Cancer [b c] (Benchmark MOE = 30) MOE – No Gloves	Chronic, Cancer [b] (Benchmark = E−04) Risk – No Gloves	Acute (Benchmark MOE = 100) MOE – No Gloves	Interm. (Benchmark MOE = 100) MOE- No Gloves	Chronic, Non-Cancer [b c] (Benchmark MOE = 30) MOE – No Gloves	Chronic, Cancer [b] (Benchmark = E−04) Risk – No Gloves
Industrial use – Fuel agents in petroleum refineries	Fuels and Related Products – Bulk Terminals (2-Hands, 0.085−0.1 wt%)	Worker (2-Hands)	CT	2.2E05	3.0E05	2.5E04	1.0E−05	–	–	–	–
			HE	6.2E04	8.5E04	7.1E03	4.7E−05	–	–	–	–
Commercial use – Fuels and related products	Fuels and Related Products – Refueling (0.085−0.1 wt%)	Worker (2-Hands)	CT	2.2E05	3.0E05	2.5E04	1.0E−05	–	–	–	–
			HE	6.2E04	8.5E04	7.1E03	4.7E−05	–	–	–	–
		Worker (1-Hand)	CT	4.4E05	6.0E05	5.0E04	5.2E−06	–	–	–	–
			HE	1.2E05	1.7E05	1.4E04	2.4E−05	–	–	–	–
Commercial use – Other use –Laboratory chemical	Laboratory Use (50−100 wt%)	Worker (2-Hands)	CT	374	509	43	**6.1E−03**	581	793	67	**4.3E−03**
			HE	**62**	**85**	**7.1**	**4.7E−02**	**84**	115	**11**	**3.3E−02**
		Worker (1-Hand)	CT	747	1.0E03	86	**3.1E−03**	1,206	1,645	135	**2.2E−03**
			HE	125	170	**14**	**2.4E−02**	171	233	**22**	**1.6E−02**
Disposal	Waste Handling, Treatment, and Disposal – Landfill (2-Hands, 50−100 wt%)	Worker	CT	374	509	43	**6.1E−03**	581	792	67	**4.3E−03**
			HE	**62**	**85**	**7.1**	**4.7E−02**	**84**	115	**11**	**3.3E−02**

COU	OES	Population	Exposure Level	Default Dermal Risk Estimates [a d]				PBPK Dermal Risk Estimates [a d]			
				Acute (Benchmark MOE = 100) MOE – No Gloves	Interm. (Benchmark MOE = 100) MOE – No Gloves	Chronic, Non-Cancer [b c] (Benchmark MOE = 30) MOE – No Gloves	Chronic, Cancer [b] (Benchmark = E−04) Risk – No Gloves	Acute (Benchmark MOE = 100) MOE – No Gloves	Interm. (Benchmark MOE = 100) MOE- No Gloves	Chronic, Non-Cancer [b c] (Benchmark MOE = 30) MOE – No Gloves	Chronic, Cancer [b] (Benchmark = E−04) Risk – No Gloves
Disposal	Waste Handling, Treatment, and Disposal – Wastewater (2-Hands, 50−100 wt%)	Worker	CT	374	509	64	**6.1E−03**	581	792	67	**4.3E−03**
			HE	**62**	**85**	**7.1**	**4.7E−02**	**84**	115	**11**	**3.3E−02**
Distribution in commerce	Distribution in Commerce	No quantitative risk assessment was performed for this OES as occupational exposures are not reasonably expected to occur									

COU = condition of use; CT = central tendency; HE = high-end; Inter. = intermediate; MOE = margin of exposure; "-" = no value could be calculated; OES = occupational exposure scenario

BLS estimates based on working year demographic data from the Bureau of Labor Statistics (U.S. Census Bureau, 2019; U.S. BLS, 2014).

[a] Risk estimates that are either below the non-cancer benchmarks (*i.e.,* non-cancer risks), or exceed the cancer benchmark (*i.e.,* cancer risks) are **bolded/shaded**.

[b] The central tendency from DEVL Model is considered a more representative and appropriate exposure estimate for a frequent, repeated dermal exposure (*i.e.,* chronic) for closed system processes.

[c] For chronic, non-cancer exposure estimates, exposure dose over the working years is averaged over the working years. Therefore, different values of working years do not affect these estimates, and EPA has presented one chronic, non-cancer estimate.

[d] For more information, and example calculations, see supplemental files #20 and 21 (Appendix C).

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4.3.3.2.1 Import and Repackaging OES

The dermal exposure and risk estimates presented in Table 4-30 for the Import and Repackaging OES covers two COUs: Manufacture – Import COU and Processing – Repackaging COU. EPA describes the modeling approach used for dermal exposure assessment of these COUs in 5.3.1 of *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

For Manufacture – Import COU, EPA assumed a concentration range for ethylene dibromide from 30 to 60 wt%, with a central tendency of 45 wt% and high-end of 60 wt%. For the Processing – Repackaging COU, EPA used a concentration range for ethylene dibromide from 0.07 to 100 wt%, with a central tendency of 50 wt% and high-end of 100 wt%.

For both COUs, EPA assumed an average adult worker may get exposed to a skin surface area equivalent to one hand (central tendency; 535 cm^2) to two hands (high-end; 1,070 cm2) from one exposure event during activities that are relevant to this OES. There is uncertainty about several assumptions EPA used to model dermal exposure estimates for this OES. This scenario represents a worker who is exposed to ethylene dibromide liquid once per 8 hours workday and will continuously be exposed to any remaining ethylene dibromide liquid on the skin after that one exposure event. EPA assumed this scenario occurs 250 exposure days per year with one exposure event during each working day. Also, the assumption of 250 days/year exposure could result in an upper bound exposure and risk estimates since the average operating days for a chemical repackaging facility ranges from 174 to 260 days/year. The representativeness of this scenario is influenced by the variability in worker activities, schedules, and facility operations across the full distribution of facilities covered by this OES. The hazard values for this OES were derived by PBPK modeling, which are specific to each COU and aligned with exposure assumptions and parameters.

The key difference between central tendency and high-end estimates for a given duration (*e.g.,* acute) is the difference in the ethylene dibromide concentration, skin surface area, and loading rate. While it is plausible for a worker to get exposed at upper bound of ethylene dibromide concentration for a given COU, the upper bound skin surface area, and at upper bound loading rate one time (*i.e.,* acute), it is less likely to occur every working day for over a year (*i.e.,* chronic duration). Therefore, high-end estimates are considered more representative for acute and intermediate exposure as short-term exposure to the upper bound concentration of ethylene dibromide under the Manufacture – Import COU (*i.e.,* 100 wt%) is plausible as some of the imported ethylene dibromide liquid are at 100 wt%.

EPA expects the high-end estimates to be more appropriate for intermediate exposures on the basis of some considerations. There are some facilities which still import and repackage ethylene dibromide at neat concentrations. For the central tendency estimates, EPA used 50 wt% ethylene dibromide concentration, and for high-end estimates, the Agency used 100 wt% ethylene dibromide concentration. Therefore, high-end estimates are more representative of intermediate exposure durations for the facilities where neat (*i.e.,* 100 wt%) or neat (*e.g.,* 98 wt%) ethylene dibromide is handled. EPA seeks more information on the use, and current practices related to import and repackaging of ethylene dibromide at neat or near neat concentration.

However, since the concentration of majority of imported ethylene dibromide ranges between 30 to 60 wt%, and worker exposures on both hands equivalent skin surface area is not expected on a daily basis, but rather infrequently, central tendency estimates of dermal exposure and risk are expected to represent chronic level exposures (*i.e.,* non-cancer and cancer) to workers involved in the import of ethylene dibromide. Similarly, for Processing – Repackaging COU, high-end estimates are more appropriate and

representative of short-term (*i.e.,* acute and intermediate) exposure and risk. Central tendency estimates are more appropriate and representative of repeated exposure since the overall concentration range of ethylene dibromide for repackaging is between 0.07 to 100 wt%, and worker exposures on both hands equivalent skin surface area is not expected on a daily basis, but rather infrequently.

Reported Use of Dermal Protection by Workers

Based on the reports EPA used for this assessment, in three out of five facilities data were gathered from, workers handling ethylene dibromide during import and repackaging generally wore rubber gloves for dermal protection (NIOSH, 1977b, c, d). Other industrial hygiene report did not present information on dermal PPE (NIOSH, 1977a). A stakeholder, Innospec reported that workers are required to wear appropriate clothing and PVC gloves during emptying ethylene-dibromide containing drums into a storage tank or direct into gasoline stream. When workers connect or disconnect transfer lines or conduct other hands-on operations, they wear white cotton workwear under chemical-resistant aprons, gloves, boots, sleeves, and head coverings (Innospec, 2025). The Chemical Repackaging GS indicated that limited information was found regarding typical PPE workers used during repackaging processes. One chemical wholesaler website indicated that commonly used dermal PPE for this OES includes gloves (U.S. EPA, 2022a). However, EPA did not identify any information to quantify the impact on dermal PPE use on exposure and risk reduction.

4.3.3.2.2 Incorporation into Formulation, Mixture or Reaction Product OES

The dermal exposure and risk estimates presented in Table 4-30 for the Incorporation into Formulation, Mixture or Reaction Product OES covers three COUs: Processing – Incorporation into formulation, mixture, or reaction product COU, Processing – As a reactant COU, and Industrial use – Other use – Processing aid not otherwise specified COU. EPA describes the modeling approach used for dermal exposure assessment of these COUs in Section 5.4.1 of *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

For the dermal exposure assessment of Processing – Incorporation into formulation, mixture, or reaction product COU, EPA assumed that the concentration of ethylene dibromide ranges between 0.07 to 60 wt%, with a central tendency of 30 wt% and high-end of 60 wt%. For Processing – As a reactant COU and Industrial use – Other use – Processing aid not otherwise specified; Pigment and dye manufacturing COU, EPA assumed that the concentration ranges from 10 to 100 wt%, with a central tendency of 55 wt% and high-end of 100 wt%.

For all COUs within this OES, EPA assumed an average adult worker may get exposed to a skin surface area equivalent to one hand (central tendency; 535 cm^2) to two hands (high-end; 1,070 cm2) from one exposure event during activities that are relevant to this OES. There is uncertainty about several assumptions EPA used to model dermal exposure estimates for this OES. This scenario represents a worker who is exposed to ethylene dibromide liquid once per 8 hours workday and will continuously be exposed to any remaining ethylene dibromide liquid on the skin after that one exposure event. EPA assumed this scenario occurs 250 exposure days per year with one exposure event during each working day. The representativeness of this scenario is influenced by the variability in worker activities, schedules, and facility operations across the full distribution of facilities covered by this OES. The hazard values for this OES were derived by PBPK modeling, which are specific to the scenarios represented under each COU and aligned with exposure assumptions and parameters.

High-end estimates are appropriate and representative of acute and intermediate exposure to ethylene dibromide liquid. Because the DEVL Model factors in the concentration of ethylene dibromide, and the concentration for this OES ranges from 10 to 100 wt%, EPA used median of this range (*i.e.,* 50 wt%) for

the central tendency estimates and upper bound (*i.e.,* 100 wt%) for high-end estimates. EPA considers that high-end estimates may also be appropriate for intermediate exposures due to the potential for continued high-end exposures over 22 working days at facilities where neat ethylene dibromide is used under this OES. Since worker exposures on both hands equivalent skin surface area is not expected on a daily basis over a working year, central tendency estimates of dermal exposure, which is based on the assumption of exposure to one hand or two palms are expected to represent potential chronic level exposures to workers involved in the processing of ethylene dibromide for this COU. EPA seeks more information on the use, and current practices related to processing of ethylene dibromide at neat concentration.

Reported Use of Dermal Protection by Workers

Based on the reports EPA used for this assessment, workers in two of the three blending and processing roles wore rubber gloves or impervious gloves (NIOSH, 1977b, c). Workers who handled raw materials or were assigned with sampling of the ethylene dibromide tank car were performed by personnel wearing rubber gloves. Innospec reported that maintenance or tasks with potential for liquid/vapor contact require the same chemical-resistant clothing ensemble as transfer operations, including gloves (Innospec, 2025). However, EPA did not identify any information to quantify the impact on dermal PPE use on exposure and risk reduction.

4.3.3.2.3 Fuels and Related Products OES

The dermal exposure and risk estimates presented in Table 4-30 for the Fuels and Related Products OES – Bulk Terminals covers Industrial use – Fuel agents in petroleum refineries COU, and Fuels and Related Products OES – Refueling covers Commercial use – Fuels and related products COU. EPA describes the modeling approach used for dermal exposure assessment of these COUs in 5.6.1 of *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

For the exposure assessment, EPA used a concentration range for ethylene dibromide from 0.07 to 0.10 wt%, with a central tendency of 0.085 wt% and high-end of 0.1 wt% and assumed an average adult worker may get exposed to a skin surface area equivalent to one hand (central tendency; 535 cm^2) to two hands (high-end; 1,070 cm^2) from one exposure event during activities that are relevant to these two COUs. For the Commercial use – Fuels and related products COU, EPA also presents an additional exposure assessment with an assumption that an average adult worker may get exposed to a skin surface area equivalent to one palm (central tendency; 267.5 cm^2) to two palms or one hand (high-end; 535 cm^2) from one exposure event during activities that are relevant to avgas refueling scenario.

There is uncertainty about several assumptions EPA used to model dermal exposure estimates for this OES. This scenario represents a worker who is exposed to ethylene dibromide liquid once per 8 hours workday and will continuously be exposed to any remaining ethylene dibromide liquid on the skin after that one exposure event. EPA assumed this scenario occurs 250 exposure days per year with one exposure event during each working day. The representativeness of this scenario is influenced by the variability in worker activities, schedules, and facility operations across the full distribution of facilities covered by this OES. The hazard values for this OES were derived by PBPK modeling, which are specific to this OES and aligned with exposure assumptions and parameters. As discussed in Section 2.5.2.2.1 of the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t), the PBPK simulations for this COU and level of exposure indicate that the formulation of ethylene dibromide in the refueling scenario is too low to reach the internal dose metric. As such, the predicted HED approaches an infinite value, meaning that it is unlikely to reach the POD in the refueling scenario, making it unable to predict a hazard value. Consequently, the dermal risk is absent for this COU. PBPK approach is used for risk determination for the COUs covered under the Fuels and Related Products OES

(*i.e.,* Industrial use – Fuel agent in petroleum refineries; and Commercial use – Fuels and related products COU).

Reported Use of Dermal Protection by Workers

EPA did not identify any evidence that dermal PPE is generally used for this OES.

4.3.3.2.4 Laboratory Use OES

The dermal exposure and risk estimates presented in Table 4-30 for the Laboratory Use OES covers one COU: Commercial use – Laboratory chemical COU. EPA describes the modeling approach used for dermal exposure assessment of this COU in 5.6.1 of *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

For the exposure assessment, EPA used a concentration range for ethylene dibromide from 0.07 to 100 wt%, with a central tendency of 50 wt% and high-end of 100 wt% and assumed an average adult worker may get exposed to a skin surface area equivalent to one hand (central tendency; 535 cm^2) to two hands (high-end; 1,070 cm^2) from one exposure event during activities that are relevant to this COU. EPA also presents an additional exposure assessment with an assumption that an average adult worker may get exposed to a skin surface area equivalent to one palm (central tendency; 267.5 cm^2) to two palms or one hand (high-end; 535 cm^2) from one exposure event when handling ethylene dibromide liquid at small quantities, such as 1 to 5 mL volume of ethylene dibromide.

There is uncertainty about several assumptions EPA used to model dermal exposure estimates for the Laboratory Use OES (*i.e.,* Commercial use – Other use – Laboratory chemical COU). This scenario represents a worker who is exposed to ethylene dibromide liquid once per 8 hours workday and will continuously be exposed to any remaining ethylene dibromide liquid on the skin after that one exposure event. EPA assumed this scenario occurs 250 exposure days per year with one exposure event during each working day. The representativeness of this scenario is influenced by the variability in worker activities, schedules, and facility operations across the full distribution of facilities covered by this OES. The hazard values for this OES were derived by PBPK modeling, which are specific to this OES and aligned with exposure assumptions and parameters.

The high-end estimates from this assessment is more representative and appropriate for short-term dermal exposure (*i.e.,* acute and intermediate) for the workers than central tendency estimates with the assumption that a worker may be exposed to the skin surface area equivalent to one hand (*i.e.,* 575 cm^2), and at upper bound concentration of ethylene dibromide (*i.e.,* 100 wt%) for shorter periods of time. However, the high-end estimates may overestimate long-term exposure, as it is less likely that a worker is exposed to concentrated ethylene dibromide on a skin surface area equivalent to one hand frequently over a year. Since the concentration of ethylene dibromide used for laboratory uses ranges between 0.07 to 100 wt%, and worker exposures on one hand, or both hands equivalent skin surface area is not expected on a daily basis, but rather infrequently, central tendency estimates of dermal exposure with 1-Hand assumption (*i.e.,* skin surface area equivalent to 1 palm), and an assumption of 50 wt% concentration are expected to represent potential chronic level (*i.e.,* non-cancer and cancer) exposures to workers involved in the processing use ethylene dibromide as a laboratory chemical.

Reported Use of Dermal Protection by Workers

Based on the reports EPA used for this assessment, two of the four laboratory sites reported use of dermal PPE for this OES. Laboratory technicians handling ethylene dibromide are reported to use gloves (rubber or chemical-resistant) as dermal PPE (NIOSH, 1977c, e). Based on the limited information identified from systematic review, during tasks with significant exposure potential (*e.g.,* QC sampling),

gloves were required, but the type and duration of glove use were not specified. NASA noted that all standard preparation and analytical procedures are performed using appropriate PPE, including gloves and safety glasses (U.S. EPA, 2026a). 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, which must include criteria for the use of PPE and engineering controls. Examples of dermal PPE include disposable gloves. 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 burns, thermal burns, and harmful temperature extremes (U.S. EPA, 2023c).

4.3.3.2.5 Waste Handling, Treatment, and Disposal OES

The dermal exposure and risk estimates presented in Table 4-30 for the Waste Handling, Treatment, and Disposal OES – Landfill covers exposure and risk at the landfill facilities, and the Waste Handling, Treatment, and Disposal OES – Wastewater covers exposure and risk at wastewater treatment facilities under one COU: Disposal COU. EPA describes the modeling approach used for dermal exposure assessment of this COU in 5.6.1 of *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

For the dermal exposure assessment of this COU, EPA used a concentration range for ethylene dibromide from 0.07 to 100 wt%, with a central tendency of 50 wt% and high-end of 100 wt%, and assumed an average adult worker may get exposed to a skin surface area equivalent to one hand (central tendency; 535 cm^2) to two hands (high-end; 1,070 cm^2) from one exposure event during activities that are relevant to this OES (*i.e.,* Disposal COU).

There is uncertainty about several assumptions EPA used to model dermal exposure estimates for this OES. This scenario represents a worker who is exposed to ethylene dibromide liquid once per 8 hours workday and will continuously be exposed to any remaining ethylene dibromide liquid on the skin after that one exposure event. EPA assumed this scenario occurs 250 exposure days per year with one exposure event during each working day. The representativeness of this scenario is influenced by the variability in worker activities, schedules, and facility operations across the full distribution of facilities covered by this OES. The hazard values for this OES were derived by PBPK modeling, which are specific to this OES and aligned with exposure assumptions and parameters.

High-end estimates are expected to be more appropriate and representative for workers' exposure to ethylene dibromide liquid at short-term durations (*i.e.,* acute and intermediate). EPA acknowledges that since the concentration of ethylene dibromide ranges between 0.07 to 100 wt%, and worker exposures on both hands equivalent skin surface area is not expected on a daily basis, but rather infrequently, central tendency estimates of dermal exposure are expected to represent potential chronic level exposures (*i.e.,* non-cancer and cancer) to workers involved in the disposal of ethylene dibromide.

Reported Use of Dermal Protection by Workers

EPA did not identify any information on the dermal PPE use for the Waste Handling, Treatment, and Disposal OES.

4.3.3.2.6 Distribution in Commerce OES

For purposes of assessment, distribution in commerce consists of the activities associated with the transportation of ethylene dibromide or ethylene-dibromide containing products and/or articles between sites that import, process, and use ethylene dibromide. Additionally, this OES includes the transportation of ethylene dibromide-containing wastes to recycling sites or for final disposal. EPA expects all the

ethylene dibromide or ethylene dibromide-containing products and/or articles to be transported in a closed system or otherwise to be transported in a form (*e.g.,* articles containing ethylene dibromide) such that there is negligible potential for releases except during an unexpected incident. Therefore, no occupational exposures are reasonably expected to occur, and no quantitative assessment was performed for estimating releases and exposures from the Distribution in commerce COU. EPA's current approach for quantitatively assessing exposures for the remaining aspects of distribution in commerce consisted of searching DOT and NRC data for incident reports pertaining to ethylene dibromide distribution. EPA did not use information from these incident reports because the Agency did not perform any quantitative risk assessment for this OES.

4.3.4 Risk Estimates for Consumers

EPA estimated risks to consumers from dermal and inhalation exposure to ethylene dibromide. These risk estimates are based on the COU-specific consumer exposure estimates described in Section 4.1.2 and the hazard values summarized in Section 4.2.7. Risk estimates for each consumer scenario are presented in this section. EPA did not evaluate chronic (non-cancer) exposure and the risk for the consumer refueling scenario because the maximum assumed exposure frequency is 52 days per year which is far below the 90-days-per-year minimum used to be considered as chronic exposure. However, cancer risk was estimated due to the intermittent nature of the exposure scenario as part of the lifetime average daily concentration (inhalation) or dose (dermal) calculation. Specifically, as described in the *Draft Hazard Assessment for Ethylene Dibromide*, as a bifunctional alkylating agent that can quickly react with nucleophilic sites, characterizing cancer risk resulting from chronic exposures to ethylene dibromide is reasonable given the mutagenic MOA of ethylene dibromide, which positively contextualizes the carcinogenic effects associated with ethylene dibromide exposures (U.S. EPA, 2026t). Additional details regarding the risk estimate calculations and a more comprehensive set of results are presented in the *Draft Risk Calculator for Occupational and Consumer Exposures for Ethylene Dibromide* (U.S. EPA, 2026d).

EPA considered aggregate cancer risk to consumers from dermal and inhalation exposure to ethylene dibromide because both pathways are likely to occur simultaneously during refueling and sampling (sumping) activities associated with this COU. Section 4.3.4.2 describes dermal risk estimation using both default and PBPK approaches. Although the default approach preliminarily identified potential dermal cancer risk, the PBPK modeling approach could not predict any CSF value for dermal route for this COU primarily due to the low weight fraction of ethylene dibromide in avgas not resulting in an internal dose that is estimated to result in toxicological effects. Therefore, cancer risk was not ultimately aggregated for inhalation and dermal exposure for this COU. EPA considers inhalation to be the primary route of exposure. Cancer risk resulting from inhalation is the driver for this consumer COU because non-cancer acute and intermediate risk was not identified.

4.3.4.1 Inhalation Risk Estimates

Consumer inhalation risk estimates were derived from modeling inhalation exposure during refueling activities. Due to the absence of monitoring or surrogate data relevant to consumer inhalation exposures for the avgas refueling scenario, the exposure was modeled using available information on product concentrations and descriptions. Because the parameters used for consumer inhalation exposures were identical for both adults and youths, the EPA did not estimate inhalation risk separately for each age group.

In addition to evaluating inhalation risks to consumers, EPA considered whether there is the potential for inhalation exposure to bystander (passengers for avgas refueling scenario). However, based on the information received from Experimental Aircraft Association (EAA), general practice is not to have

passengers in or near the aircraft while it is being refueled. Most refuelers will not fuel an occupied aircraft as a general safety procedure, and passengers typically wait inside the fixed-base operator (FBO) during refueling. Accordingly, EPA did not evaluate bystanders for this scenario.

Table 4-31 summarizes the inhalation risk estimates, using the MOE, described in Section 4.2.7 and Table 4-24, to characterize the non-cancer risk for acute and intermediate exposures, as well as the cancer risk associated with exposure to ethylene dibromide. EPA did not evaluate chronic (non-cancer) exposure and risk for the consumer refueling scenario because the maximum assumed exposure frequency is 52 days per year, which is far below the 90-days-per-year minimum used to be considered as chronic exposure. The Agency conducted an inhalation exposure assessment for consumers, considering low-, medium-, and high-intensity exposure scenarios.

EPA characterized consumer inhalation exposure risk using low-, medium-, and high-intensity exposure scenarios as presented in Table 4-31. The detailed sources and the rationale of the parameters are presented in Section 9.2 of the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

Table 4-31. Consumer Inhalation Exposure Risk Estimates

Exposure Intensity	Non-Cancer Acute Exposure Risk (Benchmark MOE = 100) [a]	Non-Cancer Intermediate Exposure Risk (Benchmark MOE = 100) [a]	Cancer Risk (Cancer Benchmark = 1E−06) [a]	Additional Lifetime Cancer Cases [b]	Additional Cancer Cases Per Year [b]
Low	3.2E04	9.7E05	**1.6E−06**	4.2E−01	5.4E−03
Medium	2.1E04	3.0E05	**1.2E−05**	3.2	4.1E−02
High	1.3E04	8.9E04	**6.8E−05**	1.8E01	2.3E−01

MOE = margin of exposure
Bolded/shaded cells indicate risks greater than the benchmark.
[a] See Section 4.2.3 and Table 4-24 for details
[b] Based on a population of 264,000 pilots (see Section 4.1.2.1 for details).

As presented in Table 4-31, EPA also calculated excess lifetime cancer cases based on inhalation cancer risk by multiplying the cancer risk by the maximum potential consumer pilot population (264,000 pilots) described in Section 4.1.2.1. The additional cancer cases per year were estimated by dividing the additional lifetime cancer cases by 78 years. These additional cancer cases consider both consumer population and risk and are used to determine whether there is an unreasonable risk to consumer pilots in this evaluation. Additional lifetime cancer cases were only calculated for inhalation exposure because EPA considers inhalation to be the primary route of exposure.

Risk Characterization of Consumer Use – Refueling Related Products COU

Uncertainty remains regarding whether the parameterization of the exposure model adequately represents the true distribution of inhalation concentrations for this consumer scenario. This scenario represents a consumer with single exposure per day and 12, 26, or 52 exposure days per year and the exposure events are intermittent. There is a time lapse between exposure events, *i.e.,* one refueling event per month for a total of 12 exposure events per year. The representativeness of this scenario depends on variability in consumer activities. As described above, three exposure scenarios, low-, medium-, and high-intensity, were modeled. Low-intensity exposure represents pilots flying to meet the minimum requirements to maintain a pilot license based on the FAA's requirement for retaining pilot licensing (14 CFR part 61 subpart F); medium-intensity exposure represents pilots flying for leisure, recreation, or

other personal use (U.S. EPA, 2025c); and high-intensity exposure represents consumer pilots flying as many hours as recreational pilots working toward a commercial pilot certificate (14 CFR part 61 subpart F). Therefore, the exposure values are considered plausible estimates of consumer exposure within the COUs covered under the Fuels and related products exposure scenario (*i.e.,* Consumer use – Fuels and related products COU).

As for the maximum potential consumer pilot population (264,000 pilots, as reported by EAGLE (2026)), the proportion of consumer pilots who actually refuel their own aircraft is unknown, therefore using the full population may overestimate cancer cases. This estimate is based on all potential consumer pilots in the US who hold a pilot certificate, whether active or inactive.

Key assumptions such as fuel volume per refueling event, exposure frequency, use duration, and the ethylene dibromide concentration in the breathing zone are uncertain due to absence of consumer monitoring data. EPA selected input parameters using professional judgment and review of reasonably available information. The high-intensity exposure scenario, anchored to activity levels typical of pilots pursuing a commercial license or similar level of flight time (250+ hours) and frequency, and the low-intensity exposure scenario, reflecting minimum activity to maintain currency, may not represent majority of consumers. Therefore, EPA recommends using medium-intensity exposure risk estimates for acute, intermediate and cancer risk characterization in the consumer unreasonable risk because the agency believes that medium-intensity exposure is the most representative of consumer avgas use while low- and high-intensity exposure risk estimates are used to inform unreasonable risk for relevant sub-consumer population.

4.3.4.2 Dermal Risk Estimates

Consumer dermal risk estimates were derived from modeling dermal exposure during sampling activities. In the absence of monitoring or surrogate data for consumer dermal exposures during avgas refueling, EPA's estimates for dermal exposure to ethylene dibromide were based on its weight fractions in products, usage amounts, and the exposed skin surface area. The agency conducted a consumer assessment with low-, medium, and high-intensity dermal exposure scenarios parameterized by product concentration, residue remaining on skin, and exposed skin area to plausible exposures bound. The DEVL modeling was used to estimate dermal exposure and risk estimate using the IH SkinPerm tool with specific dermal exposure parameters for ethylene dibromide. The estimates assume a single exposure event per day and account for handwashing approximately 5 hours post-exposure, under the assumption that a consumer or pilot washes their hands before a meal after refueling.

Table 4-32 summarizes the dermal risk estimates for consumers, using default method and HED, described in Section 4.2.3 and Table 4-24, to characterize the non-cancer risk for acute and intermediate exposures, as well as the cancer risk associated with exposure to ethylene dibromide. EPA conducted an assessment of dermal exposure for consumers, considering low-, medium, and high-intensity exposure scenarios. The agency estimated dermal exposure per age group and weighted average incorporating a youth exposure duration of 5 years into the overall adult exposure estimation, shown in Table 4-26.

As described in Section 4.2.5, the default method converts animal oral and inhalation toxicity values to HEDs using allometric scaling, assuming physiological processes scale with body size, which is widely applied when chemical-specific data are scarce. Because the PBPK approach converts between internal and external dose, it is more relevant to capture the magnitude of effects of the exposure condition (including a route of exposure), thereby increasing confidence in the estimated dermal HEDs compared to the default approach-scaled HEDs. Although the EPA utilized both the default and PBPK model approaches to estimate dermal hazard for ethylene dibromide for the avgas occupational (see Section

4.2.5) and consumer scenarios, consumer hazard from dermal exposure was reported using only the default method to show the results from the dermal tiering analysis, where dermal cancer risk was identified (Table 4-31), thereby warranting the second tiered PBPK modeling for dermal cancer risk. PBPK simulations for the consumer level of exposure indicate that the formulation of ethylene dibromide in the refueling scenario is too low for any consumer exposure to reach the internal dose metric. As such, the predicted HED approaches an infinite value, meaning that it is unlikely to reach the POD in the refueling scenario, making it unable to predict a hazard value, which indicates that no dermal risk is expected. The non-cancer dermal PODs were 28 mg/kg/day for acute and intermediate exposures. The cancer dermal slope factor for adults was 0.30 per mg/kg/day. This value is appropriate for estimating cancer risks in occupational and consumer exposure scenarios where the individuals are 16 years old or older.

Table 4-32 below presents consumer exposure and risk estimates for acute, intermediate, and chronic durations. The acute and intermediate risks were for non-cancer effects, while the chronic risks were for cancer effects. EPA did not present non-cancer chronic exposure and risk estimates because the maximum assumed exposure frequency is 52 days per year on an intermittent schedule. Toxicokinetics data, including the PBPK model for this chemical, clearly demonstrate that ethylene dibromide is rapidly eliminated from the body. Therefore, EPA expects that ethylene dibromide does not accumulate in the body with intermittent exposure and these scenarios can be modeled as a series of acute and/or intermediate exposures. Furthermore, the chronic effects seen in toxicity studies were on the liver, which has a tremendous capacity for regeneration, whereas the acute and intermediate inhalation and dermal effects were on fetal development; these effects are serious and irreversible. EPA therefore concluded that it is sufficient to use the acute and intermediate PODs for estimating MOEs for these exposure scenarios.

Table 4-32. Consumer Dermal Exposure Risk Estimates Using the Default Method

Age Group	Exposure Level	Non-Cancer Acute Exposure Risk (Benchmark MOE = 100) [a]	Non-Cancer Intermediate Exposure Risk (Benchmark MOE = 100) [a]	Chronic Cancer Risk (Cancer Benchmark = 1E−06) [a]
Youth (16–20 years)	Low-Intensity	1.2E06	3.9E07	4.0E−08
	Medium-Intensity	2.5E05	3.7E06	9.8E−07
	High-Intensity	7.2E04	5.0E05	**1.2E−05**
Adults (21+ years)	Low-Intensity	1.1E06	3.3E07	4.6E−08
	Medium-Intensity	2.2E05	3.1E06	**1.1E−06**
	High-Intensity	6.2E04	4.4E05	**1.4E−05**
Weighted Average [b]	Low-Intensity	N/A	3.3E07	4.7E−08
	Medium-Intensity	N/A	3.1E06	**1.1E−06**
	High-Intensity	N/A	4.4E05	**1.4E−05**

MOE = margin of exposure
Bolded/shaded cells indicate risks greater than the benchmark.
[a] See Section 4.2.7 and Table 4-24 for details
[b] The weighted average for intermediate and chronic cancer risk was estimated by incorporating a youth exposure duration of 5 years into the overall adult dermal risk estimation calculated from dermal exposure estimate.

Risk Characterization of Consumer Use – Refueling Related Products COU

There is uncertainty about several assumptions EPA used to model dermal exposure estimates for this consumer exposure scenario. This scenario represents a consumer who is exposed to ethylene dibromide liquid once and will continuously be exposed to any remaining ethylene dibromide liquid on the skin after that one exposure event. The hazard values for this consumer exposure scenario were derived by PBPK modeling, which are specific to this avgas refueling scenario and aligned with exposure assumptions and parameters. PBPK model explicitly accounts for dynamic changes in bioavailability for all the routes used in the route-extrapolation assessment including oral, inhalation and dermal, which means that fractional absorption varies over time and with dose. PBPK-estimated dermal HEDs (expressed in mass-based units to compared to the retained doses) reflect chemical-specific absorption (dynamic bioavailability) and systemic exposure (accounting for systemic ADME) under specific dermal exposure conditions. Because PBPK model could not predict a HED for this COU for reasons described in Section 4.2.5, the dermal risk is absent from this COU. In other words, the internal does for any scenario assessed for this COU did not result in adverse effects and therefore dermal risk is not expected. Accordingly, it is recommended that the PBPK approach is used for risk determination for the COUs covered under the fuels and related products use scenario (*i.e.,* Industrial use – Fuel agents in petroleum refineries; and Commercial use – Fuels and related products). To provide transparency, EPA also presents consumer dermal exposure risk estimates using the default method in Table 4-32.

Key assumptions such as exposed skin surface area, exposure frequency, and use duration are uncertain due to absence of consumer monitoring data. EPA selected input parameters using professional judgment and review of reasonably available information. The high-intensity exposure scenario, anchored to activity levels typical of pilots pursuing a commercial license, and the low-intensity exposure scenario, reflecting minimum activity to maintain currency, may not represent majority of consumers. Therefore, EPA places primary weight on medium-intensity exposure estimates for acute, intermediate, and chronic non-cancer risk characterization and cancer risk characterization while using low and high-intensity exposure estimates to inform unreasonable risk for smaller number of consumers.

4.3.4.3 Summary of Consumer Risk Estimates

4.3.4.3.1 Consumer Use – Fuels and Related Products COU

Based on CDR submissions, the only consumer COU identified is aviation avgas under "fuels and related products," with details provided in Section 4.1.2. EPA also identified a 2025 SDS indicating ongoing use of ethylene dibromide in certain racing fuels (VP Racing Fuels, 2025), which are reported to CDR as commercial uses. Because some racing fuels may be available to and used by private racers, this suggests a potential consumer COU. Although the final scope identified use of ethylene dibromide in racing fuel (U.S. EPA, 2020b), reasonably available information indicates that this use has largely been phased out, as Indy cars burn methanol, top fuel dragsters and funny cars burn nitromethane, and NASCAR switched to unleaded gasoline in 2008.

However, EPA lacks reasonably available information on the prevalence of consumer use, product formulations, and handling practices for these fuels. While EPA acknowledges that some racing fuels may be available in the U.S. market, the Agency cannot quantify consumer exposure or characterize risk for this potential use at this time and is seeking additional information on the presence of ethylene dibromide in racing fuels in U.S. commerce, their availability to consumers, and consumer use patterns (*e.g.,* number or types of vehicles using racing fuel containing ethylene dibromide, volume of use, frequency of refueling).

EPA presented the estimated inhalation and dermal MOEs and cancer risk used to characterize non-cancer risk for acute and intermediate exposure and cancer risk in Table 4-31 and Table 4-32. Inhalation is the primary route of exposure and driver of cancer risk for this consumer COU.

4.3.5 Risk Estimates for General Population

As detailed in Section 4.1.3, EPA conducted a quantitative exposure assessment for the air and water pathways to evaluate non-cancer and cancer risks for the general population. The following sections summarize the risk estimates and conclusions for inhalation, dermal, and oral exposures for all general population exposure scenarios. For the general population assessment, EPA considered 11 COUs. Ten COUs were from reported releases, and the last COU considered was Distribution in Commerce.

4.3.5.1 Inhalation Assessment Approach

EPA estimated risks of general population exposures to ethylene dibromide released to air, with a focus on exposures to general populations residing near ethylene dibromide emitting facilities. Risks were evaluated for air releases from industrial and commercial COUs based on exposure from reported and estimated ambient air releases (Section 3) and human health hazard values (see selected PODs in Section 4.2.7) for chronic inhalation exposures (Section 4.1.3.2). EPA estimated risks using modeling results from two programs: IIOAC as a screening assessment and HEM.

EPA estimated cancer and non-cancer inhalation risks for discrete polar-grid receptors at distances up to 10,000 m using IIOAC as a standalone program and for centroids of census block up to 50,000 m using HEM. Where available, EPA used facility releases reported to TRI and NEI and the associated site-specific data.

Risk values based on IIOAC-only results were calculated for the 10th, 50th, and 95th percentile exposures for each modeled facility at each modeled distance (Section 4.1.3.2). IIOAC as a standalone program was run for TRI reported releases (2019–2023) and NEI reported releases (2017 and 2020). To simplify presentation of results, EPA focused on modeled air concentrations at distances of 100, 100 to 1,000, and 1,000 m in this document. The distances of 100, 100 to 1,000, and 1,000 m are consistent with the community populations living near facilities as described in the fenceline methodology (U.S. EPA, 2022b).

The risk values calculated using IIOAC were used as a screening assessment to determine if running HEM was necessary. From the IIOAC analysis, EPA determined that there was a possibility of cancer risk above the screening benchmark of one-in-a-million. Therefore, EPA ran HEM to refine the results found in IIOAC and characterize populations living near releasing facilities. HEM combines U.S. Census data with estimated ambient air concentrations to calculate maximum individual risks (MIR) and the number of people within each census block with a cancer risk greater than the screening cutoff of 1.0×10^{-6}. 1.0×10^{-6} was used as a screening and presentation cutoff because it is the lower limit of the general population cancer risk benchmark, which is a range from 1.0×10^{-6} to 1.0×10^{-4}. This general population risk benchmark is further described in Section 4.2.7. HEM was run using TRI data for releases reported for reporting years 2019–2023 and for NEI reporting years 2017 and 2020.

EPA applied a tiered approach to assessing general population exposures to ethylene dibromide via the ambient air pathway. For the first-tier analysis, EPA used the IIOAC model to estimate daily-averaged and annual-averaged ethylene dibromide ambient air concentrations at three predefined distances (100, 100–1,000, and 1,000 m) from facilities reporting ethylene dibromide air releases to TRI for one or more of the reporting years evaluated (2019–2023). IIOAC results were used to evaluate potential exposures for the general population living near industrial facilities reporting releases of ethylene dibromide to the

ambient air. For this assessment, IIOAC was used for a screening analysis to inform whether higher-tier analysis and/or refined modeling is warranted to further characterize exposures of the general population to ethylene dibromide.

For this general population exposure assessment, modeled air concentrations from the IIOAC screening assessment are based on the following:

1. The annual release values reported by individual facilities (assigned to OESs and mapped to respective COUs for the TRI 2019–2023 datasets), assuming the total annual reported releases are continuous and equally distributed across all days of operation.
2. The highest reported annual releases from the NEI and TRI datasets for fugitive and stack emissions.
3. An operating scenario representing industrial facilities releasing ethylene dibromide to the ambient air operating 24 hours/day, 7 days/week, 365 days/year. This is a conservative assumption for this screening-level estimate, in which facilities are constantly releasing ethylene dibromide every day and every hour throughout the year.
4. Application of the meteorology patterns from the Lake Charles, Louisiana (south coastal), meteorological station to every facility (regardless of the facility's geographic location), and assumption of a "rural" land designation for every facility. These assumptions result in conservative air concentration results appropriate for a screening-level model. This designation of meteorology and land designation is recommended in the IIOAC user guide (EPA, 2019; U.S. EPA, 2019c) for use when conservative estimates are desired.

95th percentile results for ambient modeled concentrations across TRI facilities, reporting years and modeled distances (100, 100–1000 and 1,000 m) ranged from 0 to 8.2×10^{-2} µg/m^3 with the highest modeled concentrations at 100 m.

EPA used the IIOAC screening-level results to derive screening-level chronic non-cancer and cancer risk estimates. Although these screening level risk estimates are not used to inform regulatory decision-making in this assessment, the screening-level risk estimates are used to inform whether a higher-tier/more refined exposure analysis is warranted to confirm any screening-level exposure and associated risk concerns identified. Hazard values used to calculate screening-level risk estimates are described in the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t). Considering the hazard value for chronic inhalation exposure (11 mg/m^3 = 11,000 µg/m^3), and the highest calculated concentration from the IIOAC results (7.0×10^{-2} µg/m^3), the calculated MOE was 160,000. This is several magnitudes above the benchmark MOE of 30; therefore, EPA did not continue with additional refinements for this screening-level analysis of assessing potential non-cancer chronic risk via inhalation. All non-cancer screening-level risk estimates were also above the chronic non-cancer benchmark, so there is no expectation of non-cancer risks to the general population from TRI or NEI facility releases based on this screening level assessment (U.S. EPA, 2026t).

Although the tiered analysis with IIOAC 95th percentile modeled concentrations resulted in no expectation for non-cancer risks, estimated cancer risks based on IIOAC 95th percentile and mean modeled concentrations were at or above the 1 in a million (1×10^{-6}) benchmark. The IUR from Section 4.2.7 is 8.9×10^{-5} (µg/m^3)$^{-1}$. When multiplying this by the highest calculated air concentration from IIOAC (7.0×10^{-2} µg/m^3), there is a cancer risk of 6.26×10^{-6}. This cancer risk is above the screening threshold of 1.0×10^{-6}, therefore EPA continued the cancer analysis in HEM. HEM provides a more geographically refined analysis of ambient air concentrations using localized meteorological data and site-specific days of operation. Using modeled concentrations from HEM, EPA calculated the lifetime cancer risks.

In addition to modeling, EPA examined AMTIC monitoring data for ethylene dibromide available from 2017 through 2022. The concentrations extracted from AMTIC ranged from 0.0 to 68.1 $\mu g/m^3$ across all 24-hour sampling results. Excluding only data points that were listed as blank readings across that timeframe, the arithmetic means between 2017 and 2022 range from 0.011 to 0.046 $\mu g/m^3$ with the 95th percentile values ranging from 7.7×10^{-3} to 7.7×10^{-2} $\mu g/m^3$. The highest ambient air modeled calculation from IIOAC was 7.0×10^{-2} $\mu g/m^3$, which is in the same level of magnitude of the monitored concentrations from AMTIC. Because the calculated concentrations from IIOAC were higher and based solely on the COUs, the modeled releases were used for the screening assessment.

4.3.5.1.1 Cancer Inhalation Risks

Estimated Cancer Risks via Ambient Air and Population Analysis using HEM

The HEM modeling predicted that 20,707 people across all OESs that are represented in TRI and NEI would have an inhalation cancer risk greater than 1 in 1,000,000 across all reporting years included (Table 4-33). HEM was run using TRI (2019–2023) and NEI (2017 and 2020) data. Detailed descriptions of both modeling efforts are provided the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). The Incorporation into Formulation, Mixture, or Reaction Product and the Fuels and Related Products OESs were the largest contributors to risk with 12 facilities resulting in people in the surrounding communities having an inhalation cancer risk greater than 1 in 1,000,000. In addition, one facility from Waste Handling, Treatment, and Disposal OES resulted in cancer risk greater than 1 in 1,000,000.

As discussed in Section 4.1.3.2, facility 14217811 has the largest population with increased cancer risk, with 17,552 people with cancer risk above 1.0×10^{-6}. This facility reported releases to NEI in 2017, however, it did not report releases in 2020. EPA reviewed preliminary unpublished data from 2023 NEI releases and confirmed this facility continues to release ethylene dibromide at levels similar to 2017, therefore the risk resulting from this release is also expected to be ongoing.

EPA also calculated excess cancer cases per year and lifetime based on the HEM5.0 results by multiplying population numbers by the estimated cancer risks at specific census blocks, as seen in Table 4-33. For yearly additional cancer cases, this value was divided by 70 years. This value is also referred to as "cancer incidence" in Section 6.1.5. Based on TRI and NEI reported releases, Table 4-33 shows an estimated 20,707 people across all years analyzed would have an estimated cancer risk between 1.0×10^{-6} to 1.0×10^{-4}, which would result in 2.2×10^{-1} additional lifetime cancer cases across all OESs and facilities. When only considering the most recent year of reporting for each facility, 19,288 people had cancer risk above one-in-a-million. There were 231 people with risk above 1.0×10^{-5}, with the maximum cancer risk of 1.76×10^{-5}. For the census block with the highest cancer risk estimate (1.76×10^{-5}), there would be a 2.37×10^{-2} additional lifetime cancer cases or 3.38×10^{-4} additional yearly cancer cases.

Additional cancer cases per year consider both population and risk and are used to determine if there is an unreasonable risk to the general population within this risk evaluation. However, there are some uncertainties associated with utilizing additional cancer cases per year to determine population risk due to a chemical. In using this metric to make these determinations, fenceline communities, rural communities, and other PESS groups may not adequately be considered because of the small nature of census blocks and consideration of population to determine unreasonable risk. This shortcoming of the additional cancer cases per year metric is not protective of rural communities, who could be exposed to several chemicals that may present cancer risk above 1.0×10^{-6}, then under TSCA would never have enough excess cancer cases that would cause an unreasonable risk determination for any individual chemical.

4727 **Table 4-33. HEM-Modeled Maximum Ethylene Dibromide Concentration and Resulting Cancer Risk by Facility**

COU	OES	Facility ID	State	Year	Maximum Concentration Modeled in HEM (µg/m³)	Maximum Cancer Risk [a]	Number People Exposed to ≥1 in 100,000 Cancer Risk	Number People Exposed to ≥1 in 1,000,000 Cancer Risk	Additional Cancer Cases per Year [b]	Additional Lifetime Cancer Cases [b]
Processing – Incorporation into formulation, mixture, or reaction product; Processing – As a reactant; and/or Industrial use – Other use	Incorporation into Formulation, Mixture, or Reaction Product	70805XX-NBT4050S	LA	2019	4.2	1.6E−05	2	306	4.7E−05	3.3E−03
				2020	4.0E−02	1.6E−06	0	2		
				2021	0.27	2.9E−06	0	2		
				2022	0.27	3.0E−06	0	2		
				2023	0.27	3.0E−06	0	2		
		4208011	WI	2017	2.1	8.9E−06	0	640		
				2020	3	1.8E−05	96	1,406	3.4E−04	2.4E−02
		7154411	MS	2017	0	N/A	N/A	N/A		
				2020	1.8	2.6E−06	0	25	3.6E−06	2.5E−04
		993411	AR	2017	4.1	1.2E−05	7	134	2.9E−05	2.0E−03
				2020	0	N/A	N/A	N/A		
		6678711	WI	2017	0.14	1.8E−06	0	108	1.5E−05	1.1E−03
				2020	Not reported	N/A	N/A	N/A		
		8467211	LA	2017	0.16	1.2E−06	0	11	1.6E−06	1.1E−04
				2020	0.42	4.7E−07	0	Max cancer risk <1E−06		
		7549811	NJ	2017	Not reported	N/A	N/A	N/A		
				2020	1.0E−02	1.0E−06	0	29	4.1E−06	2.9E−04
Industrial use – Fuel agent in petroleum refineries and/or Commercial use – Fuels and related products	Fuels and Related Products	4193911	WI	2017	0.3	3.0E−06	0	449	6.4E−05	4.5E−03
				2020	7.0E−02	7.5E−07	0	Max cancer risk <1E−06		
		5681411	CA	2017	0.66	8.8E−07	0	Max cancer risk <1E−06		
				2020	0.3	4.3E−06	0	4	5.1E−07	4.0E−05
		14217811	CA	2017	16.13	9.7E−06	126	1.7E04	2.7E−03	1.9E−01
				2020	Not reported	N/A	N/A	N/A		

COU	OES	Facility ID	State	Year	Maximum Concentration Modeled in HEM (µg/m³)	Maximum Cancer Risk [a]	Number People Exposed to ≥1 in 100,000 Cancer Risk	Number People Exposed to ≥1 in 1,000,000 Cancer Risk	Additional Cancer Cases per Year [b]	Additional Lifetime Cancer Cases [b]
		6074911	MI	2017	0.02	1.7E−06	0	3		
				2020	0.02	1.5E−06	0	3	4.3E−07	3.0E−05
		17215811	CA	2017	Not reported	N/A	N/A	N/A		
				2020	0.13	1.8E−06	0	21	3.0E−06	2.1E−04
Disposal	Waste Handling, Treatment, and Disposal	1396411	CA	2017	0.88	1.0E−06	0	4		
				2020	0.88	1.0E−06	0	4	5.7E−07	4.0E−05

N/A = Value is not reported in release data or value is reported as "0"; COU = condition of use; HEM = Human Exposure Model; OES = occupational exposure scenario
[a] HEM5.0 calculates a maximum individual risk, which is equivalent to the highest cancer risk for any populated receptor modeled. When calculating cancer risk, HEM assumes that an individual breathes the ambient air at a given receptor site 24 hours per day over a 70-year lifetime.
[b] Additional cancer cases per year and additional lifetime cancer cases were only calculated once per facility, based on the releases from the reporting year that would have the highest risk estimated in HEM. Cells are shaded in gray indicating reporting years where additional cancer cases were not calculated.

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4.3.5.1.2 Chronic Non-Cancer Inhalation Risks by Discrete Distance Modeled by IIOAC

EPA used IIOAC, which incorporates AERMOD, to conduct a screening analysis to see if one or more facilities or COUs may raise exposure and associated risk concerns to determine if a more refined analysis would be needed. The details of these calculations and assumptions can be found in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

95th percentile results for ambient modeled concentrations across TRI facilities, reporting years and modeled distances (100, 100–1000, and 1000 m) ranged from 0 to 8.18×10^{-2} µg/m^3 with the highest modeled concentrations at 100 m. The maximum concentration, when compared to the POD, yields a MOE of 146,699. The benchmark MOE for chronic inhalation is 30 (U.S. EPA, 2026t). EPA concluded that if the highest concentration yielded an MOE that was four levels of magnitude above the benchmark MOE, no further analysis for the chronic inhalation was necessary.

All non-cancer screening-level risk estimates for all COUs were above the chronic non-cancer benchmark; therefore, there is no expectation of non-cancer risks to the general population from TRI or NEI facility releases based on this screening level assessment (U.S. EPA, 2026t).

4.3.5.2 General Population Risk Estimates from Oral Exposures

EPA estimated exposures to ethylene dibromide via the oral route from several sources: from drinking water exposures, fish ingestion exposures and incidental ingestion from swimming in receiving water bodies. Ingestion of ethylene dibromide via surface water is based on reported releases from facilities as found in the TRI and DMR datasets. Summaries of these exposures and assumptions for the screening assessment are found in Section 4.1.3. EPA summarized the highest exposures per OES to quantify the highest risks associated with these exposures. The full exposure and risks are presented in the supplemental files and *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d, r, 2026af).

EPA evaluated oral exposures to ethylene dibromide via drinking water ingestion. EPA then estimated TSCA facility surface water concentrations at the facility's point of release and did not assume drinking water treatment removal as a screening analysis, this resulted in an overestimation of drinking water and incidental ingestion exposures. For the drinking water analysis, the Agency did not consider releases from facilities into coastal waters, because there would not be a drinking water intake downstream from the facility. The highest chronic drinking water exposures were exposures to adults (3.6×10^{-5} mg/kg/day) from the Import and Repackaging OES releases. This was a modeled release, using the high-end estimates from the 30Q5 low flow concentrations. The highest chronic risk for this OES was for youth ages 16 through 20 from this exposure is 7,501, which is above the benchmark MOE of 30.

To assess cancer risk for exposures to ethylene dibromide via drinking water, EPA utilized the lifetime average daily dose (LADD) calculated from TSCA releases form consumption of drinking water at the point of release in surface water. The highest LADD from all OESs was for the Import and Repackaging OES with a value of 1.02×10^{-7} mg/kg/day. When multiplied by the OSF of 0.24, the cancer risk of 2.44×10^{-8}, which is below the one-in-a-million cancer threshold. Because, even with these overly conservative screening assumptions, no drinking water risk above the threshold was identified, EPA did not conduct further analysis for the drinking water pathway.

The highest modeled concentration from TSCA releases from surface water was also greater than finished drinking water and untreated ground water concentration monitoring data from EPA's 6YR 4. Therefore, no risk would be found from monitoring concentrations for drinking water.

EPA assessed the highest exposure for fish ingestion and drinking water ingestion. The OES with the highest fish ingestion acute exposures for the general population was Incorporation into Formulation, Mixture, or Reaction Product OES for toddlers (1 to <2 years) at 1.02×10^{-4} mg/kg/day (See Table 4-22). The corresponding acute risk for toddlers was 2.64×10^{4}, which is well above the acute benchmark MOE of 30. For chronic exposures via fish ingestion associated with Incorporation into Formulation, Mixture, or Reaction Product OES releases were for toddlers (2 to <3 years) at 1.07×10^{-5} mg/kg/day. The corresponding chronic risk was an MOE of 3.09×10^{5}, which is above the chronic benchmark MOE of 30.

EPA also evaluated fish ingestion exposures for tribal populations as tribal populations have ten times higher fish ingestion rates (2.7 g/kg/day) than the general population (0.277 g/kg/day). The releases of ethylene dibromide were low and the concentration of ethylene dibromide estimated at the point of release was also relatively low (26 µg/L). The highest exposures were acute tribal fish ingestion exposures and were estimated as 6.70×10^{-4} mg/kg/day. The associated MOE with the acute fish ingestion exposure was 4,027, well above the acute benchmark MOE of 30. EPA did not evaluate further risks from other oral exposures from fish ingestion associated with other OESs because they also would be above benchmarks. Even with overly conservative assumptions for the surface water pathway, as discussed in Section 4.1.3.5, no preliminary risk was identified, therefore further refinements to the fish ingestion assessment were not needed.

Likewise, for incidental ingestion, EPA considered the highest exposure for screening for risk across all of the COUs and OES releasing to surface water. The highest exposures were from releases associated with the Incorporation into Formulation, Mixture or Reaction Product OES for youth (ages 11–15 years) with acute exposures of 7.7×10^{-5} mg/kg/day (see Table 4-21). The corresponding MOE was 1.9×10^{4}, which is above the acute oral benchmark of 30. EPA did not evaluate further risks from other oral exposures from incidental ingestion associated with other OESs as they also would be above benchmarks. Even with overly conservative assumptions for the surface water pathway, as discussed in Section 4.1.3.5, no preliminary risk was identified, therefore further refinements to the incidental ingestion via swimming assessment were not needed.

Cancer risk estimates from the various COUs for drinking water ranged from 5.31×10^{-14} to 2.44×10^{-8} and are presented in Table 4-34. Given the issues with the oral cancer bioassay study in rats and mice (NCI, 1978), EPA also performed a bounding exercise where the incidence of primary tumors in the high dose group was set to a worst-case scenario of 100%. This increased the OSF by less than a factor of three. Based on the cancer risk estimates for oral exposures, the slope factor would have to increase by more than an order of magnitude to cross even the lower-end of the cancer risk range (1×10^{-6}). Specifically, it would have to increase by a factor of 41, not 3. To put this in context, given the CSF of 0.15 per mg/kg/day, a 41-fold increase would make it more potent than 84% of all chemicals with oral slope factors in the EPA IRIS database, which is also highly unlikely. Given this analysis, EPA has high confidence that the oral cancer risks from ethylene dibromide are much lower than even the lower-end of the risk range—despite the remaining uncertainty around the exact value of the oral slope factor. Drinking water non-cancer chronic oral MOEs ranged from 8.86×10^{8} to 3.58×10^{4} amongst the COUs. Maximum incidental oral acute MOEs for the swimming scenario ranged from 2.8×10^{9} to 1.94×10^{4} for all COUs. The highest estimated fish ingestion chronic MOE was 4.92×10^{3}. See Table 4-35 for all

maximum risk estimates per COU for the general population. All COUs from the oral pathway were below MOEs and cancer risk estimates were below one-in-a-million.

Table 4-34. Drinking Water Risk from Ethylene Dibromide Ingestion

OES	Primary NPDES Permit Number	Infant (Birth to <1 year)		Adult (21+ years)		Adult Cancer Risk[c]
		Acute MOE	Chronic MOE	Acute MOE	Chronic MOE	
Waste Handling, Treatment, and Disposal	CA0029947	3.2E04	5.2E05	1.1E05	1.3E06	1.2E−09
Waste Handling, Treatment, and Disposal	KS0098809	1.5E05	7.6E05	5.1E05	1.9E06	8.2E−10
Waste Handling, Treatment, and Disposal	CAZ197711	8.7E04	1.4E06	3.1E05	3.6E06	4.5E−10
Fuels and Related Products	IDG911008	1.8E09	1.2E10	4.4E09	3.0E10	5.3E−14
Waste Handling, Treatment, and Disposal [a]	AZMS66176	5.2E06	6.3E07	1.8E07	1.6E08	9.9E−12
Waste Handling, Treatment, and Disposal [a]	AZ0024911	6.0E04	5.3E05	2.1E05	1.4E06	1.2E−09
Laboratory Use [a]	N/A	1.1E08	8.9E08	3.7E08	2.3E09	7.0E−13
NIACS Code 324110 - Petroleum Refineries (Central Tendency) [b]	N/A – Modeled Releases	8.8E07	5.4E08	3.1E08	1.4E09	1.2E−12
NIACS Code 324110 - Petroleum Refineries (High-end) [b]	N/A – Modeled Releases	5.2E07	3.2E08	1.8E08	8.1E08	2.0E−12
NAICS Code 21112 - Crude Petroleum Extraction (Central Tendency) [b]	N/A – Modeled Releases	6.1E05	3.7E06	2.1E06	9.4E06	1.7E−10
NAICS Code 21112 - Crude Petroleum Extraction (High-end) [b]	N/A – Modeled Releases	3.6E05	2.2E06	1.2E06	5.5E06	2.9E−10
NAICS Code 424710 - Repackaging Facilities (Petroleum Bulk Stations and Terminals) (High-End) [b]	N/A – Modeled Releases	4.0E03	3.6E04	1.4E04	9.1E04	2.4E−08
NAICS Code 424710 - Repackaging Facilities (Petroleum Bulk Stations and Terminals) (Central Tendency) [b]	N/A – Modeled Releases	4.2E03	3.7E04	1.5E04	9.5E04	2.4E−08

HEM = Human Exposure Model; MOE = margin of exposure; NAICS = North American Industry Classification System; NPDES = National Pollutant Discharge Elimination System; OES = occupational exposure scenario

[a] Flow lookup failed and flows estimated from nearest water body.

OES	Primary NPDES Permit Number	Infant (Birth to <1 year)		Adult (21+ years)		Adult Cancer Risk[c]
		Acute MOE	Chronic MOE	Acute MOE	Chronic MOE	

[b] Modeled release. Utilized flows derived from distribution of facilities within presented NAICS codes
[c] HEM5.0 calculates a maximum individual risk, which is equivalent to the highest cancer risk for any populated receptor modeled. When calculating cancer risk, HEM assumes that an individual breathes the ambient air at a given receptor site 24 hours per day over a 70-year lifetime.

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4.3.5.3 General Population Risk Estimates from Dermal Exposures

EPA conducted a screening approach to evaluate dermal exposures to the general population from swimming in surface waters where ethylene dibromide is discharged from TSCA releases. Because the Agency is conducting a screening approach, EPA did not evaluate modeled surface water conditions with PBPK generated dermal hazard PODs. Instead, EPA used the 2.2 mg/kg/day dermal hazard value with a benchmark MOE of 30 based on inhalation-to-dermal extrapolation because this is only a screening approach and this yields a higher risk value.

EPA assessed possible risk from dermal exposures via swimming in surface waters receiving facility discharges from COUs and OESs. Across all OESs, the highest dermal exposure is from Incorporation into Formulation, Mixture or Reaction Product OES for youth (ages 11–15 years). The youth acute dermal exposures for this OES are 5.3×10^{-5} mg/kg/day. The corresponding associated acute MOE is 6.2×10^{4}, which is above the respective benchmark MOE of 100. Because dermal exposures were lower for the other remaining OESs, EPA did not quantitatively assess risk with PBPK modeling for other OESs as they would be lower than those for Incorporation into Formulation, Mixture or Reaction Product OES and would not be below the benchmark MOEs. Even with overly conservative assumptions for the surface water pathway, as discussed in Section 4.1.3.5, no risk was identified above the threshold, therefore further refinements to the dermal exposure assessment were not needed.

4.3.5.4 Summary of Risk Estimates for General Population

Table 4-35 below presents a summary of the risk estimates for the exposure scenarios associated with facility releases: ambient air inhalation, drinking water ingestion (surface water), incidental ingestion from swimming, dermal exposure from swimming, and fish ingestion.

Ambient air inhalation risk values in Table 4-35 are presented. The Incorporation into Formulation, Mixture or Reaction Product OES resulted in the highest concentration using IIOAC, however this concentration did not result in chronic risk, therefore EPA was able to screen out chronic inhalation risk for ethylene dibromide. Cancer risk for the Incorporation into Formulation, Mixture or Reaction Product, Fuels and Related Products, and Waste Handling, Treatment, and Disposal OESs are estimated to be greater than 1.0×10^{-6} for communities surrounding the emitting facilities (Table 4-33 and Table 4-35). For the general population risk assessment 1.0×10^{-6} was used as a screening benchmark for cancer risk assessment and was used to determine which facility results were presented from all modeled facility concentrations. However, unreasonable risk determination will use a range of 1.0×10^{-6} to 1.0×10^{-4} for determining if there is an unreasonable risk to the general population from ethylene dibromide exposure.

No general population risks above the benchmarks were identified from the surface water pathway, including from drinking water, incidental ingestion from swimming, dermal exposure from swimming, and fish ingestion.

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COU	OES	Exposure Route and Duration	Exposure Level	Risk Estimates for Each Exposure Scenario		
				Acute Non-Cancer (Benchmark MOE: Oral = 30; Dermal = 300)	Chronic Non-Cancer (Benchmark MOE: Oral = 30, Inhalation = 30)	Cancer (Benchmark = 1.0E−06 to 1.0E−04)
Manufacture − Import and/or Processing − Repackaging	Import and Repackaging	Ambient Air Inhalation	High-End	Acute exposure is not relevant in this scenario	>1.5E06 [a]	6.0E−09
		Drinking Water Ingestion	Central Tendency	4.2E03	3.7E04	2.4E−08
			High-End	4.0E03	3.6E04	2.4E−08
		Incidental Ingestion from Swimming	High-End	1.1E05	Chronic exposure is not relevant in this scenario	
		Incidental Dermal from Swimming	High-End	3.4E05	Chronic exposure is not relevant in this scenario	
		Fish Ingestion	High-End (tribal)	>4.0E03 [b]	>4.9E03 [b]	Not assessed in screening assessment
Processing – Incorporation into formulation, mixture, or reaction product; Processing − As a reactant; and/or Industrial use − Other use	Incorporation into Formulation, Mixture, or Reaction Product	Ambient Air Inhalation	High-End	Acute exposure is not relevant in this scenario	1.5E06	1.6E−05
		Drinking Water Ingestion	The only facility under this OES was a coastal release and is not relevant for drinking water exposures			
		Incidental Ingestion from Swimming	High-End	1.9E04	Chronic exposure is not relevant in this scenario	
		Incidental Dermal from Swimming	High-End	6.2E04	Chronic exposure is not relevant in this scenario	
		Fish Ingestion	High-End (tribal)	4.0E03	4.9E03	Not assessed in screening assessment
Industrial use − Fuel agent in petroleum refineries and/or Commercial use − Fuels and related products	Fuels and Related Products	Ambient Air Inhalation	High-End	Acute exposure is not relevant in this scenario	>1.5E06 [a]	9.7E−06
		Drinking Water Ingestion	Central Tendency	6.1E05	3.7E06	1.7E−10
			High-End	3.6E05	2.2E06	2.9E−10
		Incidental Ingestion from Swimming	High-End	9.4E06	Chronic exposure is not relevant in this scenario	
		Incidental Dermal from Swimming	High-End	3.0E07	Chronic exposure is not relevant in this scenario	
		Fish Ingestion	High-End (tribal)	>4.0E03 [b]	>4.9E03 [b]	Not assessed in screening assessment

COU	OES	Exposure Route and Duration	Exposure Level	Risk Estimates for Each Exposure Scenario		
				Acute Non-Cancer (Benchmark MOE: Oral = 30; Dermal = 300)	Chronic Non-Cancer (Benchmark MOE: Oral = 30, Inhalation = 30)	Cancer (Benchmark = 1.0E−06 to 1.0E−04)
Commercial use − Other uses − Laboratory chemical	Laboratory Use	Ambient Air Inhalation	High-End	Acute exposure is not relevant in this scenario	>1.5E06 [a]	5.9E−08
		Drinking Water Ingestion	High-End	1.1E08	8.9E08	7.0E−13
		Incidental Ingestion from Swimming	High-End	2.8E09	Chronic exposure is not relevant in this scenario	
		Incidental Dermal from Swimming	High-End	8.8E09	Chronic exposure is not relevant in this scenario	
		Fish Ingestion	High-End (tribal)	>4.3E03 [b]	>4.9E03 [b]	Not assessed in screening assessment
Disposal	Waste Handling, Treatment, and Disposal	Ambient Air Inhalation	High-End	Acute exposure is not relevant in this scenario	>1.5E06 [a]	1.2E−06
		Drinking Water Ingestion	High-End	3.2E04	5.2E05	1.2E−09
		Incidental Ingestion from Swimming	High-End	8.4E05	Chronic exposure is not relevant in this scenario	
		Incidental Dermal from Swimming	High-End	2.7E06	Chronic exposure is not relevant in this scenario	
		Fish Ingestion	High-End (tribal)	>4.0E03 [b]	>4.9E03 [b]	Not assessed in screening assessment

COU = condition of use; IIOAC = Integrated Indoor-Outdoor Air Calculator; MOE = margin of exposure; OES = occupational exposure scenario

[a] In the ambient air screening approach, described in Section 4.1.3.2, EPA used IIOAC to refine the ambient air pathway analysis. Using IIOAC, EPA calculated high-end ambient air concentrations based on releases reported from TRI. EPA used the highest release from any year from any facility for stack and fugitive releases separately then added these values together. The calculated MOE from the resulting air concentrations for chronic inhalation exposure was several levels of magnitude above the benchmark MOE, therefore EPA did not continue analysis for the chronic inhalation pathway.

[b] In the fish ingestion scenario, EPA evaluated the OES with the highest estimated surface water concentration of ethylene dibromide for tribal populations. The MOE was above the benchmark in the tribal consumption scenario, which has the highest consumption rate. The MOE for the highest water concentration for the highest consumption rate was above the benchmark MOE of 30, therefore EPA did not conduct further analysis refinements, as described in Section 4.3.5.2.

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4.3.5.4.1 Characterization and Summary of Risk via Inhalation of Ambient Air for General Population

For the ambient air pathway, Table 4-33 and Table 4-35 compiles data from Section 4.1.3.2. This section provides an overview of the factors used to estimate the cancer and non-cancer risks to the general population, with each major factor being described in its own subsection.

Releases

EPA modeled ambient air concentrations using the release data from the TRI and NEI datasets as described in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d) and summarized below.

EPA considered TRI release data from the years 2019 to 2023 for this analysis. For each facility, the Agency used the highest total emissions across the years of 2019 to 2023 as inputs to HEM5.0. TRI releases to air were categorized into five OESs. Concentrations were modeled for both fugitive and stack emissions. TRI data are reported on a total facility basis. That is, for each facility reports one emission rate is reported even if there are multiple emissions locations (stack or fugitive) at the facility. For facilities reporting both stack and fugitive emissions, modeled concentrations from both types of emissions were added together to determine a total concentration of ethylene dibromide in the ambient air at the distances evaluated specific to TSCA OESs. TRI reporters may report either with a Form R or a Form A. To use Form A, reporters must release less than 500 lb/year, and facilities do not need to report release quantities or uses/sub-uses on Form A. Due to uncertainties in the actual amount released by Form A reporting facilities, EPA included only TRI reporting Form R submissions in this analysis.

For NEI data, EPA used data reported 2017 and 2020 in this analysis. For this evaluation, the Agency modeled, in HEM5.0, all TRI and the top 15% of NEI facilities by risk based on a previous HEM run with a preliminary IUR. NEI release data are process level data and therefore there can be multiple capture releases from one facility. This is in contrast to TRI release data, which aggregates all releases at a facility to a single release location. NEI also includes source-specific parameter values used in modeling like stack parameters (*e.g.,* stack height, stack temperature, plume velocity). EPA modeled all individual releases separately. In this document, for the NEI analysis, EPA relied on concentrations resulting from individual release points for this assessment and not the combined releases. NEI releases were categorized into five OESs. Concentrations and risks reported at the census block level in this risk evaluation are aggregated across release points.

Modeling Methodologies

EPA used two modeling approaches to estimate ambient air concentrations resulting from facility releases of ethylene dibromide: (1) IIOAC to model concentrations at user-defined distances (discrete and area distances) from releasing facilities with EPA-estimated releases from generic facilities/sites as a first step in the tiering approach, and (2) HEM5.0 to model concentrations at the centroid of each census blocks and polar receptors with 50,000 m of each release. HEM5.0 has two components: (1) an atmospheric dispersion model, AERMOD, with included meteorological data; and (2) U.S. Census Bureau population data at the block level. The HEM5.0 version uses 2020 Census data—including all 50 states, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands. AERMOD has been peer reviewed as part of the regulatory model process described in Appendix W to 40 CFR part 51. HEM5.0 was developed by EPA's Office of Air and Radiation (OAR) and runs AERMOD as a compiled executable program to model ambient air concentrations. Both HEM5.0 and AERMOD are used in a fit for purpose manner for this ethylene dibromide risk evaluation. Furthermore, the AERMOD has

undergone testing and validation in comparing predicted and measured air concentrations and has been externally peer reviewed (Cimorelli et al., 2018).

Release Site Physical Characteristics Input Data

For five of the OESs evaluated in this assessment, EPA had site-specific, facility-reported releases available for use as direct inputs to HEM5.0. Availability of facility-reported data allows for use of site-specific information—such as facility location, stack height, meteorological data, and land cover—as model inputs. Additionally, HEM5.0 modeling used the meteorological station closest to each facility for all facility-reported releases, which means that estimated ambient air concentrations account for local meteorological conditions such as temperature, precipitation, and wind direction.

Exposure Scenarios and Exposure Factors

For the analysis using IIOAC, EPA assumed a 78-year lifespan and constant exposure over an entire lifetime. The 78-year lifespan is the average life expectancy of the general population (U.S. EPA, 2011a). An exposure duration of 78 years was assumed to be protective of PESS groups and communities that are located near releasing facilities. Note that the assumption of 78 years of exposure does not necessarily indicate that people are stagnant; rather, it is meant to characterize anyone that resides, works, or remains within approximately the same distance from a facility for their entire lifetime. It is also consistent with previous recommendations from SACC (U.S. EPA, 2023b). The default exposure scenario in HEM5.0 assumes an exposure duration of 70 years and a lifetime of 70 years. For both the HEM5.0 and IIOAC analyses, the averaging time and exposure time are the same, which means the risks calculated using both models can be directly compared. Overall, the assumption of constant exposure over a lifetime of either 70 or 78 years is a conservative assumption that will result in high-end risk estimates.

Hazard Values Used for Risk Calculations

The POD (HED) of 2.7 mg/kg-day for acute and intermediate oral exposures is based on increased forestomach epithelial cell proliferation and hyperkeratosis in rats administered ethylene dibromide by oral gavage 5 days/week for 2 weeks Ghanayem et al. (1986). EPA applied an interspecies extrapolation factor (UF_A) of 3 and a within-human variability factor (UF_H) of 10. Thus, for the acute and intermediate oral durations, a total UF of 30 is applied for use as the benchmark MOE. The confidence in the intermediate oral POD is moderate and the confidence in the acute oral POD is slight.

The POD (HEC) of 11 mg/m^3 is based on liver necrosis in rats after whole-body exposure for 6 hours/day, 5 days/week, across 2 years NTP (1982) to estimate non-cancer risks from chronic inhalation of ethylene dibromide. EPA applied a UF_A of 3 and UF_H of 10. Thus, a total UF of 30 is applied for use as the benchmark MOE for the chronic inhalation duration. The confidence in the chronic inhalation POD is robust.

The POD (HED) of 3.3 mg/kg-day is based on liver peliosis, adrenal cortex degenerative lesions, and testicular atrophy in rats administered ethylene dibromide by oral gavage 5 days/week for 49 weeks NCI (1978) to estimate non-cancer risks from chronic oral exposure. EPA applied a UF_A of 3 and UF_H of 10. Thus, a total UF of 30 is applied for use as the benchmark MOE for the chronic oral duration. The confidence in the intermediate dermal POD is moderate and the confidence in the acute dermal POD is slight.

For dermal assessment, the default route-to-route extrapolation from inhalation to dermal is based on fetal developmental abnormalities and increased late resorptions in mice after exposure for 24 hours/day for 10 days Short et al. (1978). The Agency calculated a HED of 28 mg/kg-day and, consistent with

guidance, is applying UF_A of 3, UF_H of 10, and an UF based on effect levels, UF_L, of 3. Thus, for the acute and intermediate dermal durations, a total UF of 100 is applied for use as the benchmark MOE. The confidence in the intermediate dermal POD is moderate and the confidence in the acute dermal POD is slight.

The inhalation cancer study of ethylene dibromide by NTP (1982) is the basis for the IUR of 8.9×10^{-5} per µg/m^3 (0.68 per ppm), derived from carcinomas, adenocarcinomas, and adenomas of the nasal cavity in rats after exposure 5 days/week for 88 to 103 weeks. The confidence in the cancer inhalation POD is robust.

The oral cancer study by NCI (1978) is the basis for the OSF of 0.24 $(mg/kg\text{-}day)^{-1}$ derived from squamous cell carcinoma of the stomach in rats following oral gavage 5 days/week for 1 year. The confidence in the cancer oral POD is robust.

Comparison of Modeled and Monitored Data

EPA compared monitoring stations from the AMTIC archive to modeled data from TRI and NEI facilities. The comparison shows that annual average and 95th percentile daily modeled concentrations are within approximately an order of magnitude of the mean and 90th percentile monitored ethylene dibromide concentrations. Of the ambient air releases resulting in cancer risk above 1.0×10^{-6}, modeled concentrations ranged from 0.01 to 16.1 µg/m³. Maximum yearly detected concentrations from AMTIC ranged from 5.8 to 68.1 µg/m³ for years 2017 to 2022. The concentrations detected from AMTIC exceed those estimated via HEM modeling, however, are still within an order of magnitude. See *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d) for more details.

Population Characterization and Cancer Risk Estimates Using HEM5.0

HEM5.0 was used to characterize the general population living near facilities releasing ethylene dibromide. For risks calculated at census block centroids, which is a single discrete location, the risk is calculated using the annual average concentrations (daily averages of hourly estimated concentrations averaged across 365 days) that account for the conditions of that specific location such as prevailing winds. The census block-level analysis using HEM5.0 provides total population with cancer risk estimates above 1.0×10^{-5} and 1.0×10^{-6} (Table 4-33). The analysis identified an estimated 231 people with an estimated cancer risk greater than 1.0×10^{-5} based on TRI and NEI releases. The analysis also identified 20,707 people with an estimated cancer risk above 1.0×10^{-6} based on TRI and NEI releases. Table 4-35 shows the highest cancer risk calculated at a census block centroid for each OES and the associated population with risk above 1.0×10^{-6} based on both TRI and NEI release data. The population analysis represents a highly refined approach, but EPA acknowledges that these risks are based on census block centroids and that the population distribution within a census block is unknown; therefore, these population estimates would be overestimated if most people lived farther from the release point than the centroid. For each release point modeled, HEM5.0 calculated an annual average concentration for each modeled receptor location. For this analysis, EPA is focusing on inhalation cancer risk estimates at discrete distances of 100 and 1,000 m. HEM5.0-calculated risk estimates for TRI and NEI-releasing facilities indicated that the OESs of Incorporation into Formulation, Mixture or Reaction Product, Fuels and Related Products, and Waste Handling, Treatment, and Disposal exceeded 1.0×10^{-6} when considering the maximum 95th annual average percentile concentrations.

Estimated Additional Cancer Cases Due to Ambient Air Inhalation of Ethylene Dibromide by the General Population

EPA also calculated additional cancer cases per year based on the HEM5.0 results by multiplying population numbers by either the estimated cancer risks at specific census blocks or risk thresholds (Section 4.3.5.1.1). Based on TRI and NEI reported releases, Table 4-33 shows an estimated 20,707 people would have an estimated cancer risk between 1.0×10^{-6} and 1.0×10^{-5}, which would result in 0.021 to 0.21 additional lifetime cancer cases across all OESs. Another way to characterize values is that there would be an estimated additional 3.19×10^{-3} excess cases per year when assuming a 70-year lifetime for the 20,707 people when considering releases reported to TRI and NEI. Additionally, based on TRI and NEI reported releases, there were 231 people with risk between 1.0×10^{-5} and 1.0×10^{-4}, which would result in 2.31×10^{-3} to 2.31×10^{-2} additional lifetime cancer cases. The facilities contributing the largest amount of risk to the 231 people was one facility associated with the OES of Fuels and Related Products. For the census block with the highest cancer risk estimate (1.76×10^{-5}), there would be a 2.37×10^{-2} additional lifetime cancer cases (3.38×10^{-4}) additional cases annually based on a 70-year lifetime) based on the population of 1406 people.

Acute and Chronic Non-Cancer Ambient Air Inhalation Risks

For estimated acute and chronic non-cancer risks, EPA did not identify any populated census blocks with risk estimates below the benchmark MOEs of 30.

4.3.5.4.2 Characterization and Summary of Risk via Exposure to Surface Water for General Population

Section 4.3.5.2 discusses risk from oral exposures to the surface water pathway. No MOE estimates below the chronic non-cancer benchmark and above the cancer benchmark were identified for drinking water (Table 4-34) or fish ingestion. Acute oral or dermal exposures do not result in MOE estimates below the non-cancer benchmark in the swimming scenario (Sections 4.3.5.2 and 4.3.5.4). The surface water pathway utilized several conservative assumptions such as assumptions of no volatilization from surface water, estimation of exposure at point of discharge, and no drinking water treatment. Despite the conservative assumptions, there were no MOEs that were below the benchmark MOEs for any surface water pathway assessed, increasing the confidence that there is unlikely to be risk from surface water releases. Maximum risk estimates from the surface water pathway for drinking water, incidental ingestion from swimming dermal exposure from swimming, and fish ingestion for each OES are presented in Table 4-35.

4.3.6 Risk Characterization for Potentially Exposed or Susceptible Subpopulations

EPA considered PESS throughout the exposure assessment, hazard identification and dose-response analysis. In general, the Agency evaluates several factors that may contribute to a group having increased exposure or biological susceptibility. Examples of these factors include life stage, preexisting disease, occupational and certain consumer exposures, nutrition, and lifestyle activities.

For the ethylene dibromide draft risk evaluation, EPA identified the following relevant PESS groups: males and females of reproductive age and their offspring, workers exposed to ethylene dibromide, individuals with certain genetic polymorphisms relevant to ethylene dibromide metabolism such as polymorphisms in glutathione S-transferase impacting glutathione conjugation activity and polymorphisms in aldehyde dehydrogenase-2 impacting clearance of aldehydes, and individuals with other co-exposures.

Table 4-36 summarizes how PESS were incorporated into the risk evaluation and the remaining sources of uncertainty related to consideration of PESS. Additional information on other factors that could

possibly impact greater biological susceptibility following exposure to ethylene dibromide was not reasonably available.

Considerations related to PESS can influence the selection of relevant exposure pathways, the sensitivity of derived hazard values, the inclusion of particular human populations, and the discussion of uncertainties throughout the assessment. Evaluation of the qualitative and quantitative evidence for PESS begins as part of the systematic review process, where any available relevant published studies and other data are identified. If adequate and complete, this evidence informs the derivation of exposure estimates and human health hazard endpoints/values that are protective of PESS.

EPA has identified a list of specific PESS factors that may contribute to a group having increased exposure or biological susceptibility, such as those presented in the table below. For ethylene dibromide, EPA identified how the risk evaluation addressed these factors as well as any remaining uncertainties. Details on how both chemical-specific and general information for these factors were considered are described in detail in the human health hazard assessment (Section 2.6.2 in the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t)) and throughout the human exposure assessment support documents.

Table 4-36. Summary of PESS Factors Incorporated into Risk Estimates

PESS Categories	Potential Increased Exposures Incorporated into Exposure Assessment	Potential Sources of Susceptibility Incorporated into Hazard Assessment
Life stage	Life stage-specific exposure scenarios included infants exposed to drinking water during formula bottle feeding. Children were considered for the swimming scenario where dermal and oral exposure was evaluated.	Males and females of reproductive age and their offspring were identified as PESS for ethylene dibromide based on epidemiology and animal toxicology studies. A rodent maternal exposure study (Short et al., 1978) was utilized quantitatively as the POD for acute inhalation hazard. Effects included fetal skeletal malformation and late resorptions. An interspecies uncertainty factor (UF_A) of 3 was used to account for toxicodynamic differences across species.
Pre-existing disease	Not applicable.	An intraspecies uncertainty factor (UF_H) of 10 was used to account for human variability.
Lifestyle activities	Evaluated elevated fish ingestion rate for sustenance fishers and tribal communities for water bodies where ethylene dibromide is released.	An intraspecies uncertainty factor (UF_H) of 10 was used to account for human variability.
Occupational and consumer exposures	EPA considered increased exposure specific to worker activities and evaluated consumer exposure to ethylene dibromide among hobbyist pilots.	Not applicable.
Geography/site-specific	EPA assessed exposure concentrations to which residential communities proximal to releasing facilities may be exposed.	Not applicable.

PESS Categories	Potential Increased Exposures Incorporated into Exposure Assessment	Potential Sources of Susceptibility Incorporated into Hazard Assessment
Sociodemographic status	EPA evaluated dermal exposure to ethylene dibromide during avgas use by age group, youth (16–20 years) and adults (≥21 years).	EPA utilized the most sensitive sex from rodent assays for modeling different PODs. A rodent maternal exposure study (Short et al., 1978) was utilized quantitatively as the POD for acute inhalation hazard. Effects included fetal skeletal malformation and late resorptions. An interspecies uncertainty factor (UF_A) of 3 was used to account for toxicodynamic differences across species. The chronic oral POD study (NCI, 1978) considers testicular atrophy a co-critical endpoint to the modeled liver effects (peliosis hepatis and focal necrosis).
Nutrition	Evaluated exposure to ethylene dibromide via fish ingestion for tribal populations and subsistence fishers.	EPA did not identify nutritional factors that influence susceptibility.
Genetics/epigenetics	EPA did not identify unique activities that influence exposure.	Potential increased susceptibility may occur in individuals with variability in CYP2E1 and GST activity, which may influence metabolic activation and formation of reactive intermediates and DNA adducts (U.S. EPA, 2004b) Individuals with CYP2E1 and aldehyde dehydrogenase-2 polymorphisms that may have a higher risk for several diseases affecting multiple organ systems including cancer (Mitra et al., 1992). An intraspecies uncertainty factor (UF_H) of 10 was used to account for human variability.
Unique activities	EPA evaluated consumer avgas refueling and sampling fuel (sumping) activity that influence exposure.	EPA did not identify unique activities that influence susceptibility.
Aggregate exposures	Aggregate exposures were considered for workers, consumers, and the general population as appropriate based on exposure scenarios. See Section 4.3.2 and Appendix F. Aggregate exposure for the general population was quantified and described in Appendix F.1. Aggregate non-cancer and cancer risk was quantified for workers and is further described in Appendix F.3 and F.4.	Potential increased susceptibility may occur for workers and consumers where it is likely that inhalation and dermal exposure may occur simultaneously. For the general population, potential increased susceptibility may occur if individuals are swimming in water bodies receiving industrial releases containing ethylene dibromide, resulting in dermal and incidental ingestion.

PESS Categories	Potential Increased Exposures Incorporated into Exposure Assessment	Potential Sources of Susceptibility Incorporated into Hazard Assessment
Other chemical and non-chemical stressors	EPA did not identify other chemical and nonchemical factors increasing exposure. However, for avgas use (*i.e.,* Fuels and Related Products OES), EPA considered the impact of other chemicals presence in the avgas on the volatility of ethylene dibromide based on their relative vapor pressure in avgas. While avgas contains ethylene dibromide at 0.07–0.1 wt% concentration, per EPA estimate, at ambient conditions (*i.e.,* 25 °C, 1 atm), the avgas VOC contains about 0.04 wt% ethylene dibromide which therefore, results in decreased inhalation exposure to ethylene dibromide compared to other components in avgas.	EPA did not identify other chemical and nonchemical factors influencing susceptibility.
DIYer = do-it-yourself consumer user (*i.e.,* hobbyist); OES = occupational exposure scenario; ONU = occupational non-user; PESS = potentially exposed or susceptible subpopulations; POD = point of departure; UF = uncertainty factor		

4.3.7 Overall Confidence and Remaining Uncertainties in Human Health Risk Characterization

4.3.7.1 Occupational Risk Estimates

Overall, EPA has moderate confidence in the risk estimates calculated for workers and ONUs for all COU. As described in Section 2.5.1 in the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t), EPA has overall robust confidence in the non-cancer and cancer endpoints selected to characterize risk from acute, intermediate, and chronic duration exposures to ethylene dibromide. As described in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d), EPA has moderate confidence in the inhalation and dermal exposure estimates for workers for all COU and slight-to-moderate confidence in the inhalation exposure estimates for ONUs depending on the COU.

Table 4-37. Overall Confidence for Acute, Intermediate, Chronic, Non-Cancer, and Chronic, Cancer Risk Characterization for COUs

COU	OES	Exposed Group	Route of Exposure	Exposure Confidence	Hazard Confidence	Risk Characterization Confidence
Manufacture – Import	Import and Repackaging	Worker	Inhalation	Moderate	Robust	Moderate
		ONU	Inhalation	Moderate	Robust	Moderate
		Worker	Dermal	Moderate	Robust	Moderate
Processing – Repackaging		Worker	Inhalation	Moderate	Robust	Moderate
		ONU	Inhalation	Moderate	Robust	Moderate
		Worker	Dermal	Moderate	Robust	Moderate

COU	OES	Exposed Group	Route of Exposure	Exposure Confidence	Hazard Confidence	Risk Characterization Confidence
Processing – Incorporation into formulation, mixture, or reaction product	Incorporation into Formulation, Mixture or Reaction Product	Worker	Inhalation	Moderate	Robust	Moderate
		ONU	Inhalation	Moderate	Robust	Moderate
		Worker	Dermal	Moderate	Robust	Moderate
Processing – As a reactant		Worker	Inhalation	Moderate	Robust	Moderate
		ONU	Inhalation	Moderate	Robust	Moderate
		Worker	Dermal	Moderate	Robust	Moderate
Industrial use – Fuel agents in petroleum refineries	Fuels and Related Products	Worker	Inhalation	Moderate	Robust	Moderate
		ONU	Inhalation	Slight	Robust	Moderate
		Worker	Dermal	Moderate	Robust	Moderate
Industrial use – Other use	Incorporation into Formulation, Mixture or Reaction Product	Worker	Inhalation	Moderate	Robust	Moderate
		ONU	Inhalation	Moderate	Robust	Moderate
		Worker	Dermal	Moderate	Robust	Moderate
Commercial use – Fuel and related product	Fuels and Related Products	Worker	Inhalation	Moderate	Robust	Moderate
		ONU	Inhalation	Slight	Robust	Moderate
		Worker	Dermal	Moderate	Robust	Moderate
Commercial use – Other uses	Laboratory Use	Worker	Inhalation	Moderate	Robust	Moderate
		ONU	Inhalation	Slight	Robust	Moderate
		Worker	Dermal	Moderate	Robust	Moderate
Disposal	Waste Handling, Treatment, and Disposal	Worker	Inhalation	Moderate	Robust	Moderate
		ONU	Inhalation	Slight	Robust	Moderate
		Worker	Dermal	Moderate	Robust	Moderate
Distribution in commerce	Distribution in Commerce	No quantitative risk assessment was performed for this OES as occupational exposures covered are not reasonably expected to occur				
COU = condition of use; OES = occupational exposure scenario; ONU = occupational non-user						

4.3.7.2 Consumer Risk Estimates

Overall, EPA has moderate confidence in risk estimates calculated for consumer exposure scenarios. As described in Section 2.5.1 in the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t), EPA has overall robust confidence in the non-cancer and cancer endpoints selected to characterize risk from acute, intermediate, and chronic duration exposures to ethylene dibromide. As described in the *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d), EPA has moderate confidence in the inhalation and dermal exposure estimates for consumer exposure scenario.

Table 4-38. Overall Confidence for Acute and Intermediate Non-Cancer and Chronic Cancer Risk Characterization for COUs Resulting in Risks

Condition of Use		Exposure Scenario	Exposed Group	Route of Exposure	Exposure Confidence	Hazard Confidence	Risk Characterization Confidence
Life Cycle Stage	Category						
Consumer use	Fuels and related products	Fuels and Related Products	Consumer	Inhalation	Moderate	Robust	Moderate
				Dermal	Moderate	Robust	Moderate

4.3.7.2.1 Inhalation

Exposure was quantified using the LADD, which represents an average daily uptake over the exposure duration and lifetime. This approach assumes continuous, low-level exposure over time, whereas actual exposures occur as short, infrequent bursts. Ethylene dibromide is rapidly cleared and is not expected to accumulate between such bursts. Accordingly, realistic internal dose time profiles would be pulsatile, while time-averaged metric implies a flat, constant internal exposure. Such a flat internal exposure profile may not reflect or may mischaracterize the biologically relevant internal dose, depending on the chemical's mode of action.

For ethylene dibromide, hazard results from metabolic activation, meaning transient peak exposures could generate short-lived but potentially significant concentrations of reactive metabolites. The rate and extent of metabolite formulation is concentration-dependent and may be nonlinear at episodic exposure conditions. For mutagenic modes of action, risk is typically assumed to scale with cumulative dose; however, uncertainty remains as to whether equivalent LADD values derived from intermittent verses continuous exposure result in the same effective target tissue dose for a rapidly cleared chemical, especially considering the paucity in internal exposure between exposure events. Evidence regarding whether exposure time profiles may influence the balance of damage and repair for this compound is insufficient/lacking at the moment. Consequently, there is uncertainty regarding whether time-averaged exposure metrics fully capture the relationship between exposure, internal dose, and cancer risk.

4.3.7.2.2 Dermal

Dermal hazard values were calculated with a PBPK model, as described in the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t). While uncertainties are inherent to PBPK models, they are well characterized and do not preclude the model's application for conducting route-to-route extrapolation across exposure conditions within the defined domain of applicability, *e.g.,* in different species. Furthermore, the model realistically captures key determinants of dermal absorption, one of which includes concentration in the formulation. Collectively, EPA has medium to high confidence in the PBPK-based route-to-route extrapolation to characterize consumer internal dose, given the low concentration of ethylene dibromide in consumer-specific scenarios, in addition to the sparsity at which consumer skin is exposed.

4.3.7.3 General Population Risk Estimates

EPA assigned confidence levels to references when selecting PODs for hazard value calculations. Confidence in each reference was dependent on several factors, including selection of the most critical endpoint across studies, availability of evidence for a particular endpoint across references, relevancy to exposure scenarios, dose-response considerations, and PESS sensitivity. Additional information on how confidence levels for the above hazard PODs were determined is located in Section 4.2.6.

For acute inhalation, EPA has robust overall hazard confidence in the reproductive endpoints reported by Short et al. (1978). Mouse fetal developmental abnormalities and increased late resorptions reported in Short et al. (1978) were selected as the basis for the POD used for characterizing risk from exposure to ethylene dibromide due to its sensitive LOAEL of 20 ppm and the severity of outcomes. The inhalation carcinogenicity POD is also supported with robust confidence (NTP, 1982). Following inhalation exposure in rats, increased incidences of tumors were observed in respiratory tract (*e.g.,* adenoma and carcinoma of nasal cavity) and circulatory system (*e.g.,* hemangiosarcoma of the spleen) at 10 ppm.

For acute oral exposure, EPA has moderate overall hazard confidence in the gastrointestinal endpoints reported by Ghanayem et al. (1986). This reference assessed exposure to ethylene dibromide in male rats, evaluating histopathological changes to organs. Forestomach epithelial cell proliferation and hyperkeratosis was selected as the basis for the POD used for characterizing risk from exposure to ethylene dibromide due to its sensitive LOAEL of 80 mg/kg/day and the severity of outcomes. For chronic oral exposure, EPA has robust overall hazard confidence in the critical liver effects, and co-critical reproductive and adrenal endpoints reported by NCI (1978). At 38 mg/kg/day, peliosis hepatis and focal necrosis of the liver, along with adrenal cortex degenerative lesions and testicular atrophy, were identified in rats. The oral carcinogenicity POD is supported with robust confidence (NCI, 1978). Following oral exposure in rats, tumorigenesis was observed in the gastrointestinal tract (*e.g.,* forestomach squamous cell carcinomas) at 38 mg/kg/day.

Route-to-route extrapolation from the inhalation POD was used to calculate an acute dermal hazard value. For acute inhalation, EPA has robust overall hazard confidence in the reproductive endpoints reported by Short et al. (1978), as described above.

4.3.7.3.1 Air Pathway

EPA applied a tiered screening approach to assess ambient air exposure to ethylene dibromide. EPA used IIOAC model as a tier one analysis to estimate daily average and annual average concentrations of ethylene dibromide in the ambient air. IIOAC estimates outdoor air concentration using pre-run results from a suite of dispersion scenarios in a variety of meteorological and land-use setting within AERMOD, thereby representing a wide variety of regional environmental conditions.

In the screening approach in IIOAC, EPA used health-protective model inputs by choosing the highest individual stack and fugitive releases across all facilities and reporting years evaluated and applied the meteorology patterns from the Lake Charles, Louisiana (south coastal) facility to every facility, regardless of the facility's geographic location. In addition, the highest calculated MOE was approximately 146,000, which is several magnitudes above the benchmark MOE of 30. Because of these assumptions and the large margin between the MOE and benchmark MOE, EPA has robust confidence that the screening-level estimates from IIOAC effectively show that there is no chronic risk from inhalation due to TSCA releases because of the conservative inputs and large margin of exposure.

To evaluate cancer risk from TSCA air releases, EPA utilized HEM to model air concentrations near facilities releasing ethylene dibromide. Due to its regular application in assessments to inform regulatory decisions, EPA has robust confidence in the modeling results from HEM. EPA utilized the final tier of analysis at their disposal by using process-specific releases from NEI, and location-specific parameters to model ambient air concentrations surrounding facilities releasing ethylene dibromide. Cancer risk above one-in-a-million was still found at this tier of analysis. HEM also utilized census blocks to determine how many people are exposed, and EPA has robust confidence in the census block population estimates from HEM. Therefore, EPA has robust confidence in these cancer risk estimates and robust

confidence in the population estimates from the HEM outputs. These results demonstrate that people are being exposed to cancer risk from ethylene dibromide as a result of facility releases reported of TRI and NEI.

A limitation of the model is the exclusion of photodegradation processes, which may be relevant to ambient air concentrations of ethylene dibromide. Without modeled decreases in concentration due to photodegradation, the results presented in this document are more health protective to the general population, various life stages, PESS, and Tribal nations. EPA's overall confidence in the inhalation carcinogenicity risk estimates is robust because of the robust confidence in the HEM model results, utilizing the final tier of analysis, and the robust confidence in the inhalation carcinogenicity POD.

4.3.7.3.2 Water Pathway

EPA relied primarily on modeling to estimate aqueous concentrations resulting from releases to surface waters as reported in TRI and DMR. EPA has robust confidence in these reported releases. For the Import and Repackaging and Fuels and Related Products OESs, releases to water needed to be modeled. EPA has moderate confidence in these modeled releases.

EPA used facility-specific releases from NPDES permits and flow data from the NHDPlus flow database in the E-FAST model to estimate ethylene dibromide concentrations at the point of release. EPA has robust confidence in the surface water concentrations of ethylene dibromide using this method.

Where reach codes or flows were not available for the receiving water body, flows from a nearby waterbody were obtained from NHDPlus. For these OESs, EPA has moderate confidence in the accuracy of these flow estimates.

For the Import and Repackaging and Fuels and Related Products OESs water releases needed to be modeled, each of these OESs represented several facilities of unknown geographic location. EPA identified NAICS codes to represent these OESs in order to aggregate flows from each of these facilities and use those flows to estimate water concentrations from releases from these OESs. The Agency has slight confidence in these flow estimates, but moderate confidence in these estimates being health-protective based on the assumptions made.

EPA used E-FAST to model surface water concentrations at the point of discharge using reported and modeled releases along with flow data. Then using this concentration data and assuming a 0% drinking water removal rate, EPA estimated exposures via drinking water, incidental ingestion during swimming, and dermal exposure during swimming. EPA also used these surface water concentrations to estimate fish ingestion exposures. This yielded adequate MOEs several magnitudes above the benchmark MOEs in all surface water exposure pathways, even for the most sensitive groups (including infants, toddlers, adolescents, and tribal populations). EPA has robust confidence in the acute oral and dermal exposure estimates from swimming in surface waters where ethylene dibromide has been released. EPA has robust confidence in the acute oral and dermal PODs. When combining these PODs with the health-protective exposure model, EPA has robust confidence in the risk estimates calculated.

Cancer risk from drinking water exposure, assuming 0% drinking water removal and drinking water uptake at the point of discharge, was also below 1.0×10^{-6}. Based on the assumptions made, EPA has robust confidence that the risk estimates resulting from the high-end exposures are protective of various life stages, PESS, and Tribal nations. EPA has robust confidence in the oral carcinogenicity POD. Because of the robust confidence of both the oral carcinogenicity POD and robust confidence in the risk estimates of the high-end exposures from drinking water.

5 ENVIRONMENTAL RISK ASSESSMENT

EPA assessed environmental risks of ethylene dibromide exposure to aquatic and terrestrial species. Section 5.1 describes environmental exposures through environmental media such as surface water, in Section 5.2, whereas environmental risk characterization is described in Section 5.3.

Ethylene Dibromide – Environmental Risk Characterization: Key Points

EPA quantitatively assessed environmental risks of ethylene dibromide exposure to aquatic and terrestrial species following releases to surface water and air.

Environmental Exposure Key Points

- Ethylene dibromide is highly volatile, and all releases are expected to remain in the air, though ethylene dibromide may precipitate to land, soil, or surface water via wet deposition, these partitioning pathways are unlikely.
- Despite expectations that ethylene dibromide will volatilize from water to air due to the high water solubility, low likelihood of sorbing to sediment, and release patterns to surface water, ethylene dibromide is expected to be present in surface water as a result of releases to surface water.

Environmental Hazard Key Points

- The acute concentrations of concern (COCs) of 550 µg/L for aquatic vertebrates and 190 µg/L for aquatic invertebrates were derived from separate species sensitivity distributions (SSDs).
- The chronic COCs of 43 µg/L for aquatic vertebrates and 36.1 µg/L for aquatic invertebrates were derived from acute LC50 data divided by an acute-to-chronic (ACR) ratio of 10 and the application of an assessment factor (AF) of 10.
- The acute hazard threshold for terrestrial mammals of 150 mg/m^3 was based on an LOAEC value for reproductive effects from one mouse study via inhalation.
- The chronic hazard threshold for terrestrial mammals of 77 mg/m was based on an LOAEC value for reproductive effects from one rat study via inhalation.
- The acute hazard threshold for birds of 2.0 $\mu g/m^3$ was estimated using the Screening Tool for Inhalation Risk (STIR Model) for mortality via inhalation.
- The acute hazard threshold for terrestrial invertebrates of 30 mg/m^3 was derived from an SSD based on arthropod mortality via air exposure.

Environmental Risk Characterization Key Points

- Risk to aquatic organisms was characterized by comparing COCs for aquatic organisms to modeled surface water by COU from facility-specific releases (TRI) and modeled data from generic scenarios for COUs without available TRI data.
    - The modeled surface water concentration does not exceed COCs for aquatic species under acute or chronic exposure durations.
- Risk to terrestrial species was characterized by comparing hazard thresholds for terrestrial species to a high-end estimated air concentration using the highest stack and fugitive release across all reported COUs.
    - The modeled air concentration does not exceed the hazard thresholds for terrestrial species.
- EPA has robust confidence in the risk characterization for the acute aquatic invertebrates, acute aquatic vertebrates, acute and chronic terrestrial mammals, and acute terrestrial invertebrates.
- EPA has moderate confidence for the terrestrial avian risk characterization due to the number of reasonably available studies.
- EPA has slight confidence in aquatic chronic risk characterization for both vertebrate and invertebrate species due to the lack of reasonably available chronic data.

5.1 Summary of Environmental Concentrations and Exposures

EPA assessed environmental concentrations of ethylene dibromide in surface water and ambient air. Ambient air and surface water were identified as the main pathways of exposure for terrestrial and aquatic species, respectively. Facility release information confirmed that these were the primary pathways for ethylene dibromide release. Ethylene dibromide has high water solubility and is highly volatile from water to air. In fact, volatilization serves as the primary removal mechanism from surface water. Properties of ethylene dibromide that are attributed to the pathways of exposure assessed are presented in the *Draft Chemistry, Fate, Release and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d). EPA did not assess sediment and soil as potential pathways for environmental exposure because (1) ethylene dibromide is readily degraded by microbes that predominate in aerobic conditions common in soil, (2) the high volatilization of ethylene dibromide from surface water to air prevents ethylene dibromide from accumulating in benthic environments, (3) monitoring data reveals that majority of ethylene dibromide data in sediments are confined to Superfund legacy use locations, and (4) low sorption potential for ethylene dibromide to partition to organic matter in soil and sediment. Ethylene dibromide has low persistence in soil and surface water (days) with moderate persistence in groundwater where biodegradation typically takes place with a half-life of around 120 days (McKeever et al., 2012). The rapid volatilization of ethylene dibromide is anticipated to be the primary controlling factor in the fate of this chemical in surface water and soil.

5.1.1 Surface Water Releases

As noted in the *Draft Chemistry, Fate, Release and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d), EPA estimated surface water concentrations using the E-FAST model (U.S. EPA, 2026q). This model used facility specific water releases reported via TRI or DMR. For the water pathway, varying hydrological flows were used for different exposure scenarios. The harmonic mean is also used for estimating human exposure through fish ingestion, if applicable, because it takes time for chemical concentrations to accumulate in fish tissue. Lastly, for aquatic and ecological exposure, a 7Q10 flow (lowest 7-day flow that occurs [on average] in a 10-year period) is used to estimate exceedances of COC for aquatic life (U.S. EPA, 1991). EPA estimated surface water concentrations per facility and mapped it to the corresponding COU/OES.

EPA identified eight facilities that reported releases of ethylene dibromide via DMR or TRI. The maximum reported annual release from each facility spanning 2019 to 2023 was used to calculate the water column concentration at these sites. The COUs for each facility is represented in Table 5-3. EPA also estimated releases from GSs for Import and Repackaging and the Fuels and Related Products OES and related COUs. These release amounts were from modeled estimates that provided central tendency (50th percentile) and high-end (95th percentile) releases from sites reported via CDR in Table 3-5. EPA modeled these releases using flow information available from the NAICS codes of all sites identified under these OES. EPA applied the flow statistics equivalent of the P10 value to these generic scenarios which is the 10th percentile of flows measured from all facilities that fall under that NAICS code, resulting in more conservative concentration estimates. The resulting calculated values for ethylene dibromide in the water column ranged from 2.46×10^{-5} to 44.9 µg/L for generic scenarios and site-specific releases. Only one site-specific release resulted in a value that exceeded a risk quotient (RQ) of 1 for chronic exposure to aquatic vertebrates and invertebrates listed in Table 5-2. This facility is associated with the Processing – Incorporation into formulation, mixture, or reaction product COU, and was also used to characterize the Incorporation into Formulation, Mixture or Reaction Product OES. The water column concentration at the facility in question was estimated at 44.9 µg/L using the reported maximum release and the corresponding 7Q10 flows. The value calculated using the E-FAST spreadsheet represents an acute 1-day average value of the water concentration while also serving as the daily water column concentration over the number of days of operation. There were no RQs exceeding 1

for the acute timeframe. The reported release from the site is evenly distributed across the days of operation resulting in a daily concentration that remains the same throughout the year. The model does not assume accumulation from the previous days.

For the facility that reported surface water releases resulting in an RQ greater than 1, EPA proceeded to perform a more refined model using Variable Volume Water Model – Point Source Calculator (PSC) to assess the risk at this facility. PSC was used to calculate the maximum daily average concentration over the days of operation (256). The difference between the two modeling tools is that PSC accounts for the chemical and physical properties of ethylene dibromide (*i.e.,* K_{OW}, K_{OC}, water column half-life, photolysis half-life, hydrolysis half-life, and benthic half-life) that could impact the water column concentration of ethylene dibromide while E-FAST calculations are solely dependent on the flow and daily release values. EPA ran a scenario for the days of reported release (256) for this facility. PSC results provided a 1-day average along with a 21-day average for each modeled scenario. The 1-day average concentration when running the 256 days of release scenario is 30.5 µg/L with a 21-day average of 30.0 µg/L. The 21-day average was used to calculate the chronic RQs while the 1-day average was used to calculate the acute RQ from the PSC. The PSC estimates resulted in chronic RQ values of 0.85 for invertebrates and 0.71 for vertebrate species that were initially above 1 before further refinement.

5.1.2 Air Releases

No reasonably available data on the ethylene dibromide concentrations in terrestrial biota were found during the systematic review process. The two studies identified in Section 3.3.4 were studies with old air monitoring data and would not be appropriate to validate current TSCA uses or releases of ethylene dibromide. The primary pathway of release reported was via the air pathway. There were no other reported releases to land thus air modeling accounted for all modeled releases to terrestrial species. The high volatility of ethylene dibromide makes it highly likely that concentrations of ethylene dibromide would be present in ambient air because of either reported releases or as it volatilizes from surface water to air. Extensive ambient air monitoring data are available for ethylene dibromide and confirm that air is the primary pathway of exposure. EPA summarizes available ethylene dibromide air measured concentrations and monitoring data in *Draft Chemistry, Fate, Release and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d).

EPA conducted a quantitative assessment of ethylene dibromide in ambient air to determine if there was risk for terrestrial species. The Agency used the IIOAC model to estimate ambient air concentrations from the reported NEI and TRI releases. EPA applied these modeling tools using a screening approach. EPA modeled ambient air concentrations using releases from two separate datasets: TRI data facility-reported releases and NEI facility-reported releases. Both two datasets capture all potential releases. TRI provides annual facility aggregated release data, while NEI provides process-level release data every 3 years (release data from 2017 and 2020 were used in this assessment). For some facilities, release data from TRI and NEI can be the same, but there are often differences between the two datasets due to differences in reporting requirements. The results of the modeling of TRI and NEI data are used as two separate lines of evidence and are used in conjunction to inform the overall risk characterization.

The screening approach for the air modeling used the highest stack and fugitive releases across all COUs and reporting sites across NEI and TRI to determine if there was any possible risk. This screening approach used the highest reported stack release as 1247.4 kg/year (5.09 kg/operating day) reported in 2017 via NEI and highest fugitive release was 141 kg/year (0.55 kg/operating day) reported via TRI in 2019. As seen below in Table 5-1, the facilities identified with the highest air releases from NEI (2017) and TRI (2019) are associated with six COUs: two, and four, respectively. The modeled facilities included in this screening approach are intended to capture the possible high-end air concentrations

across all 11 identified COUs (Table 3-1). These releases from separate sites were not temporally or spatially aligned, meaning they were reported from different sites in varying reporting years; however, they represented the highest reported releases that could be modeled. Modeling these two releases as singular and simultaneous release source resulted with a source apportioned concentration of 1.308 µg/m^3 with the most sensitive hazard threshold being 2.0 µg/m^3. This justifies why there would be no RQ exceeding 1.0 at any facility when releases are spatially and temporally aligned.

The other hazard thresholds are at least 15,000 times higher than 2.0 µg/m^3 (Table 5-2), meaning there was no further need for refinement. The estimated modeled concentration represents an acute 1-day average and chronic average daily concentration value because the model calculates the daily average concentration for each day over a 365-day period and treats each day independently with no accumulation, resulting in daily concentration equivalent to both 1-day average and the average daily concentration over a 365 day timeframe (Table 5-1). The resulting chronic RQ would be magnitudes lower than 1 because the only chronic hazard threshold reported was 77 mg/m^3 (77,000 µg/m^3). Every facility would have a combined resulting concentration that would not exceed this modeled concentration, providing additional lines of evidence that no further refinement was needed. EPA modeled the maximum release values reported from 2017 to 2023 for each TRI facility (Table 5-4) because the range of TRI releases would capture the releases of the NEI facilities that typically report lower combined releases.

Table 5-1. Maximum Source Apportioned Total Daily-Averaged and Annual-Averaged IIOAC-Modeled Concentrations at 100 m

COU	OES	Reporting Year	Daily Release (kg/day)	Source Type	Daily-Average Concentration (µg/m^3)	Annual-Average Concentration (µg/m^3)
Processing – Incorporation into formulation, mixture, or reaction product; Processing – As a reactant; and/or Industrial use – Other use	Incorporation into Formulation, Mixture or Reaction Product	2019	0.55	Fugitive	0.94	0.94
Industrial use – Fuel agent in petroleum refineries and/or Commercial use – Fuels and related products	Fuels and Related Products	2017	5.1	Stack	0.37	0.37
COU = condition of use; IIOAC = Integrated Indoor-Outdoor Air Calculator; OES = occupational exposure scenario						

5.1.3 Weight of Scientific Evidence Conclusions for Environmental Exposures

EPA used several considerations when weighing scientific evidence to determine the confidence in the monitored exposure concentrations and exposures modeled. These considerations include the quality of the databases, consistency, strength, precision, and relevance of the modeled exposures. EPA has moderate-to-robust confidence in the environmental exposures presented.

The ethylene dibromide data reported from WQP reported monitoring data did not correspond to sites that reported releases of ethylene dibromide via water. The range of the data from WQP was 0.06 to 0.29 µg/L with these samples taken in Florida, Illinois, and New Jersey. The modeled data were based on site-specific release data, so it can be inferred that these calculations produce higher concentrations than most reported samples based on proximity to release facilities and the assumption of no water

treatment prior to release. All but one of the sites modeled had a water column concentration of ethylene dibromide that would be of concern only for chronic exposure with no exceedances of the acute exposure concentrations of concern. Outlined in Section 5.3.2, this site exceeded the COC only when the flow and daily release amounts were driving factors in the E-FAST calculation. There was a decrease in the modeled concentration using PSC when considering ethylene dibromide's chemical and physical properties. There was no exceedance of the acute or chronic COC when modeled with the number of days of reported release.

EPA has moderate confidence in the exposure concentrations estimated in surface water given the monitoring data available and the results from the modeling estimates. Use of the E-FAST spreadsheet calculations as a screening tool is intended to serve as a high-end conservative exposure estimate of surface water concentrations resulting from water releases because E-FAST does not take volatilization and portioning to sediment and/or organic matter in the surface water into consideration. EPA also estimated surface water concentrations using PSC, which provides more realistic and representative surface water concentrations (*i.e.,* less conservative) because it can account for physical and chemical and fate properties that contribute to the likelihood of ethylene dibromide removal from surface water following the initial release. EPA has moderate confidence that the results from the analysis can be used to derive risk to and characterize risk for aquatic species.

Regarding the modeling of air releases to estimate air concentrations of ethylene dibromide that terrestrial organisms may be exposed to, EPA has robust confidence that the modeled air concentrations are health protective of the terrestrial species. The modeled high-end screening release scenario estimated a total source apportioned concentration of 1.308 $\mu g/m^3$. This estimated concentration reflects the concentration that would be expected in close proximity (within 100 m) to the release facility, and due to this proximity to the release point, likely results in an air concentration that is conservative and may overestimate risk. The IIOAC input parameters used conservative estimates from meteorological and environmental parameters. Over 93% of all AMTIC monitoring data points from 2017 to 2022 reported a value of "0" with a non-zero maximum value of ethylene dibromide air concentration reported of 68.08 $\mu g/m^3$. EPA does not expect modeled air concentrations will exceed the monitoring data attained from AMTIC because the modeled concentration would be from one facility (and closer to the point of release), the monitoring data may encompass an aggregate from multiple releases into ambient air and do not reflect facility-specific releases tied to the COUs. There is a wide range of data points from nationwide monitoring with no clear connection to sites of reported high-end releases. The estimated release represents a value that is in range of the monitoring data values but only due to proximity to the release facility. Although it is unclear in the connections with the monitoring data, there is robust confidence that the estimated values can be used to derive and characterize risk to terrestrial species.

5.2 Summary of Environmental Hazards

EPA evaluated the reasonably available information for environmental hazard endpoints associated with ethylene dibromide exposure to ecological receptors in aquatic and terrestrial ecosystems.

Aquatic Species Hazard

COCs were derived for acute and chronic ethylene dibromide exposures in water ((U.S. EPA, 2026t), Table 5-2). Specifically, eight studies contained relevant acute and chronic aquatic toxicity data for marine and freshwater vertebrates and invertebrates. For ethylene dibromide, two separate acute COCs (1 for vertebrates and 1 for invertebrates) were derived from SSDs using EPA's SSD Toolbox (v1.1). The acute aquatic COCs were derived from SSDs that contained lethal concentration at which 50% of test organism die (*i.e.,* LC50s) for four vertebrate and four invertebrate species identified in systematic

review and were supplemented with predictions from the Web-based Interspecies Correlation Estimation (v4.0) toxicity value estimation tool. SSDs were derived using EPA's SSD Toolbox (v1.1). Due to the general lack of chronic data, the chronic COCs were derived by applying an ACR and AF to the most sensitive acute vertebrate and invertebrate LC50s. No toxicity studies using spiked sediment for benthic exposures were identified for ethylene dibromide. Thus, all hazard data to benthic invertebrates were represented by water exposures.

Terrestrial Species Hazard

EPA derived hazard thresholds for acute and chronic inhalation exposure to terrestrial mammals, acute inhalation exposure to birds, and acute inhalation exposure to terrestrial invertebrates ((U.S. EPA, 2026t), Table 5-2). In lieu of available terrestrial wildlife mammalian studies, human health model organisms (*e.g.,* rat, mouse, rabbit) were used to determine the most sensitive and environmentally relevant ethylene dibromide concentrations that affected apical endpoints (*e.g.,* mortality, reproduction, growth) which could serve as an indication of hazard effects in wild mammalian populations resulting from ethylene dibromide releases being characterized in this risk evaluation. An acute hazard threshold of 150 mg/m^3 was found based on reasonably available rat and mice studies for reproductive effects resulting from exposure to ethylene dibromide via inhalation. A chronic hazard threshold of 77 mg/m^3 was found for exposure of mammals to ethylene dibromide via inhalation. Empirical data for avian toxicity to ethylene dibromide via inhalation were not reasonably available. EPA used available empirical oral exposure data for birds, in addition to empirical oral and inhalation toxicity data from rats, to predict an inhalation hazard threshold for acute exposure for birds. An acute hazard threshold of 2.0 µg/m^3 was estimated using the STIR Model. The acute terrestrial invertebrate hazard threshold for ethylene dibromide of 30 mg/m^3 was derived from an SSD that contained 2-hour to 7-day LD/LC50 values for eight arthropod species via air exposure. No quantitative analysis was conducted for plants and fungi due to lack of reasonably available studies with relevant endpoints.

Table 5-2. Environmental Hazard Thresholds for Ethylene Dibromide

Receptor Group	Exposure Duration	Hazard Threshold (COC or HV)	Assessment Medium	Reference	Hazard Threshold Confidence
Aquatic vertebrates	Acute	550 µg/L [a]	Water column	SSD	Robust
	Chronic	43 µg/L [b]	Water column	Kszos et al. (2003)	Slight
Aquatic invertebrates	Acute	190 µg/L [a]	Water column	SSD	Robust
	Chronic	36.1 µg/L [b]	Water column	Kszos et al. (2003)	Slight
Terrestrial mammal (inhalation)	Acute	150 mg/m^3	Air	Short et al. (1978)	Robust
	Chronic	77 mg/m^3	Air	NTP (1982)	Robust
Terrestrial avian (inhalation)	Acute	2.0 µg/m^3	Air	STIR	Moderate
Terrestrial invertebrates	Acute	30 mg/m^3 [a]	Air	SSD	Robust

COC = concentration of concern; HV = hazard value; SSD = species sensitivity distribution; STIR = screening tool for inhalation risk

[a] Represents the lower-bound 95th confidence interval of the HC05 from the SSD.

[b] An acute-to-chronic ratio (ACR) of 10 and an assessment factor (AF) of 10 were applied to the most sensitive acute vertebrate and invertebrate LC50. The ACR was applied to account for the uncertainty of extrapolating acute mortality data to various endpoints measured under chronic exposure durations. The AF accounts for uncertainty

Receptor Group	Exposure Duration	Hazard Threshold (COC or HV)	Assessment Medium	Reference	Hazard Threshold Confidence
that the most sensitive species was identified and that laboratory animals respond similarly when exposed to ethylene dibromide in the environment.					

5.2.1 Weight of Scientific Evidence Conclusions for Environmental Hazards

Based on the weight of scientific evidence and uncertainties, a confidence statement was developed to qualitatively rank (*i.e.,* robust, moderate, slight, or indeterminate) the confidence in the hazard thresholds. 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 has robust confidence in the weight of scientific evidence in these hazard thresholds for acute aquatic invertebrates, acute aquatic vertebrates, acute and chronic terrestrial mammals, and acute terrestrial invertebrates. EPA has moderate confidence in the terrestrial avian hazard threshold because empirical data for avian toxicity to ethylene dibromide via inhalation were not reasonably available; therefore, the Agency used available empirical oral exposure data for birds, in addition to empirical oral and inhalation toxicity data from rats, to predict an inhalation hazard threshold for acute exposure for birds. EPA has slight confidence in aquatic chronic exposures for both vertebrate and invertebrate species due to the lack of reasonably available studies. See the *Draft Hazard Assessment for Ethylene Dibromide* (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

EPA calculated risk estimates for terrestrial and aquatic species exposures following acute and chronic exposures. Risks were estimated for acute and chronic exposures for aquatic vertebrates and invertebrates. For terrestrial species, acute and chronic risks were estimated for mammals while only acute risk estimates were calculated for avian and invertebrate species. RQs were used to estimate these acute and chronic risks when applicable.

Equation 5-1. Equation for Risk Quotient

$$RQ = (Estimated\ Exposure\ Concentration)/(Concentration\ of\ Concern)$$

5.3.2 Risk Estimates for Aquatic Species

EPA found that there was chronic risk at one release facility (TRIFID 39567CHVRNPOBOX) out of all the reported releases of ethylene dibromide to surface water when modeled in the E-FAST spreadsheet. Upon further refinement the RQ did not exceed 1. The facility in question was identified under the Incorporation into Formulation, Mixture or Reaction Product OES. The facility is located along a coastal environment in Pascagoula, Mississippi. Actual monitoring data from that facility could be impacted by its geographical position, resulting in a more diluted concentration than modeled estimates. The E-FAST estimated daily water column concentration of ethylene dibromide at this facility over 256 days of release was 44.9 µg/L, resulting in an RQ value of 1.04 for chronic aquatic vertebrates and 1.24 for chronic aquatic invertebrates. The estimated 7Q10 concentrations are provided in Table 5-3 below. This water column concentration was calculated with the number of operating days reported (256) as the number of days of release. The resulting concentration represents both a possible acute exposure

concentration and chronic exposure concentration since this scenario is evenly allocating the annual release across all days of reported operation. The calculated concentration represents a 1-day average while simultaneously representing the average concentration over the span of the 256 days of operation. The release model represented the maximum reported release for this facility from 2017 to 2022.

EPA performed a more refined estimate for water column concentrations using PSC, which is able to account for impacts of volatilization and other physical and chemical properties of ethylene dibromide. Using PSC, the Agency was able to calculate a 1-day average and a 21-day average concentration with each model. As anticipated, the results from PSC produced a lower water column concentration of 30.5 µg/L 1-day average and 30.0 µg/L 21-day when modeled over the span of 256 operating days. The RQ value would then be 0.70 and 0.83 for chronic vertebrates and invertebrates, respectively. The 21-day average represents an average concentration over a 21-day timeframe when modeling 256 days of evenly distributed release in a 365-day period. EPA used the 21-day average to calculate the chronic RQ values from the PSC results. With the results from the PSC refined modeling, no COUs were identified that would result in calculated risk to aquatic species given the most conservative concentration of concern using the estimated days of operation as the days of release. All refinements are presented below in Table 5-3.

5492 **Table 5-3. Aquatic Species Risk Summary by COU/OES**

COU	OES	Reporting Year [a]	7Q10 E-FAST Concentration (µg/L)	E-FAST Acute RQ [b]		E-FAST Chronic RQ [b]		PSC [c] Refinement	PSC 7Q10 Water Column Concentration (µg/L)	PSC Acute RQ [b]		PSC Chronic RQ [b]	
				Invert-ebrates (COC= 190 µg/L)	Verte-brates (COC=550 µg/L)	Invert-ebrates (COC= 36.1 µg/L)	Verte-brates (COC= 43 µg/L)			Invert-ebrates (COC= 190 µg/L)	Vert-ebrates (COC= 550 µg/L)	Invert-ebrates (COC= 36.1 µg/L)	Vert-ebrates (COC=43 µg/L)
Manufacture – Import and/or Processing – Repackaging	Import and Repackaging (modeled) [c]	Modeled [d]	4.9 (Central tendency)	2.6E−02	8.9E−03	0.14	0.11	Not further evaluated	N/A	N/A	N/A	N/A	N/A
		Modeled [d]	5.1 (High-end)	2.7E−02	9.3E−03	0.14	0.12	Not further evaluated	N/A	N/A	N/A	N/A	N/A
Processing – Incorporation into formulation, mixture, or reaction product; Processing-As a reactant; and/or Industrial use – Other use	Incorporation into Formulation, Mixture or Reaction Product	2019	45	0.24	8.2E−02	1.2	1.0	Yes	30.5 (1-day average); 30.0 (21-day average)	0.16	5.5E−02	0.83	0.70
	Petroleum Refineries NAICS 324110 (modeled) [c]	Modeled [d]	2.2E−04 (Central tendency)	1.2E−06	4.0E−07	6.1E−06	5.1E−06	Not further evaluated	N/A	N/A	N/A	N/A	N/A
		Modeled [d]	3.7E−04 (High-end)	1.9E−06	6.7E−07	1.0E−05	8.6E−06	Not further evaluated	N/A	N/A	N/A	N/A	N/A
	Crude Petroleum Extraction 21112 (modeled) [c]	Modeled [d]	3.4E−02 (Central tendency)	1.7E−04	6.2E−05	9.4E−04	7.9E−04	Not further evaluated	N/A	N/A	N/A	N/A	N/A
		Modeled [d]	5.8E−02 (High-end)	3.1E−04	1.1E−05	1.6E−03	1.3E−03	Not further evaluated	N/A	N/A	N/A	N/A	N/A
Commercial use- Other use	Laboratory Use	2021	2.9E−04	1.5E−06	5.3E−07	8.1E−06	6.7E−06	Not further evaluated	N/A	N/A	N/A	N/A	N/A

COU	OES	Reporting Year [a]	7Q10 E-FAST Concentration (µg/L)	E-FAST Acute RQ [b]		E-FAST Chronic RQ [b]		PSC [c] Refinement	PSC 7Q10 Water Column Concentration (µg/L)	PSC Acute RQ [b]		PSC Chronic RQ [b]	
				Invert-ebrates (COC= 190 µg/L)	Verte-brates (COC=550 µg/L)	Invert-ebrates (COC= 36.1 µg/L)	Verte-brates (COC= 43 µg/L)			Invert-ebrates (COC= 190 µg/L)	Vert-ebrates (COC= 550 µg/L)	Invert-ebrates (COC= 36.1 µg/L)	Vert-ebrates (COC=43 µg/L)
Disposal	Waste Handling, Treatment, and Disposal	2019	1.3	6.8E−03	2.4E−03	3.6E−02	3.0E−02	Not further evaluated	N/A	N/A	N/A	N/A	N/A
		2020	0.58	3.1E−03	1.1E−03	1.6E−02	1.3E−02	Not further evaluated	N/A	N/A	N/A	N/A	N/A
		2023	0.43	2.3E−03	7.8E−04	1.2E−02	1.0E−02	Not further evaluated	N/A	N/A	N/A	N/A	N/A
		2022	0.25	1.4E−03	4.5E−04	6.9E−03	5.8E−03	Not further evaluated	N/A	N/A	N/A	N/A	N/A
		2023	5.4E−03	2.8E−04	9.8E−06	1.5E−04	1.3E−04	Not further evaluated	N/A	N/A	N/A	N/A	N/A
		2019	2.5E−03	1.3E−05	4.5E−06	6.9E−05	5.8E−05	Not further evaluated	N/A	N/A	N/A	N/A	N/A

7Q10 = lowest 7-day average flow that occurs (on average) once every 10 years; COC = concentration of concern; COU = condition of use; N/A = not assessed; NAICS = North American Industry Classification System; OES = occupational exposure scenario; PSC = Point Source Calculator; RQ = risk quotient
PSC calculated 21-day average used to calculate chronic RQ values
[a] Each row entry represents a unique site release unless noted as a modeled estimate
[b] Refer to Equation 4-2
[c] Refinement completed only if E-FAST result RQ exceeded 1
[d] Modeled values based on Monte Carlo estimation

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5.3.3 Risk Estimates for Terrestrial Species

EPA did not identify risk to terrestrial species because the RQ did not exceed 1 for any of the hazard thresholds derived for terrestrial species. The acute RQ value was 0.654 given the estimated air concentration from the first tier of the screening approach using the most sensitive hazard threshold. This value does not trigger risk for avian species. It is also unlikely that these species would have exposure to concentrations approaching or exceeding the hazard threshold due to the transient nature of avian species and the concentration modeled would be expected only in close proximity (100 m) to the releasing facility. This modeled concentration is also the result of the highest stack release and fugitive release modeled at one site simultaneously. These releases do not align spatially or temporally. There is no recorded year where the total concentration could exceed this conservative screening value at any modeled facility. The only chronic hazard threshold for terrestrial species would be 77,000 $\mu g/m^3$ for terrestrial mammals. The resulting RQ value would be magnitudes lower than 1 since the average daily concentration for a year would the same as the 1-day average acute concentration. The equal distribution of the release results in an annual daily concentration that is equal to the 1-day average. Additionally, EPA only modeled the maximum reported stack and fugitive releases from TRI facilities because the data would be more representative of the range of reported data across NEI and TRI. The results of this screening model provided enough evidence to support the conclusion that there were no facilities that would result in an RQ value that would be greater than 1 (Table 5-4).

Table 5-4. Terrestrial Risk Estimates Based on Avian Acute Inhalation Hazard TRI Facilities

Conditions of Use	TRIFID	Reporting Year of Highest Stack Release	Highest Daily Stack Release (kg/site-day)	Reporting Year of Highest Fugitive Release	Highest Daily Fugitive Release	Number of Release Days Annually	Total Modeled Concentration (µg/m^3)	RQ Based on Avian Acute Inhalation Hazard Threshold (2.0 µg/m^3)
Manufacture	70805XXNCH4999S	2021	1.3E−02	2019	0	350	1.1E−03	5.3E−04
Processing – Incorporation into formulation, mixture, or reaction product; Processing – As a reactant; and/or Industrial use – Other use	75702LGRL1702E	2023	2.3E−05	2023	8.0E−05	256	2.9E−05	1.4E−05
Processing – Incorporation into formulation, mixture, or reaction product; Processing – As a reactant; and/or Industrial use – Other Use	39567CHVRNPOBOX	2019	0	2021	6.2E−02	256	2.1E−02	1.0E−02
Processing – Incorporation into formulation, mixture, or reaction product; Processing – As a reactant; and/or Industrial use – Other use	55164KCHRFPOBOX	2019	5.3E−03	2019	7.1E−03	256	2.8E−03	1.4E−03
Processing – Incorporation into formulation, mixture, or reaction product; Processing – As a reactant; and/or Industrial use – Other use	70805XXNBT4050S	2019	0.89	2021	0.55	256	0.26	0.13
Processing – Incorporation into formulation, mixture, or reaction product; Processing – As a reactant; and/or Industrial use – Other use	77501THYLC1000N	2019	3.5E−03	2019	2.3E−02	256	1.5E−03	7.4E−04

Conditions of Use	TRIFID	Reporting Year of Highest Stack Release	Highest Daily Stack Release (kg/site-day)	Reporting Year of Highest Fugitive Release	Highest Daily Fugitive Release	Number of Release Days Annually	Total Modeled Concentration (µg/m^3)	RQ Based on Avian Acute Inhalation Hazard Threshold (2.0 µg/m^3)
Processing – Incorporation into formulation, mixture, or reaction product; Processing- As a reactant; and/or Industrial use – Other use	94802CHVRN841ST	2020	6.2E−02	2021	7.1E−03	256	2.7E−02	1.3E−02
Processing – Incorporation into formulation, mixture, or reaction product; Processing – As a reactant; and/or Industrial use – Other use	59101CNBL401SO	2022	0	2023	5.9E−03	256	1.9E−03	9.8E−04
Industrial use – Fuel agent in petroleum refineries and/or Commercial use – Fuels and related products	1204NRLTC628SO	2019	7.5E−05	2020	3.4E−05	365	1.1E−03	5.6E−04
Disposal	43920VNRLL1250S	2019	3.7E−05	2021	5.1E−03	365	1.6E−03	8.3E−04
RQ = risk quotient; TRI = Toxics Release Inventory; TRIFID = Toxics Release Inventory facility identification number								

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5.3.4 Risk Estimates Categorized by Conditions of Use

All calculated values for each of the proceeding subsections are presented above in Table 5-3 and Table 5-4. The proceeding sections contain the risk estimate characterization by COUs.

5.3.4.1 Manufacture – Import COU

The OES relevant to this COU is Import and Repackaging OES. EPA did not identify any risk to aquatic or terrestrial species from any facility identified under this COU. All facilities identified under this COU category resulted in RQ values that were magnitudes lower than 1 for both aquatic and terrestrial exposures. The screening approach for air modeling provided enough information to conclude there was no risk to terrestrial species across all COUs.

5.3.4.2 Processing – Repackaging COU

The OES relevant to this COU (*i.e.,* Import and Repackaging OES) is the same as for the OES that is relevant to Manufacture – Import COU. Therefore, the risk estimates and risk characterization for the Manufacture – Import COU as described above are also applicable to this COU (*i.e.,* Processing – Repackaging COU). There was no risk to aquatic or terrestrial species by a facility identified under this COU.

5.3.4.3 Processing – Incorporation into Formulation, Mixture, or Reaction Product – Fuels and Fuel Additives in All Other Petroleum and Coal Products Manufacturing COU

Another COU identified was the Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in all other petroleum and coal products manufacturing COU. EPA did not identify any risk to aquatic or terrestrial species from any facility identified under this COU. All facilities identified under this COU category were below an RQ of 1 for each air release. The Processing – Incorporation into formulation, mixture, and reaction product COU did not exceed the RQ value of one for the terrestrial species most sensitive hazard threshold. The screening approach for air modeling provided enough information to conclude there was no risk for any COU to terrestrial species. There was one facility identified under this COU category that exceeded an RQ value of 1 for its reported water release (Table 5-3). The facility in question required a refined model to confirm. After modeling the release in PSC, the calculated RQ value was below 1 with the value provided from the PSC model, indicating there was no risk to aquatic species for this COU.

5.3.4.4 Processing – Incorporation into Formulation, Mixture or Reaction Product – Fuels and Fuel Additives in Petroleum Refineries COU

The OES relevant to this COU (*i.e.,* Incorporation into Formulation, Mixture, and Reaction Product OES) is the same as for the OES that is relevant to Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in all other petroleum and coal products manufacturing COU. Therefore, the risk estimates and risk characterization for the Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in all other petroleum and coal products manufacturing COU as described above are also applicable to this COU (*i.e.,* Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in petroleum refineries COU).

5.3.4.5 Processing – As a Reactant COU

The OES relevant to this COU (*i.e.,* Incorporation into Formulation, Mixture and Reaction Product OES) is the same as the OES that is relevant to Processing – Incorporation into formulation, mixture, or reaction product COU. Therefore, the risk estimates and risk characterization for the Processing –

Incorporation into formulation, mixture, or reaction product COU as described above are also applicable to this COU (*i.e.,* Processing – As a reactant COU).

5.3.4.6 Distribution in Commerce COU

EPA did not identify any risk to aquatic or terrestrial species under the Distribution in Commerce COU or its subcategories. The Agency did not model any site-specific release from a site under this COU; however, the screening approach used for terrestrial and aquatic exposures provided enough justification to make this conclusion. There were no site-specific releases identified under this COU for air or water releases.

5.3.4.7 Industrial Use – Fuel Agents in Petroleum Refineries COU

EPA did not identify any risk to aquatic or terrestrial species from any facility identified under Industrial use COU. No facility specific release was identified under this COU; therefore, the Agency did not identify risk to aquatic species under this COU. The screening approach for air modeling did not identify any risk to terrestrial species.

5.3.4.8 Industrial Use – Other Use – Processing Aid Not Otherwise Specified; Pigments and Dye Manufacturing COU

EPA did not identify any risk to aquatic or terrestrial species from any facility identified under Industrial use – Other use COU. No site-specific water release modeled under this COU resulted in an RQ value above 1. The screening approach for air modeling provided enough information to conclude there was no risk to terrestrial species across all COUs.

5.3.4.9 Commercial Use – Fuels and Related Products COU

EPA did not identify any risk to aquatic or terrestrial species from any facility identified under the Commercial use COU or its subcategories. Site-specific water releases under this COU did not result in any risk, with the only facility estimated RQ being magnitudes below 1, indicating there was no risk to aquatic species under this COU. The screening approach for air modeling provided enough information to conclude there was no risk to terrestrial species across all COUs.

5.3.4.10 Commercial Use – Other Use – Laboratory Chemical COU

EPA did not identify any risk to aquatic or terrestrial species from any facility identified under Commercial use – Other use – Laboratory chemical COU. Site specific air and water releases identified under this COU did not result in RQ values above 1 when modeled. The screening approach for air modeling provided enough information to support the conclusion that there was no risk to terrestrial species across all COUs.

5.3.4.11 Disposal COU

All facility releases identified under the Disposal COU resulted in RQ values below 1. RQ values calculated under this COU were magnitudes below 1 for aquatic species, indicating there was no risk to aquatic species under this COU. For the modeled TRI air release identified under this COU, the calculated RQ was below 1. Additionally, the screening approach for air modeling provided enough information to support the conclusion that there was no risk to terrestrial species across all COUs.

5.3.4.12 Consumer Use – Fuels and Related Products COU

EPA did not identify any risk to aquatic or terrestrial species from any facility identified under the consumer use COU or its subcategories. The Agency did not model any site-specific release from a facility identified under this COU.

5.3.5 Environmental Risk Conclusions, Overall Confidence, and Remaining Uncertainties

The overall confidence in the environmental risk characterization synthesizes confidence from both environmental exposures and environmental hazards. Environmental hazard confidence is detailed in the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t) with additional confidence summary presented in Table 5-2.

Aquatic Risk Characterization

EPA identified site-specific water releases used as inputs for surface water column in E-FAST and PSC. The Agency utilized NHDPlus flow database to provide site specific receiving water body flow metrics. The Agency has moderate confidence that the surface water concentration estimates at the point of release are representative of site-specific conditions. E-FAST employs conservative, health-protective approach to estimate the water concentration from flow data available. The calculation is reliant on flow data that could diminish the impact of volatilization when using the E-FAST spreadsheet.

EPA performed a more refined model for sites that exceeded the concentration of concern when calculated concentrations were greater than the concentration of concern from the spreadsheet. The Agency did find that the calculated values in PSC were in fact lower than the values in E-FAST when accounting for other variables that the spreadsheet simply does not have the capability to do. PSC confirms that the E-FAST spreadsheet is in fact a more health-protective estimation, and therefore a more conservative model for the water column concentration calculation. PSC calculates a 1-day average along with averages for chronic timeframes including a 21-day average whereas the E-FAST spreadsheet only calculates one concentration based on the days of operation. The calculated E-FAST concentration represents an acute 1-day average while simultaneously representing the chronic average daily concentration over the days of operation. Each day is treated independently of each other with no accumulation from the previous day resulting in a constant daily average.

This additional refinement further provides lines of evidence that if RQs above 1 existed at any facility the E-FAST calculations would have found these incidences. Furthermore, there is limited monitoring data of ethylene dibromide concentrations in surface water that demonstrates a correlation between release facilities and the location of monitoring data samples. EPA has slight-to-moderate confidence in the aquatic exposure risk since there were many uncertainties due to the lack of chronic hazard data from ethylene dibromide exposure that limited confidence in the chronic COCs. This general lack of chronic data results in slight confidence in the chronic risk estimates; however, EPA has moderate confidence that there are no acute RQs above 1. The calculated acute RQ values are magnitudes below 1, and there is robust confidence in the hazard threshold obtained for the acute timeframes. EPA only calculated resulting water column concentration based on the highest reported release for each facility, which also adds some uncertainty because there can be variances in releases from year to year. Using the maximum reported release is another element of being health protective.

Terrestrial Risk Characterization

EPA identified site-specific releases for air releases used as inputs for modeling air concentrations in IIOAC. The Agency has robust confidence in the IIOAC-modeled results used to characterize exposures. EPA has robust confidence that there is no acute or chronic risk to terrestrial species via inhalation resulting from the COUs. Multiple lines of evidence support this conclusion. EPA used a conservative high-end estimate as a screening approach to evaluate if the maximum reported releases of stack and fugitive releases across all COU would generate RQs above 1 when comparing this value to the most sensitive terrestrial hazard threshold. This modeled scenario represents the most conservative estimate that could result from the release data available. The calculated acute RQ did not exceed 1. The most sensitive acute terrestrial hazard threshold was for avian species. This hazard threshold was

magnitudes lower than the other acute terrestrial hazard thresholds. The RQ values would be magnitudes lower than the calculated RQ for this high release scenario if the other hazard thresholds were used to calculate RQ. The only chronic hazard threshold was reported as 77 mg/m^3 for terrestrial mammals. The average daily concentration estimated over a 365-day release scenario was 1.308 $\mu g/m^3$. The resulting chronic RQ would be less than 0.001. EPA has robust confidence that the modeled scenario represents an upper bound of likely air concentrations. There was moderate-to-robust confidence in the all the terrestrial hazard thresholds. Furthermore, the estimated air calculation is for a proximity of 100 m from the facility. Avian species, along with many terrestrial organisms, are transient in nature, making it unlikely exposures would exceed the concentrations calculated for a period long enough to experience some hazardous effects.

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 under the COUs—without consideration of costs or other non-risk factors—including an unreasonable risk to PESS identified by the Agency as relevant to this risk evaluation. Ethylene dibromide is a colorless heavy liquid and has a mildly sweet, chloroform-like odor (U.S. EPA, 2004b). Ethylene dibromide was previously used industrially and commercially as a lead (Pb) scavenger in gasoline for automotive vehicles and as a soil and crop fumigant; however, due to safety concerns those uses have been mostly phased out. Currently, ethylene dibromide is primarily used in the United States as a lead scavenger in avgas (fuel for piston engine aircraft) and has limited specific commercial uses (*e.g.,* laboratory use) and industrial uses (*e.g.,* as a reactant) (U.S. EPA, 2020b).

Workers may be exposed to ethylene dibromide in their workplaces when handling ethylene dibromide or products containing ethylene dibromide (Section 4.1.1). Only one consumer use was identified for ethylene dibromide, which is the refueling of private planes/handling of avgas where the primary function of ethylene dibromide is to increase the octane level and prevent engine knock (Wells and Wells, 2014). If released into air, ethylene dibromide will largely remain volatile but also might undergo indirect photodegradation or wet deposition onto land or water (Section 3.3.4). Should ethylene dibromide be released into surface water, it will likely remain soluble and volatilize out of the water column and into the atmosphere (Section 2.2); the portion that remains in surface water will undergo biodegradation and volatilize out of the water column. Ethylene dibromide is unlikely to bioaccumulate or bioconcentrate in exposed organisms (Section 2.2).

EPA evaluated 12 COUs for ethylene dibromide. The Agency has preliminarily determined that 10 COUs significantly contribute to unreasonable risk of ethylene dibromide to human health, specifically for workers (via inhalation and dermal exposure) and ONUs (via inhalation). EPA did not preliminarily identify unreasonable risk to consumers (Section 6.1.4) or the general population, including fenceline communities (Section 6.1.5).

The Agency did not preliminarily identify unreasonable risk of injury to the environment due to exposures through environmental media such as air, soil, or surface water (*e.g.,* reproductive effects to aquatic invertebrates, growth, and developmental effects to algae) under the COUs.

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

The unreasonable risk determination is informed by science. 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—including PESS) and the confidence in the information used to inform the hazard and exposure values. This draft risk evaluation discusses important assumptions and key sources of uncertainty in the preliminary risk characterization. These are described in more detail in the respective weight of scientific evidence conclusions sections: environmental concentrations (Section 3.3), environmental exposures (Section 5.1), environmental hazards (Section 5.2), and human health

hazards (Section 4.2). It also includes overall confidence and remaining uncertainties sections for human health (Section 4.3.7) and environmental risk characterizations (Section 5.3.5).

Workers and ONUs

EPA evaluated 12 COUs for ethylene dibromide, listed in Table 1-1. The Agency preliminarily determined that ethylene dibromide presents an unreasonable risk of injury to human health due to non-cancer and cancer risk to population group(s) such as workers and ONUs from inhalation and/or dermal exposures driven by 10 of the 12 COUs under TSCA.

EPA has preliminarily determined that the following 10 COUs significantly contribute to unreasonable risk to human health for workers:

- Manufacture – Import (inhalation and dermal)
- Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in all other petroleum and coal products manufacturing (inhalation and dermal)
- Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in petroleum refineries (inhalation and dermal)
- Processing – As a reactant – *E.g.,* in Pigment and dye manufacturing; Plastic material and resin manufacturing (inhalation and dermal)
- Processing – Repackaging (inhalation and dermal)
- Industrial use – Fuel agents in petroleum refineries (inhalation)
- Industrial use – Other use – Processing aid otherwise not specified, Pigment and dye manufacturing (inhalation and dermal)
- Commercial use – Other use – Laboratory chemical (inhalation and dermal)
- Commercial use – Fuels and related products (inhalation)
- Disposal (dermal).

For the nine COUs where EPA identified unreasonable risk to workers from inhalation exposure, when workers wear respirators that achieve a minimum APF 10 to 1,000 (depending on the expected workplace activity) or use other exposure controls (*e.g.,* engineering controls) equally or more effective in reducing worker exposures, the unreasonable risk identified from inhalation exposure would no longer be unreasonable. Similarly, for eight COUs with dermal risk, dermal protections (*e.g.,* gloves) that demonstrate an impervious barrier to ethylene dibromide during expected durations of use and normal conditions of exposure within the workplace—accounting for potential chemical permeation, penetration, or breakthrough times, as identified in the "Hand Protection" section of OSHA's Personal Protective Equipment Guidance and in alignment with the OSHA Hand Protection PPE Standard (29 CFR 1910.138)—would also be expected to reduce dermal exposures such that they are no longer unreasonable.

Four COUs also have significant contributions to the preliminary unreasonable risk determination for ethylene dibromide due to identified unreasonable risk to ONUs from inhalation exposure:

- Manufacture – Import;
- Processing – Repackaging;
- Industrial use – Fuel agents in petroleum refineries; and
- Commercial use – Other use – Laboratory chemical.

The two COUs for which EPA has preliminarily determined do *not* significantly contribute to unreasonable risk of ethylene dibromide are

- Distribution in commerce; and

- Consumer use – Fuels and related products.

Consumers

EPA evaluated risk to consumers (aged 16+ years) from inhalation and dermal exposures under one COU (*i.e.,* Consumer use – Fuels and related products). The Agency has preliminarily determined ethylene dibromide does not significantly contribute to unreasonable risk to consumers based on EPA's assessment.

General Population

EPA evaluated risk of injury to the general population due to exposures via air and water pathways. The general population risk characterization for ethylene dibromide involved quantitative analysis of risk to evaluate non-cancer and cancer risks for the general population. The Agency's analysis did not indicate any non-cancer risk for the general population. Inhalation cancer risk was indicated with excess individual cancer risk in the range of 1.0×10^{-6} to 1.0×10^{-4} (Section 4.3.5.1.1), with a yearly additional cancer cases found to be below 0.1 (2.69×10^{-3} for ethylene dibromide) for the populations surrounding the facilities, including fenceline communities. The Agency has preliminarily determined ethylene dibromide does not significantly contribute to unreasonable risk to the general population, including fenceline communities.

Environment

EPA evaluated risk of injury to the environment due to exposures via ambient air and surface water. The environmental risk characterization for ethylene dibromide involved quantitative analysis of risk to aquatic species via surface water releases. The Agency also estimated exposures to terrestrial mammals from air releases. EPA did not identify risk to aquatic or terrestrial species from any facility identified under any COU or its subcategories. The Agency has preliminarily determined ethylene dibromide does not present unreasonable risk of injury to the environment.

6.1 Unreasonable Risk to Human Health

Calculated non-cancer risk estimates (MOE[3] or cancer risk estimates[4]) can provide a risk profile of ethylene dibromide by presenting a range of estimates for different health effects for different COUs. When characterizing the risk to human health from exposures during risk evaluation under TSCA, EPA conducts baseline assessments of risk and makes its determination of unreasonable risk in a manner that takes into consideration reasonably available information (*e.g.,* stakeholder information). The baseline assessment allows EPA to make unreasonable risk determinations based on the information regarding workers wearing PPE where the Agency has such reasonably available information. In some cases, baseline conditions may reflect certain mitigation measures, such as engineering controls, in instances where exposure estimates are based on monitoring data at facilities that have such controls in place. In addition, risk estimates are based on workplace exposure scenarios, including monitoring data that reflect existing OSHA workplace requirements (*i.e.,* OSHA permissible exposure limits [PELs]) and industry or sector exposure controls. In this draft risk evaluation, the preliminary risk estimates calculated reflect exposure to ethylene dibromide both with and without PPE—including information on PPE that could be used to reduce the exposures. EPA identified some PPE information for certain ethylene dibromide COUs, which is further described in Section 4.3.3. In general, the Agency does not have enough confidence in the prevalence of respirator use (Section 4.3.3.1) or in the duration or frequency of use for those wearing respirators (examples provided but not limited to Sections 4.3.3.1.1, 4.3.3.1.2, 4.3.3.1.3) to consider respiratory PPE use to be sufficient and comprehensive. As described in

[3] EPA derives non-cancer MOEs by dividing the non-cancer POD (HEC [mg/m^3] or HED [mg/kg-day]) by the exposure estimate (mg/m^3 or mg/kg/day). Section 4.3.1.1 has additional information on the risk assessment approach for human health.
[4] Section 4.3.1.2 explains how cancer risk estimates for ethylene dibromide are calculated.

Section 4.1.1.6, EPA did not identify sufficient information to consider dermal PPE in these risk assessments. The Agency will consider any additional information received on PPE use in the development of the final risk evaluation for ethylene dibromide.

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. An MOE less than the benchmark MOE indicates non-cancer risk and is a starting point for informing a determination of unreasonable risk of injury to health. Similarly, a calculated cancer risk estimate greater than the cancer benchmark is a starting point for informing a determination of unreasonable risk of injury to health from cancer. Inhalation cancer risk estimates represent the incremental increase in probability of an individual in an exposed population developing cancer over a lifetime (excess lifetime cancer risk [ELCR]) following exposure to the chemical. EPA considers a range of extra cancer risk from 1.0×10^{-4} to 1.0×10^{-6} to be relevant benchmarks for risk assessment (U.S. EPA, 2017). Consistent with NIOSH guidance (Whittaker et al., 2016), under TSCA the Agency applied a 1.0×10^{-4} benchmark for occupational scenarios in industrial and commercial work environments subject to OSHA.

6.1.1 Populations and Exposures EPA Assessed for Human Health

EPA evaluated risk to workers (aged 16+ years) and ONUs; consumers (aged 16+ years); and 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 evaluated risk from inhalation and dermal exposure to workers, inhalation exposure to ONUs, and inhalation and dermal exposure to consumers. Finally, the Agency evaluated risk via (1) incidental surface water ingestion during swimming, drinking water, fish ingestion (including subsistence and tribal fishers); (2) dermal exposure to surface water during swimming; and (3) inhalation of ethylene dibromide in ambient air resulting from industrial releases to the general population. EPA's evaluation of the general population included populations living near facilities releasing ethylene dibromide to the ambient air, which includes fenceline communities, as part of the ambient air exposure assessment.

EPA also evaluated PESS, described in Section 4.3.6 and shown in Table 4-36. The Agency identified the following relevant PESS groups: males and females of reproductive age and their offspring, workers exposed to ethylene dibromide, individuals with certain genetic polymorphisms, and individuals with other co-exposures. EPA was able to incorporate considerations for multiple PESS factors into risk estimates through the use of exposure factors, uncertainty factors (Ufs), and PESS group-specific data.

Descriptions of the data used for human health exposure are provided in Section 4.1. Uncertainties for overall exposures are presented in the respective occupational, consumer, and general population exposure sections of this draft risk evaluation and are considered in the unreasonable risk determination.

6.1.2 Summary of Human Health Effects

EPA has preliminarily determined that ethylene dibromide presents unreasonable risk to human health due to non-cancer and cancer effects in the following populations:

- non-cancer and cancer risk to workers from inhalation and/or dermal exposures; and
- non-cancer and cancer risk to ONUs from inhalation exposures.

EPA derived an oral slope factor and an inhalation unit risk for ethylene dibromide through dose-response modeling of available rodent cancer bioassay data on this chemical. The inhalation unit risk was extrapolated to a dermal cancer slope factor through route-to-route extrapolation because the dermal bioassay results were not appropriate for dose-response modeling given the uncertainty in the magnitude of the dermal exposures. EPA also selected PODs for non-cancer endpoints observed following

exposure to ethylene dibromide. In selecting a benchmark MOE for the selected non-cancer POD, EPA considered recommendations for application of uncertainty factors from existing Agency guidance. For oral exposures, the acute and intermediate benchmark MOE for ethylene dibromide is 30. For inhalation exposures, the acute and intermediate benchmark MOEs are 100, and the chronic benchmark MOE is 30. For dermal exposures, the acute and intermediate benchmark MOEs are 100 and the chronic benchmark MOE is 30. Derived from the total uncertainty factors, these benchmark MOEs are considered protective given the reasonably available information as described in Section 4.2.

The overall confidence in the selected POD for each exposure duration and route is summarized in Section 4.2.6. The most sensitive adverse health effects of ethylene dibromide exposure are cancer effects. Other critical health effects include reproductive and developmental toxicity, liver toxicity, and gastrointestinal toxicity. EPA has determined that protecting at the cancer endpoint would also address the risk for other acute or chronic non-cancer endpoints resulting for all routes of exposure. The Agency's exposure and overall risk characterization confidence levels again varied from moderate-to-high and are summarized in Table 4-37 and Section 4.3.7.

The health risk estimates for workers and ONUs (Table 4-28 and Table 4-30), consumers (Table 4-31 and Table 4-32), and for the general population (Table 4-35) are characterized in Section 4.3. The human health risk characterization in Section 4.3.7 describes respective confidence and identified uncertainties for each scenario. Section 4.2.7 also describes EPA's selection of benchmark MOEs for use in different risk estimates and the respective confidence and identified uncertainties for each scenario.

6.1.3 Basis for the Unreasonable Risk to Workers

Based on the occupational risk estimates and related risk factors, EPA has preliminarily determined that 10 COUs significantly contribute to unreasonable risk to workers from inhalation and/or dermal exposure to ethylene dibromide. Four of those 10 COUs significantly contribute to the unreasonable risk to ONUs from exposure to ethylene dibromide via inhalation. All but 3 of the 10 COUs (*i.e.,* Industrial use – Fuel agents in petroleum refineries [inhalation only]; Commercial use – Fuels and related products [inhalation only]; and Disposal [dermal only]) have significant contributions to unreasonable risk to workers from both dermal and inhalation exposures.

In this draft risk evaluation, EPA calculated risk estimates for both central tendency and high-end exposure levels for workers and ONUs. Risk estimates based on high-end exposure levels are generally intended to address individuals exposed at sentinel exposure levels, whereas risk estimates at the central tendency exposure are intended to cover average or typical worker exposure. To determine whether a specific COU significantly contributes to the unreasonable risk, EPA considers chemical-specific information and risk-related factors—including how the central tendency and high-end risk estimates best represent each COU. Overall risk characterization confidence presented in Table 4-37 is indicated as moderate for all worker and ONU associated COUs (Section 4.3.7.1). For nine COUs where PBZ or area monitoring data are available and with sufficient confidence to support a preliminary risk determination, based on the reasonably available information as well as the Agency's confidence and uncertainties described earlier in this draft risk evaluation, EPA considers both central tendency and high-end exposures, as appropriate, for shorter durations (*i.e.,* acute and intermediate) and central tendency exposures for longer durations (*e.g.,* chronic and cancer) as well as the bases of its preliminary unreasonable risk determination for workers and ONUs for all inhalation exposures. For one COU (*i.e.,* Commercial use – Fuels and related products) where EPA's preliminary unreasonable risk determination is based on modeled inhalation exposure estimates, the Agency's determination considers both the low-end and high-end risk estimates. EPA's preliminary unreasonable risk determination for ethylene

dibromide is driven by non-cancer risk for two COUs (*i.e.,* Import and Repackaging) and cancer risks from chronic inhalation and/or dermal exposures for all 10 COUs.

EPA estimated inhalation exposure in the occupational scenarios (except for the Commercial use – fuels and related products COU) using a TWA for a typical 8-hour shift (see Section 4.1.1.5) for workers. EPA estimated dermal exposure to average adult workers using a deterministic modeling approach (see Section 4.1.1.6). Estimates of central tendency (or "low-end" for the Commercial use – fuels and related products COU refueling scenario as described in Section 4.1.1.5) and high-end inhalation exposures were estimated for workers directly working with ethylene dibromide as well as separate estimates for inhalation exposures for ONUs not directly handling ethylene dibromide, as appropriate. Based on the COUs of ethylene dibromide and their associated worker activities, EPA does not expect workers to be younger than 16 years old. Non-cancer risk estimates were calculated for acute, intermediate, and chronic exposures. For all COUs except for the Commercial use – Fuels and related products COU, acute refers to an exposure timeframe of one 8-hour workday, intermediate refers to an exposure timeframe of 22 workdays (8 hours per day) over 30 days, and chronic refers to an exposure timeframe of 250 days per year for 31 to 40 years (8 hours per day). For the Commercial use – Fuels and related products COU, acute refers to an exposure timeframe of 5.3 minutes (1 aircraft refueling event/day) to 42.4 minutes (8 aircraft refueling events/day) within an 8-hour workday, intermediate refers to an exposure timeframe of 22 workdays (1–8 aircraft refueling events/day) over 30 days, and chronic refers to an exposure timeframe of 250 days per year for 31 to 40 years (1–8 aircraft refueling events/day).

6.1.3.1 Nine COUs with Significant Contributions to Unreasonable Risk from Inhalation Exposures

Import and Repackaging OES – COUs Covered by Inhalation Monitoring Data

EPA has preliminarily determined that the following two COUs significantly contribute to unreasonable risk to both workers and ONUs driven by high-end non-cancer acute and intermediate inhalation risk (MOEs = 41 and 45 for acute and 56 and 62 for intermediate exposures with a benchmark MOE of 100, for workers and ONUs, respectively) and cancer inhalation risk based on central tendency exposures (cancer risk estimates were 2.1×10^{-3} for workers and 3.6×10^{-4} for ONUs):

- Manufacture – Import; and
- Processing – Repackaging.

Ethylene dibromide is not manufactured in the United States and is primarily imported to the United States at a concentration range from 30 to 60 wt% in TEL-B for fuel use (*i.e.,* Commercial use – Fuels and related products COU; Industrial use – Fuel agents in petroleum refineries COU). Some ethylene dibromide is imported to the United States at 100 wt% for other uses (*i.e.,* Commercial use – Other use – Laboratory chemical COU, Processing – As a reactant COU). For the inhalation exposure assessment of these two COUs, EPA used exposure monitoring data from literature (as described in 4.3.3.1.1) from 1977 to1980 specific to worker activities relevant for these COUs. The dataset used for this assessment contained some exposure monitoring data gathered from facilities that manufactured ethylene dibromide at a higher concentration (*i.e.,* 100 wt%) than the majority of facilities identified for current use under this OES. The dataset also contained exposure monitoring data gathered from ethylene dibromide processing facilities where ethylene dibromide was used at a concentration range (*i.e.,* 18–35 wt%) more relevant to the majority of current ethylene dibromide imports (*i.e.,* 30–60 wt%). Although EPA considers the central tendency risk estimates representing worker activities (*e.g.,* loading, shipping) at those ethylene dibromide manufacturing and processing facilities to be the more representative of the majority of facilities, EPA identified SDSs reporting up to 100 wt% of ethylene dibromide and identified market information showing bulk ethylene dibromide imports at higher concentrations (*e.g.,* 98 wt%) in recent years (Sigma-Aldrich, 2024; TradeData.Pro, 2022). Therefore, the Agency expects that ethylene

dibromide is still imported and repackaged at a much higher concentration than TEL-B imports and so high-end risk estimates representing facilities that manufactured ethylene dibromide at a higher concentration (*i.e.,* 100 wt%), coupled with the likelihood that there could be short-term, high-end exposure, was used for EPA's preliminary risk determination for acute and intermediate durations under these two COUs.

Based on the Agency's confidence in the exposures, and informed by inhalation monitoring data selected based on worker activities that are relevant to both COUs from ethylene dibromide manufacturing and processing sites, acute non-cancer risk for both workers and ONUs were identified for these COUs. EPA has less confidence in high-end exposures occuring for longer durations (*i.e.,* chronic, non-cancer as well as chronic, cancer). This is due in part to the Agency receiving information from one facility that suggests this activity may occur periodically throughout a year making continuous exposure (*i.e.,* more than acute or intermediate) less likely. However, this may not reflect all facilities considered in this OES under these COUs. Therefore, EPA's has preliminarily determined the Manufacture – Import as well as Processing – Repackaging COUs significantly contribute to the unreasonable risk of ethylene dibromide due to both non-cancer (*i.e.,* acute and intermediate) and cancer risks from inhalation exposures. As described in Table 4-3, where data types used to inform OES-specific analysis is provided, an important uncertainty with this assessment is that the monitoring data EPA used for this assessment are nearly 50 years old (*i.e.,* from 1977) and there is lack of evidence on how the practices have changed. Exposure potential may have changed since 1977.

Incorporation into Formulation, Mixture, or Reaction Product OES – COUs Covered by Inhalation Monitoring Data

EPA has preliminarily determined that the following four COUs significantly contribute to unreasonable risk to workers (no risk to ONUs) driven by cancer inhalation risk based on central tendency exposures (cancer risk estimates of 4.4×10^{-4}):

- Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in all other petroleum and coal products manufacturing;
- Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in petroleum refineries;
- Processing – As a reactant – *E.g.,* in Pigment and dye manufacturing; Plastic material and resin manufacturing COUs; and
- Industrial use – Other Use – Processing aid not otherwise specified; Pigment and dye manufacturing.

EPA assessed exposures and risks for these COUs using OES-specific monitoring datasets as described in Section 4.3.3.1.2. The Agency expects that the majority of ethylene dibromide processing facilities produce avgas. Workers in general are not expected to be exposed at the high-end value or 95th percentile of ethylene dibromide exposure concentration from this assessment on a daily basis, but rather infrequently—though it is plausible that a small percentage of workers (*e.g.,* 5% or less) may be exposed at concentrations closer to the upper-bound estimates of this assessment on a daily basis. Because the monitoring dataset used for this assessment is over 50 years old, there is uncertainty with how the workplace practices, including engineering controls, may have changed over time (described in Section 4.3.3.1.2). Thus uncertainty may impact how the exposure distributions to ethylene dibromide have changed in current facilities compared to the older facilities.

The high-end estimates are based on a statistically high percentage that originates from datapoints specific to certain activities (*e.g.,* drum washing) that may or may not be practiced the same way as in the past (1977–1980). In a majority of ethylene dibromide processing facilities, ethylene dibromide is

processed in batch operation and not continuous operations. There is uncertainty with the duration of each batch operation and the number of batches processed in a facility on a typical workday. EPA assumed that the activities for an average worker on a typical workday are continuous for 8 hours, which may be an upper-bound assumption for facilities where batch operations are much shorter in duration and workers switch from activities related to ethylene dibromide processing to other job responsibilities where exposure concentration is not at the same level. Furthermore, due to the lack of data on number of exposure days, EPA assumed 250 days per year as maximum exposure frequency value for estimating chronic exposures. This is an upper-bound assumption, and these assumptions in conjunction with high-end exposure concentration value may result in high-end exposure estimates that may be less representative than central tendency exposure estimates for longer exposure scenarios (*i.e.,* chronic non-cancer and cancer) under this OES.

For these COUs, no non-cancer risk was identified at the high-end or central tendency exposures for acute and intermediate. High-end risk was indicated for chronic non-cancer exposures with an MOE slightly below benchmark (MOE = 93). However, due to the lack of clear evidence on the applicability of high-end exposure scenarios based on the ongoing use of ethylene dibromide under this OES, central tendency estimates are more appropriate for use in risk determination for chronic non-cancer and cancer risks. There are also uncertainties with how the workplace practices, including engineering controls, may have changed over time because the dataset used for this assessment is nearly 50 years old. Central tendency estimates were based on the 50th percentile of ethylene dibromide exposure concentrations from the same dataset and are expected to be more representative of potential acute, intermediate, and chronic level exposures to workers involved in the processing of ethylene dibromide. Although there is still uncertainty due to the age of the monitoring data, the central tendency value from this assessment is a more representative and appropriate exposure estimate for frequent, repeated inhalation exposure (*i.e.,* chronic) for workers than the high-end value for the assessment of cancer risks for the same reasons. EPA has preliminarily determined that these four COUs significantly contribute to the unreasonable risk to workers driven by inhalation cancer risk based on central tendency exposures.

Additionally, though the upper-bound concentration of ethylene dibromide under the Processing – As a reactant – *E.g* in Pigment and dye manufacturing; Plastic material and resin manufacturing COU (*i.e.,* 10–100 wt%) is expected to be used at neat concentration (*i.e.,* 100 wt%), there is a lack of information on the process descriptions and statistical distribution of ethylene dibromide concentration used under this COU or worker activities relevant to this COU. Therefore, central tendency estimates are more appropriate to represent chronic exposure potential for various worker activities under this COU.

Laboratory COU Covered by Inhalation Monitoring Data

EPA has preliminarily determined that the following COU significantly contributes to unreasonable risk to both workers and ONUs driven by cancer inhalation risk based on central tendency exposures (cancer risk estimates of 5.6×10^{-4} for workers and ONUs):

- Commercial use – Other use – Laboratory chemical.

For this COU, EPA did not find exposure monitoring data from an isolated laboratory facility where no other ethylene dibromide use-related activities occur near the site. The Agency used reasonably available exposure monitoring data (data gathered in the 1970s; described in Section 4.3.3.1.5) from laboratory sites located near other sites (*i.e.,* manufacturing and processing) where the laboratories were in either a separate building or area but within the same facility complex. Therefore, there is uncertainty regarding the representation of ethylene dibromide concentrations (*i.e.,* PBZ) from monitoring data used for this COU because secondary exposure to ethylene dibromide from nearby sites could also be possible. There are also uncertainties with how workplace practices, including engineering controls, may

have changed over time because the dataset used for this assessment is nearly 50 years old. Consequently, central tendency estimates of inhalation exposure are expected to be more representative of chronic level exposures to workers involved in the laboratory use of ethylene dibromide because EPA expects that laboratory use of ethylene dibromide at high concentrations is very limited based on the information identified (*i.e.,* environmental release information from programmatic database, stakeholders feedback). Exposures at the 95th percentile of ethylene dibromide exposure concentration from this assessment are not expected to occur on a daily basis, but rather infrequently as suggested by the statistically high percentile value. No non-cancer risk was identified at the high-end or central tendency for acute and intermediate exposures. EPA has preliminarily determined that this COU significantly contributes to the unreasonable risk to both workers and ONUs driven by cancer inhalation risk based on central tendency exposures (no risk from non-cancer effects).

COU Assessed Using Modeling

EPA is preliminarily determining that the following COU significantly contributes to unreasonable risk to workers driven by cancer inhalation risk based on the low-end and high-end exposures (cancer risk estimates of 1.1×10^{-4} for workers at the low-end and 1.1×10^{-3} for workers at the high-end):

- Commercial use – Fuels and related products.

For this COU, EPA assessed three exposure scenarios based on the variation of windspeeds in the United States:

- Low exposure scenario (high windspeed representing 95th percentile);
- Medium exposure scenario (medium windspeed representing 50th percentile); and
- High exposure scenario (low windspeed representing 5th percentile)

For each of these three exposure scenarios, EPA estimated separate low- and high-end estimates based on the different assumptions on the number of exposure events per day and number of working years (see Section 4.3.3.1.3 for more details) For low-end exposure estimates, the Agency assumed a worker is exposed to ethylene dibromide once per day from a single aircraft refueling activity and works for 31 years. For high-end exposure estimates, EPA assumed a worker is exposed to ethylene dibromide eight times per day from refueling eight aircraft and works for 40 years. The Agency is using the low- and high-end estimates from the medium exposure scenario (medium windspeed, 50th percentile windspeed in the United States) for the basis of its risk determination. Both low- and high-end exposure estimates are considered plausible because there is a large variation in the number of exposure events per day for this scenario depending on location, demand, season, and uncertainty with the tenure of workers.

Based on the analysis, EPA assumed that on average, a refueler worker may refuel one to eight aircraft per day within an 8-hour work shift. Therefore, the worker may be exposed to ethylene dibromide one to eight times per day during the refueling activity for 250 days per year over 31 to 40 years. For ONUs, EPA determined there is no unreasonable risk because they are farther from the refueling or exposure source, and the exposure is expected to be significantly lower than a worker in ambient conditions under the medium exposure scenario as explained in Section 4.3.3.1.4.

COUs Assessed Using Surrogate Monitoring Data

EPA has preliminarily determined that the following COU significantly contributes to the unreasonable risk to both workers and ONUs driven by cancer inhalation risk based on the central tendency exposures (cancer risk estimates of 1.1×10^{-4} for workers at the low-end, 1.1×10^{-3} for workers at the high-end, and 1.1×10^{-4} for ONUs):

- Industrial use – Fuel agents in petroleum refineries.

For the Industrial use – Fuel agents in petroleum refineries COU, no non-cancer risk was identified at the high-end or central tendency for acute and intermediate exposures. EPA generally has higher confidence in the central tendency exposure estimates than the high-end estimates for longer durations (*i.e.,* chronic non-cancer and cancer) because of uncertainties with the representativeness of the high-end exposure estimates. The Agency made two assumptions to use reasonably available surrogate monitoring data from petroleum products bulk terminals for this assessment. First, the assessment assumes that some of the bulk terminals storing ethylene dibromide containing fuel may have vapor recovery (VR) systems and others do not. Therefore, EPA used monitoring data on petroleum products VOC released from bulk terminals where some of the bulk terminals had VR systems in place and others did not. Second, the assessment assumes that avgas is stored at bulk terminals with similar operations and worker activities for storing other petroleum products (*e.g.,* jet fuel). Because the surrogate data are from petroleum products and are not specific to avgas or ethylene dibromide-containing fuel, EPA adjusted the exposure concentrations to represent ethylene dibromide exposure by factoring in the concentration of ethylene dibromide, composition of avgas, and physical and chemical properties of each component in avgas.

The high-end estimates assume that ethylene dibromide concentration in avgas is 0.1 wt%, whereas the central tendency estimates assume that ethylene dibromide concentration in is 0.085 wt%. EPA identified that the majority of avgas contains ethylene dibromide avgas at 0.07 wt% concentration. Workers in general are not expected to be exposed at the high-end value or 95th percentile of ethylene dibromide exposure concentration from this assessment on a daily basis, but rather infrequently—though it is plausible that a small percentage of workers (*e.g.,* <5%) may be exposed at concentrations closer to the upper-bound estimates of this assessment on a daily basis. This is mainly because the upper-bound concentration of ethylene dibromide used in this assessment (*i.e.,* 0.1 wt%) is much higher than majority of avgas used (0.7 wt%) and the surrogate dataset used for this assessment has a wide range of exposure concentrations, depending on certain factors (*e.g.,* presence of vapor recovery systems). The upper-bound concentrations from surrogate monitoring dataset represent scenarios where engineering controls are lacking or less effective in controlling exposures.

Consequently, central tendency estimates were based on the ethylene dibromide concentration that is more representative of the majority of avgas used and 50th percentile of ethylene dibromide exposure concentrations from the surrogate dataset that has exposure concentrations gathered from different facilities with various levels of engineering controls. The 50th percentile value of the surrogate dataset presents exposure concentrations in consideration of both the presence of vapor recovery systems to limit exposure and the lack of vapor recovery systems. Because there is uncertainty regarding the presence and extent of engineering controls in place at bulk terminals where ethylene dibromide containing fuel are stored, the central tendency value from this assessment is also more representative and appropriate for a frequent, repeated inhalation exposure (*i.e.,* chronic non-cancer and cancer) for workers than the high-end value for the assessment of cancer risks for the same reasons.

COU Assessed Quantitively That Does Not Contribute to Unreasonable Risk from Inhalation Exposure

For the last COU in this category, Disposal, EPA has preliminarily determined that this COU does not significantly contribute to unreasonable risk to workers and ONUs from inhalation exposure to ethylene dibromide. For determining risk from inhalation exposure at ethylene dibromide wastewater treatment (WWT) facilities, EPA used PBZ data for ethylene dibromide from a facility in Turkey and PBZ data for 1,2-dichloroethane exposure obtained from a facility in Finland. For the assessment of risk at landfills where ethylene dibromide may be disposed, the Agency used area data for 1,2-dichloroethane exposure

obtained from a landfill in Greece. EPA preliminarily determined that there is no inhalation risk for workers from activities occuring at landfills receiving municipal and industrial waste containing ethylene dibromide. Because the Agency did not identify monitoring data from the United States with ethylene dibromide concentration data that could provide a reliable range of inhalation exposure concentrations that a worker may experience during activities related to disposal, the concentration of ethylene dibromide present at wastewater treatment plants and landfills receiving waste containing ethylene dibromide is uncertain. EPA considers central tendency values of exposure estimates to be most representative of workers chronic exposure as there are uncertainties with assumptions (*e.g.,* worker activities, exposure duration, exposure frequency) made for this assessment, as discussed in Sections 4.3.3.1.6.

6.1.3.2 Eight COUs with Significant Contributions to Unreasonable Risk from Dermal Exposures

EPA has preliminarily determined that the following eight COUs significantly contribute to unreasonable risk to workers due to cancer dermal risk based on the central tendency exposures (cancer risk estimates range from 2.2×10^{-3} to 4.7×10^{-3} for workers) and/or acute non-cancer risk based on high-end exposures (MOE = 84 with benchmark MOE of 100):

- Manufacture – Import (cancer);
- Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in all other petroleum and coal products manufacturing (cancer);
- Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in petroleum refineries (cancer);
- Processing – As a reactant – *E.g.,* in Pigment and dye manufacturing; Plastic material and resin manufacturing (cancer and non-cancer);
- Processing – Repackaging (cancer and non-cancer);
- Industrial use – Other use – Processing aid otherwise not specified, Pigment and dye manufacturing (cancer and non-cancer);
- Commercial use – Other use – Laboratory chemical (cancer); and
- Disposal (cancer and non-cancer).

Because ethylene dibromide is a volatile liquid that evaporates from the skin, EPA conducted a screening-level assessment to estimate dermal exposures using the DEVL Model to calculate retained doses of ethylene dibromide to the skin. The deterministic model calculates an acute retained dose rate based on an assumed amount of liquid ethylene dibromide on skin during one contact event per day. EPA did not identify data on fractional absorption of ethylene dibromide on skin and, therefore estimated a fractional absorption of 0.016 using IH SkinPerm tool. As discussed above and within Section 4.2.5, the default approach converts animal oral and inhalation toxicity values to HEDs with allometric scaling, which is often applied when there is a dearth of chemical-specific data. Because the PBPK approach converts between internal and external dose, it captures a more relevant magnitude of effects from exposure conditions such as route of exposure and thus increases confidence in estimated dermal HEDs compared to the default approach with scaled HEDs.

EPA derived dermal risk estimates using a deterministic calculation. The deterministic exposure assessment model used a single set of representative parameters but did not address variability in exposure duration and frequency. The Agency derived dermal human equivalent hazard doses to calculate risks using a default approach and a PBPK modeling approach, as described above in Section 4.2.5, as well as in the *Draft Human Health Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t). Specifically, while the default approach primarily uses allometric scaling, which assumes physiological processes scale with body size, PBPK modeling is able to consider time-dependent

changes in the systemically absorbed dose under defined exposure conditions. These are then compared to the retained dose estimates, thereby allowing estimation of exposure scenario-specific-HEDs. Understanding how different exposure scenario assumptions may result in different bioavailability of ethylene dibromide via dermal exposure and HEDs provides greater confidence in the PBPK risk estimates. EPA used the deterministic exposure assessment model in combination with hazard values derived by PBPK modeling approach as the basis for the unreasonable risk determination for ethylene dibromide.

EPA is preliminarily basing its unreasonable risk determination for dermal exposures to workers on high-end exposures for short-term durations (*i.e.,* acute and intermediate) and on central tendency exposures for chronic durations (*i.e.,* non-cancer, and cancer). The high-end exposure estimates were identified as more appropriate than the central tendency estimates for calculating non-cancer, acute, and intermediate risk because high-end estimates are based on the upper bound use concentration of ethylene dibromide for each COU EPA identified, and it is plausible that a worker is exposed to the upper-bound concentration of ethylene dibromide once (*i.e.,* acute) or for a brief period of time (*i.e.,* intermediate, 22 days). Central tendency exposure estimates were identified as more appropriate than the high-end exposure estimates for calculating dermal cancer risks for uses due to differences in the magnitude and frequency of expected workplace exposures for frequent, repetitive use for over a year (*i.e.,* non-cancer) or during the entire tenure (*i.e.,* cancer).

For Disposal COU, EPA preliminarily determined that the central tendency estimates for dermal exposures significantly contribute to unreasonable risk to workers and are driven by cancer dermal risks. Central tendency exposure estimates were identified as more appropriate than high-end exposure estimates for calculating dermal cancer risks, as the majority of ethylene dibromide use is at a much lower concentration than neat (*i.e.,* 100 wt%) and the high-end estimates are based on neat concentration. The concentration of ethylene dibromide used for the central tendency estimates is 50 wt%. Also, for chronic, cancer exposures (*i.e.,* 31–40 years) under this COU, the likeliness of a worker having dermal contact with liquid ethylene dibromide every workday on a skin surface area equivalent of both hands is lower than the likeliness of dermal exposure to skin surface area equivalent to one hand for central tendency estimates.

Occupational dermal risk estimates did not assume the use of gloves or other types of controls (see Section 4.3.3.2) and may overestimate dermal exposures. EPA did not have sufficient information to assume the use of ethylene dibromide chemically resistant gloves to apply PPE for any COU.

COUs Assessed Quantitively That Do Not Contribute to Unreasonable Risk from Dermal Exposure

For the two COUs covered by the Fuels and Related Products OES—Industrial use – Fuel agent in petroleum refineries COU; and Commercial use – Fuels and related products COU—PBPK simulations for central tendency and high-end levels of exposure resulted in formulation of ethylene dibromide in the refueling scenario being too low for any exposure to reach the internal dose metric. This caused the predicted HED to approach an infinite value. These results indicate that the internal dose of ethylene dibromide resulting from the refueling scenario is unlikely to reach the POD (Section 4.3.3.2.3). As a result of this PBPK analysis, EPA preliminarily determined that dermal exposures from these two COUs do not significantly contribute to unreasonable risk.

Based on the uncertainties described in Section 4.3.7.1, EPA has moderate confidence that the dermal risk estimates generated by the model are sufficient for determining whether a COU presents unreasonable risk. In cases where the Agency based its preliminary unreasonable risk determination on

the dermal route, EPA determined that cancer risk significantly contributes to unreasonable risk for workers.

COU Assessed Qualitatively That Does Not Contribute to Unreasonable Risk

The following COU does not significantly contribute to the determination of unreasonable risk of injury to human health for workers or ONUs:

- Distribution in commerce.

For this COU, EPA characterized the risk by integrating limited amounts of reasonably available information in a qualitative characterization. For purposes of assessment in this draft risk evaluation, Distribution in commerce consists of the transportation associated with moving ethylene dibromide or ethylene dibromide containing products between manufacturing, processing, and use sites, or the transportation of ethylene dibromide containing wastes to recycling sites or for final disposal. EPA expects all ethylene dibromide or ethylene dibromide-containing products to be transported in a closed system such that there is limited potential for releases except during an incident. Based on this qualitative characterization in 4.3.3.1.3, the Agency does not expect this COU to contribute to the unreasonable risk of ethylene dibromide due to negligible human exposures during distribution in commerce.

6.1.3.3 No Significant Contributions to Unreasonable Risk from Aggregate Exposures

EPA considered aggregate non-cancer and cancer risks from inhalation and dermal exposures to ethylene dibromide for all COUs assessed for workers.

The non-cancer aggregation of risks for all COUs is described in Appendix F.3. For non-cancer risk, aggregation of risks by duration (*i.e.,* acute, intermediate, and chronic) did not affect whether the margin of exposure (MOE) was above or below the benchmark—except for the Commercial use – Other use – Laboratory chemical COU for intermediate duration as described in Appendix F.3.1.2. However, due to many uncertainties with the aggregate risk assessment for intermediate duration for Commercial use – Other use – Laboratory chemical COU, EPA preliminarily determined there is no significant contribution to unreasonable risk to workers for this COU from aggregate exposure at intermediate durations. This is mainly due to the lack of information EPA identified to accurately characterize risk of this scenario. There is uncertainty about worker activities, frequency of using neat ethylene dibromide at laboratory facilities, the assumption of continuous inhalation exposure to ethylene dibromide during a full workday, and the assumption that a worker may be exposed to a skin surface area equivalent to 1 hand during every workday in 30 days. Based on the limited information EPA identified, the Agency does not expect the ongoing use of ethylene dibromide in laboratory settings to result in any significant contribution to unreasonable risk for intermediate duration.

EPA also explored aggregate exposure assessment for cancer risks for workers as described in Appendix F.3. However, as discussed previously (Section 4.3.2), there is significant uncertainty in aggregating cancer risks from inhalation and dermal exposures. For instance, though ethylene dibromide is a direct-acting mutagen and systemic tumor effects are possible, when aggregating cancer risks across routes of exposure the most sensitive findings are portal-of-entry effects, which are less suitable for cross-route aggregation. Additionally, the supporting animal data are based on relatively high doses, which introduces some uncertainty in how well those data support aggregation across routes at lower exposure levels. EPA acknowledges that the current PBPK model does not account for dose loss at the route of entry, which may overestimate systemic internal dose during route-to-route extrapolation. Therefore, the Agency is basing the preliminary unreasonable risk determination for ethylene dibromide on the specific routes of exposure for each COU instead of on the aggregated cancer risk values. Furthermore, for no COUs was the risk from inhalation and dermal both below the cancer risk threshold of 1×10^{-4} and the

aggregate risk above the threshold. For all scenarios where there was aggregate risk, there was also risk from one of the component pathways, such that the overall conclusion regarding unreasonable risk was unchanged. For further details on the aggregate assessment, see Appendix F.

6.1.4 Basis for the No Unreasonable Risk to Consumers

Based on risk estimates and related risk factors, EPA has preliminarily determined that the one consumer COU, Consumer Use – Fuels and Related Products, does not significantly contribute to unreasonable risk. The Agency makes this preliminary determination by having assessed inhalation and dermal exposure to ethylene dibromide during aircraft refueling. EPA does not expect ingestion to be significant and therefore did not estimate oral exposure. Given the use, the Agency assessed exposure to people 16 years and older.

As described in Section 4.1.2, EPA assessed inhalation exposure at low-, medium-, and high-intensity scenarios, with a range of values used for each scenario briefly summarized below. Low-intensity exposure represents pilots flying to meet the minimum requirements to maintain a pilot license based on the FAA's requirement for retaining pilot licensing (14 CFR part 61 subpart F); medium-intensity exposure represents pilots flying for leisure, recreation, or other personal use (U.S. EPA, 2025c); and high-intensity exposure represents consumer pilots flying as many hours as recreational pilots working toward a commercial pilot certificate (14 CFR part 61 subpart F), which reflects a greater number of annual flight time per year (at least 250 hours). The three scenarios considered for refueling were for 12 days/year for 14 years, 26 days/year for 32 years, and 52 days/year for 56 years for low-, medium-, and high-intensity, respectively. Low-, medium-, and high-intensity scenarios were assessed based on a weight fraction of ethylene dibromide in avgas of 0.07, 0.085, and 0.1%, respectively. EPA used wind speeds of 4.49, 2.99, and 1.79 m/s (10, 6.5, and 4 mph) for the low-, medium-, and high-intensity scenarios, respectively, to estimate the ethylene dibromide concentration in the breathing zone because the refueling activity occurs outdoors, and wind speed is inversely proportional to ethylene dibromide concentration in the air. Because the parameters used for consumer inhalation exposures were identical for both adults and youths, EPA did not estimate inhalation risk separately for each age group. No risk was indicated (*i.e.,* no MOEs below the benchmark MOE) for non-cancer effects for any scenario (Table 4-31). Cancer risk estimates for all three scenarios fell within the cancer benchmark range. EPA considers a range of extra cancer risk from 1.0×10^{-4} to 1.0×10^{-6} to be relevant benchmarks for risk assessment of consumers.

Although these three scenarios are informed by real world weight fractions (*i.e.,* EPA identified SDSs for avgas that confirmed the presence of ethylene dibromide) and potential consumer use patterns (*i.e.,* considers a single exposure per day resulting in 12, 26, or 52 exposure days per year intermittently), the Agency considers the medium-intensity scenario representing pilots flying for leisure, recreation, or other personal use to be most representative. Therefore, it is the basis for EPA's preliminary risk determination for consumers. The inhalation cancer risk estimate for the medium-intensity is 1.16×10^{-5} based on 26 days per year and personal pilots averaging approximately 100 flight hours annually (U.S. EPA, 2025c). Given the individual cancer risk estimates are within EPA's cancer benchmark range for consumers, it warrants consideration of the confidences and uncertainties that inform the Agency's estimate in making this preliminary determination of no unreasonable risk.

EPA acknowledges that without consumer monitoring data there is uncertainty with the assumption of 26 days/year of refueling as it can vary across the country and may depend on the season. Additionally, for the consumer assessment, the Agency considered FAA regulations in developing certain consumer exposure input (*e.g.,* FAA's requirement for retaining pilot licensing; 14 CFR part 61 subpart F) or the age of consumers being exposed (14 CFR 61.83). Although this helps inform EPA's exposure

assessment, there is uncertainty in how the number of flight days directly relate to the number of refueling scenarios (*e.g.,* fueling can fluctuate based on various factors, including actual fuel use per day, weather conditions, wind speed, altitude, and the specific model of the aircraft). Lastly, EPA also calculated excess cancer cases based on ethylene dibromide inhalation cancer risk using the maximum potential consumer pilot population (264,000 pilots) described in Section 4.3.4.1 (Table 4-31) resulting in 0.0054, 0.0406, and 0.2302 excess cancer cases per year for the low-, medium-, and high-intensity scenarios, respectively. It is important to note that the proportion of consumer pilots who refuel their own aircraft is unknown and that these estimates of extra cancer cases are based on all potential consumer pilots in the United States who hold a pilot certificate—whether they actually fly or not. Therefore, using the full population may result in an overestimation of cancer cases.

Based on the strengths and limitations described above and due to EPA's conservative risk estimates still being within the cancer benchmark range for consumer risk, the Agency has preliminarily determined the Consumer use – Fuels and related products COU does not significantly contributes to the unreasonable risk from ethylene dibromide.

As described in Section 4.1, dermal exposure monitoring data were not reasonably available for consumers. For the assessment of dermal exposure for consumers, EPA used the same approach as described for workers under the Commercial use – Fuels and related products COU in Section 6.1.3.2. The Agency has moderate overall confidence in the non-cancer (acute and intermediate) and cancer risk estimates for consumers' inhalation and dermal exposure across low-, medium-, and high-intensity scenarios. For the dermal risk determination, EPA used PBPK modeling (a more refined estimate for exposure scenario-specific HEDs for risk characterization), which predicted no dermal risk for consumers as described in Section 4.3.4.2.

6.1.5 Basis for the No Unreasonable Risk to the General Population

Based on the draft risk estimates calculated using releases from processing, industrial, and commercial uses of ethylene dibromide, as well as related risk factors, EPA has preliminarily determined that ethylene dibromide presents no unreasonable risk of injury to the general population. This preliminary determination is based on considerations of cancer risks from inhalation of ethylene dibromide and from other assessed routes of exposure (dermal exposure from swimming, drinking water exposure, fish ingestion, and incidental oral ingestion from swimming). Although cancer risk was identified within the cancer risk benchmark (*i.e.,*1.0×10^{-6} to 1.0×10^{-4}) for the general population, EPA has preliminarily determined that these facilities do not significantly contribute to unreasonable risk for the reasons discussed below. The maximum yearly cancer incidence for a census block, as determined by HEM modeling from an NEI release, was 2.69×10^{-3}, and the greatest risk from a facility was 1.76×10^{-5}, as described in greater detail below and previously in Section 4.3.7.3.1. Additionally, the non-cancer risk estimates for ambient air exposure for fenceline communities do not drive unreasonable risk to the general population for any pathway. All non-cancer screening-level risk estimates were above the chronic non-cancer benchmark; therefore, there is no expectation of non-cancer risks to the general population from TRI or NEI facility releases based on this screening level assessment (U.S. EPA, 2026t).

Ambient Air

Ambient air was the primary pathway of concern for risk to the general population, including fenceline communities, from ethylene dibromide. EPA applied a tiered approach to assessing general population exposures to ethylene dibromide via the ambient air pathway. The Agency used IIOAC and HEM to conduct the top tier of modeling with facility and process-specific parameters. EPA identified several facilities presenting cancer risk above 1.0×10^{-6} to the surrounding communities from ambient air

releases. However, considering all relevant risk-related information and uncertainties, EPA has preliminarily determined that ethylene dibromide exposures to the general population do not contribute to unreasonable cancer risk from inhalation exposure under these COUs (the reasons are discussed below). Cancer risk estimates for ambient air exposures indicated an increased cancer risk for seven COUs at or above 1 in 1,000,000 to 1 in 10,000 (*i.e.,* risk estimates from 1.02×10^{-6} to 1.76×10^{-5}):

- Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in all other petroleum and coal products manufacturing;
- Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in petroleum refineries;
- Processing – As a reactant – *e.g.,* in Pigment and dye manufacturing; Plastic material and resin manufacturing;
- Industrial use – Fuel agents in petroleum refineries;
- Industrial use – Other use – Processing aid otherwise not specified, Pigment and dye manufacturing;
- Commercial use – Fuels and related products; and
- Disposal.

For risk to the general population, EPA typically considers an increased cancer risk above 1 in 1,000,000 to 1 in 10,000 (*i.e.,* 1.0×10^{-6} to 1.0×10^{-4}). Again, these estimates are not treated as a "bright line," and other risk-based factors are considered (*e.g.,* confidence in the hazard and exposure characterization, duration, magnitude, uncertainty, and populations exposed) for the purpose of making an unreasonable risk determination. Table 4-33 shows all facilities under seven COUs that modeled results indicate risk to the general population within the 1.0×10^{-6} to 1.0×10^{-4} range, the maximum individual risks, the number of people within each census block with cancer risk above certain benchmarks, and excess cancer cases for populations surrounding those facilities. The facility releases resulted in increased maximum cancer risk estimates within the cancer range resulting in a maximum estimated 2.7×10^{-3} excess cancer cases per year for the populations living within 50 km of the facilities (see Table 4-33). The risk estimates for the general population all being within the risk range, with the maximum risk estimate being 1.76×10^{-5} for the Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in petroleum refineries COU, fall below the cancer risk benchmark of 1 in 10,000 considered for the risk determination indicating low risk. In addition, the lifetime additional cancer cases for ethylene dibromide were found to be well below 0.1 (2.7×10^{-3}), which is not considered unreasonable. Based on the evidence above and the robust confidence EPA has in the overall ambient air assessment for ethylene dibromide, the Agency finds ethylene dibromide does not significantly contribute to unreasonable risk to the general population.

EPA's analytical framework under TSCA is similar to other EPA programs (*e.g.,* the Clean Air Act, Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA]), which include consideration of other relevant risk-related information and uncertainties such as overall excess cancer cases as well as number of persons exposed within each individual lifetime risk range. As required by TSCA, EPA also considers PESS. EPA used NEI and TRI data to assess ambient air inhalation risks to the general population. EPA used IIOAC to evaluate exposures and then HEM to characterize risk to populations living near releasing facilities (fenceline communities). Risk estimates based on AERMOD modeling were calculated for the 10th, 50th, and 95th percentile exposures for each facility at each modeled distance (*i.e.,* 100–1,000, 1,000, and 2,500 m) and utilized TRI-reported releases (2019–2023), NEI-reported releases (2017 and 2020), and EPA-estimated releases for generic facilities/sites. Unlike IIOAC, which does not consider whether populations may or may not be living near releasing facilities, HEM combines U.S. Census data with estimated ambient air concentrations to calculate maximum individual risks and the number of people within each census block with cancer risk above certain

benchmarks. HEM was run using TRI and NEI data for all reported years considered. HEM results were calculated using the daily averages of hourly estimated concentrations averaged across 365 days that account for the conditions of that specific facility location, such as prevailing winds and local meteorology.

Based on EPA's analysis, there are seven COUs (*i.e.,* Processing – Incorporation into formulation, mixture, or reaction product; Processing – As a reactant; and/or Industrial use – Other use, Industrial use – Fuel agent in petroleum refineries and/or Commercial use – Fuels and related products, and Disposal) where the facility releases resulted in increased maximum cancer risk estimates within or above this cancer range. This maps to three OESs: Incorporation into Formulation, Mixture, or Reaction Product; Fuels and Related Products; and Waste Handling, Treatment, and Disposal (mapping of COUs and OES available in Table 3-2). The Incorporation into Formulation, Mixture or Reaction Product and the Fuels and Related Products were the OESs that represented most of the 13 facilities resulting in people in the surrounding communities having an inhalation cancer risk greater than 1 in 1,000,000. In addition, one facility from the Waste Handling, Treatment, and Disposal OES resulted in risk 1.02×10^{-6}. The HEM modeling predicted that 20,707 people across all OESs that are represented in TRI and NEI would have an inhalation cancer risk greater than 1 in 1,000,000 across all reporting years included in this analysis (Table 4-33). No facilities had resulting cancer risk above 1 in 10,000. The total additional lifetime cancer cases based on risk and the populations impacted was 2.2×10^{-1} across all facilities.

Of the 20,707 people with cancer risk above 1 in 1,000,000, 17,552 were due to air releases of ethylene dibromide from a single facility that reported to NEI in California. The highest yearly cancer incidence from this facility was 2.69×10^{-3}, which is the highest cancer incidence from all facilities releasing ethylene dibromide. This number was determined by multiplying the cancer risk from this facility (9.69×10^{-6}) by the population impacted by this risk (17,552), then dividing that by the estimated lifetime used in HEM (70 years). Regardless of whether a facility reports a release in a given reporting year, the Agency assumed these single reported releases (*i.e.,* a population of 17,552 surrounding a California facility in 2017) are ongoing activities. The facility resulting in the highest incidence rate was from the Fuels and Related Products OES, and there was a resulting inhalation cancer risk of 9.69×10^{-6} and 1.88×10^{-1} additional lifetime cancer cases resulting from this facility's releases of ethylene dibromide. This drives the majority of the population exposed to increased cancer risk from ethylene dibromide air releases, based on a 2017 reported release. The facility did not report releases in 2020, but preliminary NEI data show releases from this facility were reported in 2023 at levels similar to 2017, demonstrating that the estimated inhalation risk resulting from ethylene dibromide releases at this facility is relevant for this draft risk evaluation.

As described in Section 4.3.7.3.1, EPA described various strengths and limitations regarding the ambient air general population risk estimate analysis. Overall, the Agency has robust confidence in risk estimates calculated using release data reported to both TRI and NEI (TRI-reported releases [2019–2023]; NEI-reported releases [2017 and 2020]) and that the risks are representative of actual exposures to the general population living near releasing facilities and PESS. EPA's robust confidence is based on high levels of confidence in underlying TRI and NEI release information used to estimate exposures, the completeness of the datasets modeled, and the modeling methods (IIOAC and HEM) used. Additionally, the use of HEM allowed for the characterization of populations living near facilities and provided strong evidence for distances that are most relevant for general population exposure.

Although the model does not account for photodegradation, while indirect photodegradation is expected to occur slowly in the air (see Section 2.2), there is potential that the model may be overestimating exposure and risk due to air releases. As noted above, the modeled scenario informing both the radial

distance and HEM estimates is based on continuous inhalation (24 hours/day) of ambient air concentrations over a lifetime (*i.e.,* 70–78 years) using the inputs from the highest release year for the facility. There is uncertainty in the assumption of continuous ethylene dibromide exposure from ambient air to an individual all day, year-round, for their entire lifetime. This uncertainty extends to whether people spend a lifetime living in proximity to the specific facilities where risks are highest to ethylene dibromide ambient air concentrations from releasing facilities. Yearly additional cancer cases estimates are likely to be representative of these populations, but lifetime additional cancer case estimates can be an overestimation based on the assumed scenario.

Surface Water

EPA estimated exposures to ethylene dibromide via the oral route from drinking water exposures, fish ingestion exposures, and incidental ingestion from swimming in receiving water bodies. EPA then assessed possible risk from dermal exposures via swimming in surface waters receiving facility discharges from COU/OES. No general population risks were identified from the surface water pathway, including from drinking water, incidental ingestion from swimming, dermal exposure from swimming, and fish ingestion.

EPA used E-FAST to model surface water concentrations at the point of discharge using reported (TRI and DMR) and modeled facility-specific releases along with flow data NHDPlus flow database. The Agency has robust confidence in the surface water concentrations of ethylene dibromide using this method. Using this concentration data and assuming a 0% drinking water removal rate as a conservative assumption in this screening assessment, EPA estimated exposures via drinking water, incidental ingestion during swimming, and dermal exposure during swimming. EPA also used these surface water concentrations to estimate fish ingestion exposures. This surface water analysis resulted in MOEs several magnitudes above benchmark MOEs in all surface water exposure pathways, even for the most sensitive groups (including infants, toddlers, adolescents, and tribal populations). Also, cancer risk from drinking water exposure, assuming 0% drinking water removal and drinking water uptake at the point of discharge as conservative assumptions for the screening assessment, was below 1.0×10^{-6}.

Based on the assumptions made, EPA has robust confidence that the risk estimates resulting from the high-end exposures are protective of various life stages, PESS, and Tribal nations. However, there are uncertainties and potential conservatisms considered in the risk characterization and in EPA's preliminary determination of no unreasonable risk to the general population from the surface water pathway. Additional information on the Agency's overall confidence and uncertainties for the general population risk estimates for surface water can be found in Section 4.3.7.3. EPA is requesting comments on its approach for assessing surface water exposure for the general population which will be used to inform the Agency's final risk evaluation for ethylene dibromide.

6.2 Unreasonable Risk to Environment

Based on the risk evaluation for ethylene dibromide—including the risk estimates, the environmental effects of ethylene dibromide, the exposures, physical and chemical properties of ethylene dibromide, and consideration of uncertainties—EPA has preliminarily determined ethylene dibromide does not present unreasonable risk of injury to the environment.

For environmental pathways that were quantitatively assessed, EPA evaluated whether the potential releases and resultant exposures of ethylene dibromide in water or air will exceed the concentrations that result in hazardous effects for aquatic or terrestrial organisms, respectively. EPA characterized the environmental risk of ethylene dibromide using risk quotients (RQs) from the IIOAC screening

approach for terrestrial exposure and the final refined concentrations from the PSC aquatic concentrations modeling.

Calculated RQs can provide a risk profile by presenting a range of estimates for different environmental hazard effects for different COUs. An RQ equal to 1 indicates that the exposures are the same as the concentration that causes effects. An RQ less than 1, when the exposure is less than the effect concentration, generally indicates that there is no risk of injury to the environment that would support a determination of unreasonable risk for ethylene dibromide. An RQ greater than 1, when the exposure is greater than the effect concentration, generally indicates that there is risk of injury to the environment that would support a determination of unreasonable risk for ethylene dibromide. Additionally, if a chronic RQ is 1 or greater, the Agency evaluates whether the chronic RQ is 1 or greater for 256 days of release before making a determination of unreasonable risk. EPA's assessment of risk to the environment for ethylene dibromide did not result in any RQ above 1 after refinements were made to incorporate facility specific information as opposed to modeled input for one facility.

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 ethylene dibromide and concentrations of ethylene dibromide in the environment as part of its environmental risk assessment. Ethylene dibromide is expected to be released to the environment via air and water. Because the physical and chemical properties of ethylene dibromide indicate that it is not expected to be persistent or to sorb to soil and sediment, it has moderate migration potential to groundwater. Ethylene dibromide will have limited persistence and is expected to undergo moderate biodegradation in surface water. Given these characteristics and reasonably available data, the environmental risk characterization for ethylene dibromide involved quantitative analysis of risk to aquatic and terrestrial species via exposure pathways from surface water and air, respectively.

Ambient air and surface water were determined to be the drivers of exposure to ethylene dibromide for terrestrial and aquatic species, respectively. Release information confirmed that these were the main release pathways from facilities that reported releases for ethylene dibromide.

As explained in Section 5.3.1, EPA used a screening level approach in this risk evaluation to evaluate risk to terrestrial species using conservative environmental release estimates for occupational COUs with the highest releases to determine whether there is risk to the environment. The Agency first characterized risk based upon the COU with the highest estimated concentrations for a given pathway, based on the OES and the associated environmental media assessed in the risk evaluation. If this exposure concentration did not exceed the hazard thresholds harmful to organisms, EPA based the risk determination on this maximum exposure scenario to be most inclusive and protective by encompassing the exposures from other COUs within the OES.

6.2.2 Summary of Environmental Effects

EPA has preliminarily determined that none of the COUs assessed for ethylene dibromide significantly contribute to unreasonable risk to the environment, as environmental concentrations are well below identified environmental hazard thresholds. Reasonably available data for ethylene dibromide allowed for the identification of hazard thresholds for a variety of receptor groups (aquatic and terrestrial) and

exposure durations (acute and chronic) that increase confidence in the risk determination for this chemical (Table 5-2). Limited data was available for aquatic organisms under chronic exposure durations, which decreased confidence in the risk determination for longer exposures in surface water. EPA has preliminarily determined that the effects of ethylene dibromide to aquatic organisms, including fish and invertebrates, do not present an unreasonable risk to the environment. EPA has also preliminarily determined that the effects to terrestrial organisms, including terrestrial mammals, birds and invertebrates via inhalation, do not present an unreasonable risk to the environment. More information about EPA's confidence in the aquatic and terrestrial hazard assessments are provided in Section 5.3.5 of this draft risk evaluation.

6.2.3 Basis for No Unreasonable Risk to the Environment

EPA has preliminarily determined that ethylene dibromide does not present an unreasonable risk to the environment for both aquatic and terrestrial organisms.

Basis for No Unreasonable Risk to Aquatic Organisms

As discussed in Section 5.3.2, EPA evaluated the effect of ethylene dibromide exposure through surface water releases to aquatic organisms; the Agency notes that aquatic invertebrates appear more sensitive under acute conditions (acute invertebrate concentration of concern [COC] = 190 µg/L) than vertebrate species (acute vertebrate COC = 550 µg/L). Risk was characterized by comparing hazard thresholds (COCs) for aquatic organisms to modeled surface water exposures from (1) DMR data for OESs mapped to COUs with facility-specific data; (2) modeled data from generic scenarios of water releases for OESs mapped to COUs with water releases, but no facility- specific data; and (3) modeled data from generic scenarios of water releases from OESs mapped to COUs with multimedia releases that did not distinguish among wastewater, incineration, or landfill. The Agency evaluated the calculated RQs, the modeled surface water concentrations, and the confidence in the exposure and hazard assessments to determine unreasonable risk to the environment. EPA modeled surface water concentrations of ethylene dibromide for all facilities that reported surface water releases to TRI and DMR, where all facilities but one did not indicate RQs greater than 1. The surface water releases for the single facility that resulted in RQs above 1 for both acute and chronic exposures to aquatic organisms were then used to estimate surface water concentrations using PSC (detailed further below), which did not result in acute or chronic RQs above 1 for aquatic organisms. EPA determined that none of the facilities that reported surface water releases of ethylene dibromide contribute to unreasonable risk to the environment.

Modeled Surface Water Exposure Using Facility-Specific Data: Based on the screening assessment for COUs with generic scenarios of water releases described below, EPA determined that the following refinement to estimate surface water concentrations was necessary to better characterize when preliminary RQs above 1 were identified.

EPA modeled surface water concentrations using E-FAST, which used facility-specific water release reported via TRI or DMR. For the water pathway, different hydrological flows were used for different exposure scenarios. To estimate aquatic exposure, a 7Q10 flow (lowest 7-day flow [on average] that occurs in a 10-year period) was used to estimate exceedances of COCs for aquatic life (U.S. EPA, 1991). Regarding E-FAST estimations of surface water concentrations, given the use of such site-specific and reported release data, EPA has moderate confidence in the quantitative assessment for the site-specific releases but low confidence for the sites where industry normal values were used to assume flows.

EPA refined the estimate for water column concentrations using PSC for the single facility that preliminarily identified acute and chronic RQs above 1. PSC accounts for impacts of volatilization and

other physical and chemical properties of ethylene dibromide. The results from PSC produced water column concentration of 30.5 µg/L 1-day average and 30.0 µg/L 21-day when modeled over the span of 256 operating days, which were lower than the E-FAST estimates. The 21-day average represents an average concentration over a 21-day period, which is representative of a chronic timeframe. The RQ values from this analysis were 0.70 and 0.83 for chronic vertebrates and invertebrates, respectively. With the results from the PSC refined modeling, EPA demonstrated that risk to aquatic organisms was not identified for any COUs that had surface water releases.

Basis for No Unreasonable Risk to Terrestrial Species

EPA did not identify risk to terrestrial species because the RQ did not exceed 1 for any of the terrestrial species. The most sensitive species were the avian species that had an RQ value of 0.654. It is also unlikely that these species would have exposure to concentrations approaching or exceeding the value modeled due to the transient nature of avian species and the concentration modeled representing a value that would be expected only in close proximity (100 m) to the releasing facility. EPA estimated the air concentrations of ethylene dibromide by using the maximum release values reported from 2017 to 2023 for each TRI facility because the range of TRI releases would capture the releases of the NEI facilities that typically report lower combined releases, see Table 5-1. As a screening approach, EPA modeled the highest reported stack and the highest reported fugitive releases of ethylene dibromide from two different facilities as one point source to represent the highest concentration possible as a screening approach air across all COUs based on TRI data. The resulting source-apportioned concentration was 1.308 µg/m^3 and resulted in an RQ less than 1 when compared to the most sensitive hazard threshold of 2.0 µg/m^3. This screening approach based on the maximum total air release estimates demonstrated that there would be no RQ exceeding 1 at any other facility that reported air releases to TRI and/or NEI, when considering that releases are spatially and temporally aligned. Additionally, the other hazard thresholds are at least 15,000 times higher than 2.0 µg/m^3, suggesting that no additional refinements to estimate air concentrations were needed.

EPA conducted a quantitative assessment of ethylene dibromide in ambient air to determine if there was potential risk for terrestrial species. The Agency the IIOAC Model as a tier one analysis to estimate daily average and annual average concentrations of ethylene dibromide in the ambient air. EPA expects ambient air exposure for terrestrial organisms for all COUs to be negligible and due to the finding that no terrestrial hazard thresholds are exceeded by the estimated air concentrations of ethylene dibromide, there is no unreasonable risk to the environment. The primary limitations of the AMTIC data are presented in this ambient air exposure assessment. The data has not been annualized and therefore represents a diverse collection of sampling durations (none of which are annual averages) that are not directly comparable to either IIOAC-, HEM-, or AirToxScreen-modeled data. Additionally, because monitored data represents a total aggregate concentration from all sources of ethylene dibromide contributing to ambient air concentrations, the AMTIC data cannot be associated with the COUs for purposes of characterizing exposures from the COUs.

EPA has robust confidence in the IIOAC modeling used in this assessment to evaluate high-end, health protective exposure scenarios to inform whether there are exposures that would warrant further refined analysis or if exposures of concern are identified and requiring further analysis. Strengths of this ambient air exposure assessment include use of actual environmental release data across multiple years that are reported by industry, as required by statute, and undergo repeatable quality control reviews. The estimated ambient air concentrations represent health-protective estimates of exposure to terrestrial species and are likely overestimated values of actual concentrations.

EPA has robust confidence in the exposures modeled for the terrestrial species and aquatic species. The Agency used peer-reviewed modeling tools and equations available to produce these modeled concentrations. EPA assessed these exposures using health-protective assumptions, which was confirmed with the monitoring data available for review. The Agency did not identify risk to terrestrial or aquatic species from any facility identified under any COU or its subcategories. EPA will incorporate additional refinements or data received during the public comment period and following SACC review.

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 by identifying the type of effect (*e.g.,* non-cancer and cancer for human health) as well as the exposure route to the population or receptor that results in such significant contribution presented in this draft chemical risk evaluation. In Table 6-1, the bolded/shaded values indicate that a COU significantly contributes to the unreasonable risk for workers and/or ONUs. The identified PPE (noted in parentheses in Table 6-1) indicates the minimum identified controls needed in the absence of other exposure controls (*e.g.,* engineering controls) such that the risk is no longer unreasonable. If EPA did not identify unreasonable risk under the COU when considering all reasonably available information and risk-related factors substantiating the use of the known to be used, the numbers are not bolded/shaded.

6658 **Table 6-1. Supporting Basis for the Preliminary Unreasonable Risk Determination to Workers and ONUs for Ethylene Dibromide**

COU	OES	Population	Exposure Level	Inhalation Risk Estimates (with APF to Address Risk [a])				PBPK Dermal Risk Estimates			
				Acute, Non-Cancer (Benchmark MOE = 100)	Inter. Non-Cancer (Benchmark MOE = 100)	Chronic, Non-Cancer (Benchmark MOE = 30)	Lifetime Cancer (Benchmark 1.0E−04)	Acute, Non-Cancer (Benchmark MOE = 100)	Inter. Non-Cancer (Benchmark MOE = 100)	Chronic, Non-Cancer (Benchmark MOE = 30)	Lifetime Cancer (Benchmark = 1.0E−04)
Manufacture – Import	Import and Repackaging (2-Hands, 45–60 wt%)	Worker	CT	1,100	1,500	130	**2.1E−03 (APF 25)**	654	892	75	**3.9E−03**
			HE	**41 (APF 10)**	**56 (APF 10)**	4.8	7.2E−02	148	202	18	2.0E−02
		ONU	CT	6,375	8,693	745	**3.6E−04 (APF 10)**	N/A	N/A	N/A	N/A
			HE	**45 (APF 10)**	**62 (APF 10)**	5.3	6.5E−02	N/A	N/A	N/A	N/A
Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in all other petroleum and coal products	Incorporation into Formulation, Mixture, or Product (2-Hands, 30–60 wt%)	Worker	CT	5,219	7,117	610	**4.4E−04 (APF 10)**	1,005	1,370	115	**2.6E−03**
			HE	796	1,085	93	3.7E−03	148	202	18	2.0E−02
		ONU	CT	7.2E04	9.8E04	8,389	3.2E−05	N/A	N/A	N/A	N/A
			HE	3,585	4,889	419	8.2E−04	N/A	N/A	N/A	N/A
Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in petroleum refineries	Incorporation into formulation, mixture, or reaction product (2-Hands, 30–60 wt%)	Worker	CT	5,219	7,117	610	**4.4E−04 (APF 10)**	1,005	1,370	115	**2.6E−03**
			HE	796	1,085	93	3.7E−03	148	202	18	2.0E−02
		ONU	CT	7.2E04	9.8E04	8,389	3.2E−05	N/A	N/A	N/A	N/A
			HE	3,585	4,889	419	8.2E−04	N/A	N/A	N/A	N/A

COU	OES	Population	Exposure Level	Inhalation Risk Estimates (with APF to Address Risk [a])				PBPK Dermal Risk Estimates			
				Acute, Non-Cancer (Benchmark MOE = 100)	Inter. Non-Cancer (Benchmark MOE = 100)	Chronic, Non-Cancer (Benchmark MOE = 30)	Lifetime Cancer (Benchmark 1.0E−04)	Acute, Non-Cancer (Benchmark MOE = 100)	Inter. Non-Cancer (Benchmark MOE = 100)	Chronic, Non-Cancer (Benchmark MOE = 30)	Lifetime Cancer (Benchmark = 1.0E−04)
Processing – As a reactant (*E.g.* in Pigment and dye manufacturing; Plastic material and resin manufacturing)	Incorporation into Formulation, Mixture or Reaction Product (2-Hands, 55–100 wt%)	Worker	CT	5,219	7,117	610	**4.4E−04 (APF 10)**	521	711	61	**4.7E−03**
			HE	796	1,085	93	3.7E−03	**84**	115	11	3.3E−02
		ONU	CT	7.2E04	9.8E04	8,389	3.2E−05	N/A	N/A	N/A	N/A
			HE	3,585	4,889	419	8.2E−04	N/A	N/A	N/A	N/A
Processing – Repackaging	Import and Repackaging (2-Hands, 50–100 wt%)	Worker	CT	1,106	1,508	129	**2.1E−03 (APF 25)**	581	792	67	**4.3E−03**
			HE	**41 (APF 10)**	**56 (APF 10)**	4.8	7.2E−02	**84**	115	11	3.3E−02
		ONU	CT	6,375	8,693	745	**3.6E−04 (APF 10)**	N/A	N/A	N/A	N/A
			HE	**45 (APF 10)**	**62 (APF 10)**	5.3	6.5E−02	N/A	N/A	N/A	N/A
Industrial use – Fuel agents in petroleum refineries	Fuels and Related Products – Bulk Terminals (2-Hands, 0.09–0.1 wt%)	Worker	CT	6,482	8,839	757	**3.5E−04 (APF 10)**	–	–	–	–
			HE	2,168	2,957	253	1.4E−03	–	–	–	–
		ONU	CT	6,482	8,839	757	**3.5E−04 (APF 10)**	N/A	N/A	N/A	N/A
Industrial use – Other use (Processing aid not otherwise specified; Pigment and dye manufacturing)	Incorporation into Formulation, Mixture or Reaction Product (2-Hands, 55–100 wt%)	Worker	CT	5,219	7,117	610	**4.4E−04 (APF 10)**	521	711	61	**4.7E−03**
			HE	796	1,085	93	3.7E−03	**84**	115	11	3.3E−02
		ONU	CT	7.2E04	9.8E04	8,389	3.2E−05	N/A	N/A	N/A	N/A
			HE	3,585	4,889	419	8.2E−04	N/A	N/A	N/A	N/A

COU	OES	Population	Exposure Level	Inhalation Risk Estimates (with APF to Address Risk [a])				PBPK Dermal Risk Estimates			
				Acute, Non-Cancer (Benchmark MOE = 100)	Inter. Non-Cancer (Benchmark MOE = 100)	Chronic, Non-Cancer (Benchmark MOE = 30)	Lifetime Cancer (Benchmark 1.0E−04)	Acute, Non-Cancer (Benchmark MOE = 100)	Inter. Non-Cancer (Benchmark MOE = 100)	Chronic, Non-Cancer (Benchmark MOE = 30)	Lifetime Cancer (Benchmark = 1.0E−04)
Commercial use – Other use – Laboratory chemical	Laboratory Use (2-Hands, 50–100 wt%)	Worker	CT	4,099	5,589	479	5.6E−04	581	793	67	4.3E−03
			HE	131	178	15	2.3E−02	84	115	11	3.3E−02
Commercial use – Other use – Laboratory chemical	Laboratory Use (1-Hand, 50–100 wt%)	Worker	CT	4,099	5,589	479	**5.6E−04 (APF 10)**	1,206	1,645	135	**2.2E−03**
			HE	131	178	15	2.3E−02	171	233	22	1.6E−02
Commercial use – Other use – Laboratory chemical	Laboratory Use (50–100 wt%)	ONU	CT	4,099	5,589	479	**5.6E−04 (APF 10)**	N/A	N/A	N/A	N/A
Commercial use – Fuels and related products	Fuels and Related Products – Refueling, Medium Exposure (2-Hands, 0.09–0.1 wt%)	Worker	LE	2.1E04	2.9E04	2,481	**1.1E−04 (APF 10)**	–	–	–	–
			HE	2,656	3,621	310	**1.1E−03 (APF 25)**	–	–	–	–
Commercial use – Fuels and related products	Fuels and Related Products – Refueling, Medium Exposure (1-Hand, 0.09–0.1 wt%)	Worker	LE	2.1E04	2.9E04	2,481	**1.1E−04 (APF 10)**	–	–	–	–
			HE	2,656	3,621	310	**1.1E−03 (APF 25)**	–	–	–	–

COU	OES	Population	Exposure Level	Inhalation Risk Estimates (with APF to Address Risk [a])				PBPK Dermal Risk Estimates			
				Acute, Non-Cancer (Benchmark MOE = 100)	Inter. Non-Cancer (Benchmark MOE = 100)	Chronic, Non-Cancer (Benchmark MOE = 30)	Lifetime Cancer (Benchmark 1.0E−04)	Acute, Non-Cancer (Benchmark MOE = 100)	Inter. Non-Cancer (Benchmark MOE = 100)	Chronic, Non-Cancer (Benchmark MOE = 30)	Lifetime Cancer (Benchmark = 1.0E−04)
Commercial use – Fuels and related products	Fuels and Related Products – Refueling, Medium Exposure (0.09–0.1 wt%)	ONU	LE	2.1E04	2.9E04	2,481	1.1E−04	N/A	N/A	N/A	N/A
Disposal	Waste Handling, Treatment, and Disposal – Landfill (2-Hands, 50–100 wt%)	Worker	CT	2.6E05	3.5E05	3.0E04	8.8E−06	581	792	67	**4.3E−03**
			HE	7.3E04	9.9E04	8,495	4.0E−05	**84**	115	11	3.3E−02
		ONU	CT	2.6E055	3.5E05	3.0E04	8.8E−06	N/A	N/A	N/A	N/A
	Waste Handling, Treatment, and Disposal – Wastewater (2-Hands, 50–100 wt%)	Worker	CT	2.6E04	3.5E04	2,985	8.9E−05	581	792	67	**4.3E−03**
			HE	7,941	1.1E04	927	3.7E−04	**84**	115	11	3.3E−02
		ONU	CT	2.6E04	3.5E04	2,985	8.9E−05	N/A	N/A	N/A	N/A

APF = assigned protection factor; COU = condition of use; CT = central tendency; HE = high-end; LE = low-end; MOE = margin of exposure; OES = occupational exposure scenario; ONU = occupational non-user; PPE = personal protective equipment; "–" = inhalation APF not needed as the MOE is greater than benchmark MOE, or the cancer risk is lower than the benchmark of cancer without any PPE

Bolded/shaded cells show values higher than the benchmark and indicating the basis for unreasonable risk for each COU listed.

[a] APF listed in parentheses is the minimum level of protection needed for estimated MOEs to be above benchmark.

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REFERENCES

Adkins, B; Van, SEW; Simmons, JE; Eustis, SL. (1986). Oncogenic response of strain A/J mice to inhaled chemicals. J Toxicol Environ Health 17: 311-322. https://dx.doi.org/10.1080/15287398609530825 (accessed August 11, 2026).

AIHA. (2024). IH SkinPerm [Computer Program]. Falls Church, VA: AIHA Exposure Assessment Strategies Committee (EASC). Retrieved from https://www.aiha.org/public-resources/consumer-resources/apps-and-tools-resource-center/aiha-risk-assessment-tools/ihskinperm (accessed August 11, 2026).

Andersen, ME; Clewell, HJ, III; Gargas, ML; Smith, FA; Reitz, RH. (1987). Physiologically based pharmacokinetics and the risk assessment process for methylene chloride. Toxicol Appl Pharmacol 87: 185-205. https://dx.doi.org/10.1016/0041-008X(87)90281-X (accessed August 11, 2026).

Arnts, RR; Seila, RL; Bufalini, JJ. (1989). Determination of room temperature OH rate constants for acetylene, ethylene dichloride, ethylene dibromide, p-dichlorobenzene and carbon disulfide. JAPCA 39: 453-460. https://dx.doi.org/10.1080/08940630.1989.10466544 (accessed August 11, 2026).

ASTM. (2014). Standard guide for conducting acute toxicity tests on test materials with fishes, macroinvertebrates, and amphibians. (E 29-96(2014)). West Conshohocken, PA. https://compass.astm.org/document/?contentCode=ASTM%7CE0729-96R14%7Cen-US (accessed August 11, 2026).

ATSDR. (2007). Medical Management Guidelines (MMG) for Ethylene dibromide. Atlanta, GA. https://semspub.epa.gov/work/07/40269750.pdf (accessed August 11, 2026).

ATSDR. (2018). Toxicological profile for 1,2-dibromoethane [ATSDR Tox Profile]. Atlanta, GA. https://www.atsdr.cdc.gov/ToxProfiles/tp37.pdf (accessed August 11, 2026).

Bakoğlu, M; Karademir, A; Ayberk, S. (2004). An evaluation of the occupational health risks to workers in a hazardous waste incinerator. J Occup Health 46: 156-164. https://dx.doi.org/10.1539/joh.46.156 (accessed August 11, 2026).

Brown, RP; Delp, MD; Lindstedt, SL; Rhomberg, LR; Beliles, RP. (1997). Physiological parameter values for physiologically based pharmacokinetic models [Review]. Toxicol Ind Health 13: 407-484. https://dx.doi.org/10.1177/074823379701300401 (accessed August 11, 2026).

Bugher, NA; Xiong, B; Gentles, RI; Glist, LD; Siegel, HG; Johnson, NP; Clark, CJ; Deziel, NC; Saiers, JE; Plata, DL. (2024). Domestic groundwater wells in Appalachia show evidence of low-dose, complex mixtures of legacy pollutants. Environ Sci Process Impacts 26: 2250-2263. https://dx.doi.org/10.1039/d4em00364k (accessed August 11, 2026).

CalEPA. (2001). TSD for noncancer RELs - Appendix D.3 Chronic RELs and toxicity summaries using the previous version of the Hot Spots Risk Assessment guidelines (OEHHA 1999). Sacramento, CA: California Office of Environmental Health Hazard Assessment :: OEHHA. http://oehha.ca.gov/media/downloads/crnr/appendixd3final.pdf (accessed August 11, 2026).

CalEPA. (2023). Table 1: Consolidated table of OEHHA/ARB approved risk assessment health values. Sacramento, CA: Office of Environmental Health Hazard Assessment (OEHHA), Air Resources Board (ARB). https://ww2.arb.ca.gov/sites/default/files/classic/toxics/healthval/contable05012023.pdf (accessed August 11, 2026).

CEB. (1991). Chemical Engineering Branch manual for the preparation of engineering assessments: Volume I. CEB engineering manual. Washington, DC: Office of Pollution Prevention and Toxics, US Environmental Protection Agency. https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P10000VS.txt (accessed August 11, 2026).

Cessna Aircraft Company. (1998). Information Manual: SKYHAWK SP, Cessna Model 172S. Wichita, KS: Cessna Aircraft Company. https://www.befa.org/wp-content/uploads/2019/12/POH-Cessna-172S.pdf (accessed August 11, 2026).

Chevron USA. (2024). Safety Data Sheet (SDS): Aviation Gasoline. San Ramon, CA: Chevron Products Company.

Cimorelli, AJ; Perry, SG; Venkatram, A; Weil, JC; Paine, RJ; Wilson, RB; Lee, RF; Peters, WD; Brode, RW; Paumier, JO; Thurman, J. (2018). AERMOD Model Formulation and Evaluation, April 2018 (EPA-454/R-18-003). Cimorelli, AJ; Perry, SG; Venkatram, A; Weil, JC; Paine, RJ; Wilson, RB; Lee, RF; Peters, WD; Brode, RW; Paumier, JO; Thurman, J.

Cohen, MA; Ryan, PB; Yanagisawa, Y; Spengler, JD; Ozkaynak, H; Epstein, PS. (1989). Indoor/outdoor measurements of volatile organic compounds in the Kanawha Valley of West Virginia. JAPCA 39: 1086-1093. https://dx.doi.org/10.1080/08940630.1989.10466593 (accessed August 11, 2026).

Deacon, BN; Silva, S; Lian, G; Evans, M; Chen, T. (2024). Computational Modelling of the Impact of Evaporation on In-Vitro Dermal Absorption. Pharm Res 41: 1979-1990. https://dx.doi.org/10.1007/s11095-024-03779-y (accessed August 11, 2026).

EAA. (2020). Comments of the Experimental Aircraft Association: Proposed designation of ethylene dibromide (CASRN 106-93-4) as a High-Priority Substance for Risk Evaluation (EPA Docket No. EPA-HQ-OPPT-2018-0488). Oshkosh, WI.

EAGLE. (2026). Eliminate Aviation Gasoline Lead Emissions (EAGLE) data: Pilots [Database]: flyEAGLE.org. Retrieved from https://app.powerbi.com/view?r=eyJrIjoiZTc5ZDU4NDYtOTJlYi00MmMzLTlkNTgtNWNjYTA3ZDFiMTk1IiwidCI6IjRiYjdlYzcwLWJjOTAtNDI5Ni05NTUxLWQ4ZGY1MDg0MDllMyJ9 (accessed August 11, 2026).

Edwards, K; Jackson, H; Jones, AR. (1970). Studies with alkylating esters--II: a chemical interpretation through metabolic studies of the antifertility effects of ethylene dimethanesulphonate and ethylene dibromide. Biochem Pharmacol 19: 1783-1789. https://dx.doi.org/10.1016/0006-2952(70)90171-1 (accessed August 11, 2026).

EPA, US. (2019). User's Guide: Integrated Indoor-Outdoor Air Calculator (IIOAC). Washington, DC: U.S. EPA.

Equitable Environmental Health Inc. (1977). A retrospective study of inferred fertility of married men occupationally exposed to ethylene dibromide (EDB).

FAA. (1998). Advisory Circular: Reciprocating engine power-loss accident prevention and trend monitoring. (20-105B). Washington, DC: U.S. Department of Transportation. https://www.faa.gov/documentLibrary/media/Advisory_Circular/ac20-105b.pdf.

FAA. (2002). All About Fuel - P-8740-35. Available online at https://www.faasafety.gov/gslac/ALC/libview_normal.aspx?id=6846 (accessed August 11, 2026).

FAA. (2021). Private pilot for airplane category: Airman certification standards. Washington, DC: U.S. Department of Transportation. https://www.faa.gov/training_testing/testing/acs/private_airplane_acs_6.pdf (accessed August 11, 2026).

FAA. (2025). 2024 Active Civil Airmen Statistics. Available online at https://www.faa.gov/data_research/aviation_data_statistics/civil_airmen_statistics (accessed August 11, 2026).

FAA. (2026). Part IV: Airports and aeronautical users - Chapter 11. Self-service. In FAA Order 51906C, Airport Compliance Manual. Washington, DC: U.S. Department of Transportation. https://www.faa.gov/airports/resources/publications/orders/compliance_5190_6/order-5190-6c-compliance-chapter-11 (accessed August 11, 2026).

Federal Register. (1999). OPPTS–53171A; FRL–6097–7: Category for Persistent, Bioaccumulative, and Toxic New Chemical Substances. Fed Reg 64: 60194-60204.

Frink, CR; Bugbee, GJ. (1989). Ethylene dibromide: persistence in soil and uptake by plants. Soil Sci 148: 303-307. https://dx.doi.org/10.1097/00010694-198910000-00010 (accessed August 11, 2026).

Ghanayem, BI; Maronpot, RR; Matthews, HB. (1986). Association of chemically induced forestomach cell proliferation and carcinogenesis. Cancer Lett 32: 271-278. https://dx.doi.org/10.1016/0304-3835(86)90179-5 (accessed August 11, 2026).

Godschalk, R; Faulk, C; LaRocca, J; van Benthem, J; Marchetti, F. (2025). Epigenotoxicity: Decoding the epigenetic imprints of genotoxic agents and their implications for regulatory genetic toxicology. Environ Mol Mutagen 66: 166-180. https://dx.doi.org/10.1002/em.22626 (accessed August 11, 2026).

Haldén, E; Jakobson, S; Janerås, L; Norlén, K. (1982). Effects of positive end-expiratory pressure on cardiac output distribution in the pig. Acta Anaesthesiol Scand 26: 403-408.

Hansch, M; Ehlis, T; Wagner, B. Patent US 2011/0038815 A1: Dimeric benzylidene malonates, (United States Patent Office2011).

He, M; Dabideen, DR; Kumar, A; Xu, R. Patent US 8,545,984 B2: Photochromic compounds and compositions, (United States Patent Office2013).

Hissink, AM; Wormhoudt, LW; Sherratt, PJ; Hayes, JD; Commandeur, JNM; Vermeulen, NPE; Van Bladeren, PJ. (2000). A physiologically-based pharmacokinetic(PB-PK) model for ethylene dibromide: Relevance of extrahepatic metabolism. Food Chem Toxicol 38: 707-716. https://dx.doi.org/10.1016/S0278-6915(00)00059-4 (accessed August 11, 2026).

Hölzer, J; Voss, B; Karroum, S; Hildmann, H; Wilhelm, M. (2008). A comparative study of chemically induced DNA damage in isolated nasal mucosa cells of humans and rats assessed by the alkaline comet assay. J Toxicol Environ Health A 71: 936-946. https://dx.doi.org/10.1080/15287390801988954 (accessed August 11, 2026).

Howard, CJ; Evenson, KM. (1976). Rate constants for the reactions of OH with ethane and some halogen substituted ethanes at 296 K. J Chem Phys 64: 4303-4306. https://dx.doi.org/10.1063/1.432115 (accessed August 11, 2026).

IARC. (1999). Ethylene dibromide (1,2-dibromoethane) [IARC Monograph]. In Re-evaluation of some organic chemicals, hydrazine and hydrogen peroxide, pt 2 (pp. 641-669). (RISKLINE/1999110014). Lyon, France: World Health Organization, IARC. http://monographs.iarc.fr/ENG/Monographs/vol71/mono71-28.pdf (accessed August 11, 2026).

IARC. (2000). Some antiviral and antineoplastic drugs, and other pharmaceutical agents [IARC Monograph]. Lyon, France. http://monographs.iarc.fr/ENG/Monographs/vol76/mono76.pdf (accessed August 11, 2026).

IGHRC. (2006). Guidelines on route-to-route extrapolation of toxicity data when assessing health risks of chemicals. Bedfordshire, UK: Institute of Environment and Health. http://www.iehconsulting.co.uk/IEH_Consulting/IEHCPubs/IGHRC/cr12.pdf.

Innospec. (2020). Public comment submitted by Innospec regarding the Draft Scope of the Risk Evaluation for Ethylene dibromide. Cheshire, UK. https://www.regulations.gov/comment/EPA-HQ-OPPT-2018-0488-0028 (accessed August 11, 2026).

Innospec. (2025). Documentation from meeting with Innospec regarding ethylene dibromide (provided via email). Cheshire, UK.

Isaacson, PJ; Frink, CR. (1985). EDB applied to soil not accumulated by plants. 37: 4-5.

Kszos, L; Talmage, S; Morris, G; Konetsky, B; Rottero, T. (2003). Derivation of aquatic screening benchmarks for 1,2-dibromoethane. Arch Environ Contam Toxicol 45: 66-71. https://dx.doi.org/10.1007/s00244-002-0151-5 (accessed August 11, 2026).

LAB Research. (2010a). Acute immobilisation test with Ethylene Dibromide Industrial (EDB) on Daphnia (Daphnia magna). (10/112-023DA). Shelton, CT: Chemtura Corporation.
LAB Research. (2010b). Acute toxicity test with Ethylene Dibromide Industrial (EDB) on rainbow trout (Oncorhynchus mykiss). (10/112-009HR). Shelton, CT: Chemtura Corporation.
LAB Research. (2010c). Growth inhibition test with Ethylene Dibromide Industrial (EDB) on algae (Pseudokirchneriella subcapitata). (10/112-022AL). Shelton, CT: Chemtura Corporation.
LAB Research. (2010d). Ready biodegradability of ethylene dibromide industrial (EDB) in a closed bottle test [TSCA Submission]. (10/112-322AN). Middlebury, CT: Chemtura Corporation.
Landmeyer, JE; Campbell, BG. (2014). Assessment of ethylene dibromide, dibromochloropropane, other volatile organic compounds, radium isotopes, radon, and inorganic compounds in groundwater and spring water from the Crouch Branch and McQueen Branch aquifers near McBee, South Carolina, 2010-2012. https://hero.epa.gov/reference/5639273/ (accessed August 11, 2026).
Lazowski, Z; Janczewski, Z; Polowiec, Z. (1982). The effect of alkylating agents on the reproductive and hormonal testicular function in patients with rheumatoid arthritis. Scand J Rheumatol 11: 49-54. https://dx.doi.org/10.3109/03009748209098115 (accessed August 11, 2026).
Lehtinen, J; Veijanen, A. (2011). Determination of odorous VOCs and the risk of occupational exposure to airborne compounds at the waste water treatment plants. Water Sci Technol 63: 2183-2192. https://dx.doi.org/10.2166/wst.2011.372 (accessed August 11, 2026)
Loizidou, M; Kapetanios, EG. (1992). Study on the gaseous emissions from a landfill. Sci Total Environ 127: 201-210. https://dx.doi.org/10.1016/0048-9697(92)90503-K (accessed August 11, 2026).
Mallick, P; Moreau, M; Song, G; Efremenko, AY; Pendse, SN; Creek, MR; Osimitz, TG; Hines, RN; Hinderliter, P; Clewell, HJ; Lake, BG; Yoon, M. (2020). Development and Application of a Life-Stage Physiologically Based Pharmacokinetic (PBPK) Model to the Assessment of Internal Dose of Pyrethroids in Humans. Toxicological sciences : an official journal of the Society of Toxicology 173: 86-99. https://dx.doi.org/10.1093/toxsci/kfz211 (accessed August 11, 2026).
Marks, CF; Thomason, IJ; Castro, CE. (1968). Dynamics of the permeation of nematodes by water, nematocides and other substances. Exp Parasitol 22: 321-337. https://hero.epa.gov/reference/5598156/.
McKeever, R; Sheppard, D; Nüsslein, K; Baek, KH; Rieber, K; Ergas, SJ; Forbes, R; Hilyard, M; Park, C. (2012). Biodegradation of ethylene dibromide (1,2-dibromoethane [EDB]) in microcosms simulating in situ and biostimulated conditions. J Hazard Mater 209-210: 92-98. https://dx.doi.org/10.1016/j.jhazmat.2011.12.067 (accessed August 11, 2026).
Midwest Research Institute. (1975). Sampling and analysis of selected toxic substances. Task II-ethylene dibromide. (EPA-560/6-75-001). Washington, DC: U.S. Environmental Protection Agency. https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/PB246213.xhtml (accessed August 11, 2026).
Mitra, A; Hilbelink, DR; Dwornik, JJ; Kulkarni, A. (1992). Rat hepatic glutathione S-transferase-mediated embryotoxic bioactivation of ethylene dibromide. Teratology 46: 439-446. https://dx.doi.org/10.1002/tera.1420460508 (accessed August 11, 2026).
Moran, WJ. Patent 3,036,095: Process for the alkylation of dihydroxy-dibenzanthrone with alkylene dihalides, (United States Patent Office1962).
Mustian, KM; Darling, TV; Janelsins, MC; Jean-Pierre, P; Roscoe, JA; Morrow, GR. (2008). Chemotherapy-induced nausea and vomiting. US Oncol 4: 19-23.
NCEI. (2026). ASOS 1 Minute: Average wind speed for 917 airports in the US (2005-2026). Retrieved from https://mesonet.agron.iastate.edu/ASOS/ (accessed August 11, 2026).
NCI. (1978). Bioassay of 1,2-dibromoethane for possible carcinogenicity (pp. 1-129). (ISSN 0163-7185 DHEW Publication No. (NIH) 78-1336 & CAS No. 106-93-4). Bethesda MD: National Institute of Health. http://ntp.niehs.nih.gov/ntp/htdocs/LT_rpts/tr086.pdf (accessed August 11, 2026).

NICNAS. (2013). Ethane, 1,2-dibromo-: Human health tier II assessment. Sydney, Australia: Australian Department of Health, National Industrial Chemicals Notification and Assessment Scheme. https://www.industrialchemicals.gov.au/sites/default/files/Ethane%2C%201%2C2-dibromo-_Human%20health%20tier%20II%20assessment.pdf (accessed August 11, 2026).

NICNAS. (2014). Ethane, 1,2-dibromo-: Environment tier II assessment. Sydney, Australia: Australian Department of Health, National Industrial Chemicals Notification and Assessment Scheme. https://www.industrialchemicals.gov.au/sites/default/files/Ethane%2C%201%2C2-dibromo-_%20Environment%20tier%20II%20assessment.pdf (accessed August 11, 2026).

NIDDK. (2015). Alkylating agents. In LiverTox: Clinical and Research Information on Drug-Induced Liver Injury, 2012. Bethesda, MD: National Library of Medicine. https://www.ncbi.nlm.nih.gov/books/NBK547849/ (accessed August 11, 2026).

Niehoff, NM; Gammon, MD; Keil, AP; Nichols, HB; Engel, LS; Sandler, DP; White, AJ. (2019). Airborne mammary carcinogens and breast cancer risk in the Sister Study. Environ Int 130: 104897. https://dx.doi.org/10.1016/j.envint.2019.06.007 (accessed August 11, 2026).

NIOSH. (1977a). Criteria for a recommended standard occupational exposure to ethylene dibromide. Washington DC.

NIOSH. (1977b). An industrial hygiene study of ethylene dibromide at Dupont, Deepwater, New Jersey. Cincinnati, OH: National Institute for Occupational Safety and Health. https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/PB81231334.xhtml (accessed August 11, 2026).

NIOSH. (1977c). An industrial hygiene study of ethylene dibromide at Nalco Chemical Company in Freeport, Texas. National Institute for Occupational Safety and Health. https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/PB82109968.xhtml (accessed August 11, 2026).

NIOSH. (1977d). An industrial hygiene study of ethylene dibromide at the Ethyl Corporation in Magnolia, Arkansas. Cincinnati, OH: National Institute for Occupational Safety and Health. https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/PB82112160.xhtml (accessed August 11, 2026).

NIOSH. (1977e). An industrywide industrial hygiene study of ethylene dibromide. Cincinnati, OH: National Institute for Occupational Safety and Health. https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/PB82199654.xhtml (accessed August 11, 2026).

NIOSH. (2013). Derivation of immediately dangerous to life or health (IDLH) values. (DHHS (NIOSH) Publication No. 2014–100). Cincinnati, OH: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. https://www.cdc.gov/niosh/docs/2014-100/ (accessed August 11, 2026).

NITE; CHRIP. (1977). 1,2-Dibromoethane - #32: Bioaccumulation: aquatic/sediment; Cyprinus carpio. National Institute of Technology and Evaluation, Japanese Government. https://www.nite.go.jp/chem/jcheck/template.action?ano=28027&mno=2-0059&cno=106-93-4&request_locale=en (accessed August 11, 2026).

NLM. (2025). PubChem: Hazardous Substance Data Bank: 1,2-Dibromoethane, 106-93-4. Available online at https://pubchem.ncbi.nlm.nih.gov/compound/7839#source=HSDB (accessed August 11, 2026)

NRC. (2001). Standing operating procedures for developing acute exposure guideline levels (AEGLs) for hazardous chemicals. Washington, DC: National Academies Press. https://dx.doi.org/10.17226/10122 (accessed August 11, 2026).

NTP. (1982). Carcinogenesis bioassay of 1,2-dibromoethane (CAS no 106-93-4) in F344 rats and B6C3F1 mice (inhalation study) (pp. 1-163). (TR-210). https://search.proquest.com/docview/1859405604?accountid=171501.

NTP. (2016). Report on carcinogens, fourteenth edition: 1,2-dichloroethane. Research Triangle Park, NC: U.S. Department of Health and Human Services, National Institutes of Health, National Toxicology Program. https://ntp.niehs.nih.gov/ntp/roc/content/profiles/dichloroethane.pdf (accessed August 11, 2026).

NWQMC. (2024). Water quality portal [Database]. Washington, DC. Retrieved from https://www.waterqualitydata.us/ (accessed August 11, 2026)

O'Brien, C. (2008). Nausea and vomiting. Can Fam Physician 54: 861-863.

O'Neil, MJ. (2013). Ethylene dibromide. 106-93-4. In MJ O'Neil; PE Heckelman; PH Dobbelaar; KJ Roman; CM Kenney; LS Karaffa (Eds.), The Merck index: An encyclopedia of chemicals, drugs, and biologicals (15th ed., pp. 702). Cambridge, UK: The Royal Society of Chemistry.

OECD. (2020). Emission scenario document on chemical additives used in automotive lubricants. Paris, France.

OSHA. (2017). Section II: Chapter 2: Surface contaminants, skin exposure, biological monitoring and other analyses, Part 2. Washington, DC: U.S. Department of Labor, Occupational Safety and Health Administration Office of Training and Education. https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=770&p_table=preambles.

OSHA. (2018). Ethylene dibromide (1,2-dibromoethane). Retrieved from https://www.osha.gov/chemicaldata/chemResult.html?recNo=48 (accessed August 11, 2026)

Peoples, SA; Maddy, KT; Riddle, LC. (1978). Human occupational health problems resulting from exposure to ethylene dibromide in California in 1975 and 1976. Vet Hum Toxicol 20: 241-244.

Ploemen, JHT, M; Wormhoudt, LW; Van Ommen, B; Commandeur, JNM; Vermeulen, NPE; Van Bladeren, PJ. (1995). Polymorphism in the glutathione conjugation activity of human erythrocytes towards ethylene dibromide and 1,2-epoxy-3-(p-nitrophenoxy)-propane. Biochim Biophys Acta 1243: 469-476. https://dx.doi.org/10.1016/0304-4165(94)00175-w (accessed August 11, 2026).

Ploemen, JP; Wormhoudt, LW; Haenen, GR; Oudshoorn, MJ; Commandeur, JN; Vermeulen, NP; de Waziers, I; Beaune, PH; Watabe, T; van Bladeren, PJ. (1997). The use of human in vitro metabolic parameters to explore the risk assessment of hazardous compounds: the case of ethylene dibromide. Toxicol Appl Pharmacol 143: 56-69. https://dx.doi.org/10.1006/taap.1996.8004 (accessed August 11, 2026).

Plotnick, HB; Conner, WL. (1976). Tissue distribution of 14C-labeled ethylene disbromide in the guinea pig. Res Commun Chem Pathol Pharmacol 13: 251-258. [Research communications in chemical pathology and pharmacology].

Plotnick, HB; Weigel, WW; Richards, DE; Cheever, KL. (1979). The effect of dietary disulfiram upon the tissue distribution and excretion of 14C-1,2-dibromoethane in the rat. Res Commun Mol Pathol Pharmacol 26: 535-545.

Poole, SK; Poole, CF. (1999). Chromatographic models for the sorption of neutral organic compounds by soil from water and air. J Chromatogr A 845: 381-400. https://dx.doi.org/10.1016/S0021-9673(98)01085-1 (accessed August 11, 2026).

Potts, RO; Guy, RH. (1992). Predicting skin permeability. Pharm Res 9: 663-669. https://dx.doi.org/10.1023/A:1015810312465 (accessed August 11, 2026).

Ramsey, JC; Andersen, ME. (1984). A physiologically based description of the inhalation pharmacokinetics of styrene in rats and humans. Toxicol Appl Pharmacol 73: 159-175. https://dx.doi.org/10.1016/0041-008X(84)90064-4 (accessed August 11, 2026).

RIVM. (2007). Environmental risk limits for twelve substances, prioritised on the basis of indicative risk limits (pp. 230). (601782003/2007). Bilthoven, Netherlands: National Institute for Public Health and the Environment (RIVM). https://www.rivm.nl/bibliotheek/rapporten/601782003.pdf (accessed August 11, 2026).

Rumble, JR. (2018a). 1,2-dibromoethane. In CRC handbook of chemistry and physics (99th ed.). Boca Raton, FL: CRC.

Rumble, JR. (2018b). Aqueous solubility and Henry's law constants of organic compounds. In CRC Handbook of Chemistry and Physics (99 ed.). Boca Raton, FL: CRC Press. Taylor & Francis Group. https://hbcp.chemnetbase.com/faces/documents/05_32/05_32_0001.xhtml (accessed August 11, 2026).

Saraswat, PK; Kandara, M; Ak, D; Malhotra, VK; Jhanwar, RS. (1986). Poisoning by ethylene di-bromide -- six cases: a clinicopathological and toxicological study. Indian J Med Sci 40: 121-123.

Sharer, MS. (1998) The effects of aging on the sorption/desorption behavior of organic chemicals in soils and relation to bioavailability. (Doctoral Dissertation). Michigan State University, Ann Arbor. Retrieved from https://d.lib.msu.edu/etd/28429 (accessed August 11, 2026).

Short, RD; Minor, JL; Winston, JM; Seifter, J; Lee, CC. (1978). Inhalation of ethylene dibromide during gestation by rats and mice. Toxicol Appl Pharmacol 46: 173-182. https://dx.doi.org/10.1016/0041-008X(78)90148-5 (accessed August 11, 2026).

Short, RD; Winston, JM; Hong, CB; Minor, JL; Lee, CC; Seifter, J. (1979). Effects of ethylene dibromide on reproduction in male and female rats. Toxicol Appl Pharmacol 49: 97-105. https://dx.doi.org/10.1016/0041-008X(79)90281-3 (accessed August 11, 2026).

Sigma-Aldrich. (2024). Safety Data Sheet (SDS): 1,2-Dibromoethane. St. Louis, MO: Sigma-Aldrich Inc.

Singh, N; Jatav, OP; Gupta, RK; Tailor, MK; Jain, R. (2007). Outcome of sixty four cases of ethylene dibromide ingestion treated in tertiary care hospital. J Assoc Physicians India 55: 842-845.

Sriram, S; Macedo, T; Mavinkurve-Groothuis, A; van de Wetering, M; Looijenga, LHJ. (2024). Alkylating agents-induced gonadotoxicity in prepubertal males: Insights on the clinical and preclinical front. Clinical and Translational Science 17: e13866. https://dx.doi.org/10.1111/cts.13866 (accessed August 11, 2026).

Steinberg, SM; Pignatello, JJ; Sawhney, BL. (1987). Persistence of 1,2-dibromoethane in soils - entrapment in intraparticle micropores. Environ Sci Technol 21: 1201-1208. https://dx.doi.org/10.1021/es00165a007 (accessed August 11, 2026).

Stott, WT; Mckenna, MJ. (1984). The comparative absorption and excretion of chemical vapors by the upper, lower, and intact respiratory tract of rats. Fundam Appl Toxicol 4: 594-602. https://dx.doi.org/10.1016/0272-0590(84)90049-6 (accessed August 11, 2026).

Sweeney, LM; Gargas, ML. (2016). Route-to-route extrapolation of 1,2-dichloroethane studies from the oral route to inhalation using physiologically based pharmacokinetic models. Regul Toxicol Pharmacol 81: 468-479. https://dx.doi.org/10.1016/j.yrtph.2016.10.005 (accessed August 11, 2026).

ten Berge, WF; Zwart, A; Appelman, LM. (1986). Concentration-time mortality response relationship of irritant and systemically acting vapours and gases. J Hazard Mater 13: 301-309. https://dx.doi.org/10.1016/0304-3894(86)85003-8 (accessed August 11, 2026).

TradeData.Pro. (2022). United States import history records for ethylene dibromide. Available online at https://tradedata.pro/trade-database-demo/united-states/import-data/hs-code/290331/ (accessed August 11, 2026)

TRB. (2014). Research Results Digest 21: Best practices for general aviation aircraft fuel-tank sampling. Washington, DC: National Academies, Federal Aviation Administration. https://www.nationalacademies.org/read/22343/chapter/1 (accessed August 11, 2026).

U.S. BLS. (2014). Employee Tenure News Release. Available online at http://www.bls.gov/news.release/archives/tenure_09182014.htm (accessed August 11, 2026)

U.S. BLS. (2023). May 2023 Occupational Employment and Wage Estimates: National industry-specific estimates. Washington, DC. https://www.bls.gov/oes/tables.htm (accessed August 11, 2026).

U.S. Census Bureau. (2017). 2017 SUSB Annual Data Tables by Establishment Industry: U.S. & states, 6-digit NAICS. Suitland-Silver Hill, MD. https://www.census.gov/data/tables/2017/econ/susb/2017-susb-annual.html (accessed August 11, 2026).

U.S. Census Bureau. (2019). Survey of Income and Program Participation data. Available online at https://www.census.gov/programs-surveys/sipp/data/datasets/2008-panel/wave-1.html (accessed August 11, 2026).

U.S. EPA. (1983). Ethylene dibromide (EDB): Position document 4. Washington, DC: Office of Pesticide Programs. https://nepis.epa.gov/Exe/ZyPDF.cgi/93000PQA.PDF?Dockey=93000PQA.PDF (accessed August 11, 2026).

U.S. EPA. (1991). Technical support document for water quality-based toxics control. (EPA/505/2-90-001). Washington, DC: Office of Water. http://water.epa.gov/scitech/datait/models/upload/2002_10_25_npdes_pubs_owm0264.pdf (accessed August 11, 2026).

U.S. EPA. (1992a). Dermal exposure assessment: Principles and applications (interim report) [EPA Report]. (EPA/600/8-91/011B). Washington, DC: Office of Health and Environmental Assessment. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=12188 (accessed August 11, 2026).

U.S. EPA. (1992b). Guidelines for exposure assessment. Federal Register 57(104):22888-22938 [EPA Report]. In Risk Assessment Forum. (EPA/600/Z-92/001). Washington, DC. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=15263 (accessed August 11, 2026).

U.S. EPA. (1992c). A laboratory method to determine the retention of liquids on the surface of hands [EPA Report]. (EPA/747/R-92/003). Washington, DC.

U.S. EPA. (1993a). Reference Dose (RfD): description and use in health risk assessments background document 1A, March 15, 1993. Washington, DC: U.S. Environmental Protection Agency, Integrated Risk Information System. https://www.epa.gov/iris/reference-dose-rfd-description-and-use-health-risk-assessments (accessed August 11, 2026).

U.S. EPA. (1993b). Wildlife exposure factors handbook [EPA Report]. (EPA/600/R-93/187). Washington, DC: Office of Research and Development. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=2799 (accessed August 11, 2026).

U.S. EPA. (1994a). Guidelines for Statistical Analysis of Occupational Exposure Data: Final. United States Environmental Protection Agency :: U.S. EPA.

U.S. EPA. (1994b). Methods for derivation of inhalation reference concentrations and application of inhalation dosimetry [EPA Report]. (EPA600890066F). Research Triangle Park, NC. https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=71993&CFID=51174829&CFTOKEN=25006317 (accessed August 11, 2026).

U.S. EPA. (1998). Guidelines for ecological risk assessment [EPA Report]. (EPA/630/R-95/002F). Washington, DC: U.S. Environmental Protection Agency, Risk Assessment Forum. https://www.epa.gov/risk/guidelines-ecological-risk-assessment (accessed August 11, 2026).

U.S. EPA. (2002a). A review of the reference dose and reference concentration processes [EPA Report]. (EPA630P02002F). Washington, DC. https://www.epa.gov/sites/production/files/2014-12/documents/rfd-final.pdf (accessed August 11, 2026).

U.S. EPA. (2002b). Short-term methods for estimating the chronic toxicity of effluents and receiving water to freshwater organisms [EPA Report]. (EPA-821-R-02-013). Washington, DC. https://nepis.epa.gov/Exe/ZyPDF.cgi/P10031PY.PDF?Dockey=P10031PY.PDF.

U.S. EPA. (2004a). Docket EPA-HQ-OPP-2004-0005: Refined (Level II) terrestrial and aquatic models for probabilistic and ecological assessment of pesticides. Washington, DC: Office of Pesticide

Programs. https://www.regulations.gov/docket/EPA-HQ-OPP-2004-0005 (accessed August 11, 2026).

U.S. EPA. (2004b). Toxicological review of 1,2-dibromoethane (CAS no. 106-93-4). Washington, DC: U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment. https://cfpub.epa.gov/ncea/iris/iris_documents/documents/toxreviews/0361tr.pdf (accessed August 11, 2026).

U.S. EPA. (2005a). Guidelines for carcinogen risk assessment [EPA Report]. (EPA630P03001F). Washington, DC. https://www.epa.gov/sites/production/files/2013-09/documents/cancer_guidelines_final_3-25-05.pdf (accessed August 11, 2026).

U.S. EPA. (2005b). Supplemental guidance for assessing susceptibility from early-life exposure to carcinogens [EPA Report]. (EPA/630/R-03/003F). Washington, DC: U.S. Environmental Protection Agency, Risk Assessment Forum. https://www.epa.gov/risk/supplemental-guidance-assessing-susceptibility-early-life-exposure-carcinogens (accessed August 11, 2026).

U.S. EPA. (2008a). Chapter 5.2: Transportation and marketing of petroleum liquids. Compilation of air pollutant emission factors. Volume I: Stationary point and area sources, fifth edition, AP-42. Washington, DC. https://www.epa.gov/sites/production/files/2020-09/documents/5.2_transportation_and_marketing_of_petroleum_liquids.pdf.

U.S. EPA. (2008b). Natural attenuation of the lead scavengers 1,2-dibromoethane (EDB) and 1,2-dichloroethane (1,2-DCA) at motor fuel release sites and implications for risk management. (EPA 600/R-08/107). Ada, OK: National Risk Management Research Laboratory. https://nepis.epa.gov/Exe/ZyPDF.cgi/P1002UTI.PDF?Dockey=P1002UTI.PDF.

U.S. EPA. (2010). STIR Version 1.0 User's Guide for Pesticide Inhalation Risk: Screening tool for inhalation risk. Available online at https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/stir-version-10-users-guide-pesticide-inhalation (accessed August 11, 2026)

U.S. EPA. (2011a). Exposure factors handbook: 2011 edition [EPA Report]. (EPA/600/R-090/052F). Washington, DC: U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment. https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100F2OS.txt.

U.S. EPA. (2011b). Recommended use of body weight 3/4 as the default method in derivation of the oral reference dose. (EPA100R110001). Washington, DC. https://www.epa.gov/sites/production/files/2013-09/documents/recommended-use-of-bw34.pdf (accessed August 11, 2026).

U.S. EPA. (2012a). Advances in inhalation gas dosimetry for derivation of a reference concentration (RfC) and use in risk assessment (pp. 1-140). (EPA/600/R-12/044). Washington, DC. https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=244650&CFID=50524762&CFTOKEN=17139189 (accessed August 11, 2026).

U.S. EPA. (2012b). Benchmark dose technical guidance [EPA Report]. (EPA100R12001). Washington, DC: U.S. Environmental Protection Agency, Risk Assessment Forum. https://www.epa.gov/risk/benchmark-dose-technical-guidance (accessed August 11, 2026).

U.S. EPA. (2012c). Ecological effects test guidelines: OCSPP 850.2400: Wild mammal toxicity testing [EPA Report]. (EPA 712-C-022; EPA-HQ-OPPT-2009-0154-0013). Washington, DC: U.S. Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention. https://www.regulations.gov/document/EPA-HQ-OPPT-2009-0154-0013 (accessed August 11, 2026).

U.S. EPA. (2012d). Estimation Programs Interface Suite™ for Microsoft® Windows, v 4.11 [Computer Program]. Washington, DC. Retrieved from https://www.epa.gov/tsca-screening-tools/epi-suitetm-estimation-program-interface (accessed August 11, 2026).

U.S. EPA. (2013). Interpretive assistance document for assessment of discrete organic chemicals. Sustainable futures summary assessment [EPA Report]. Washington, DC. http://www.epa.gov/sites/production/files/2015-05/documents/05-iad_discretes_june2013.pdf (accessed August 11, 2026).

U.S. EPA. (2014a). Framework for human health risk assessment to inform decision making. Final [EPA Report]. (EPA/100/R-14/001). Washington, DC: U.S. Environmental Protection, Risk Assessment Forum. https://www.epa.gov/risk/framework-human-health-risk-assessment-inform-decision-making (accessed August 11, 2026).

U.S. EPA. (2014b). Guidance for applying quantitative data to develop data-derived extrapolation factors for interspecies and intraspecies extrapolation [EPA Report]. (EPA/100/R-14/002F). Washington, DC: Risk Assessment Forum, Office of the Science Advisor. https://www.epa.gov/sites/production/files/2015-01/documents/ddef-final.pdf (accessed August 11, 2026).

U.S. EPA. (2016a). Chemical Data Reporting (CDR): Complete 2016 submissions. Washington, DC.

U.S. EPA. (2016b). Ecological effects test guidelines: OCSPP 850.1075: Freshwater and saltwater fish acute toxicity test [EPA Report]. (EPA 712-C-16-007; EPA-HQ-OPPT-2009-0154-0035). Washington, DC: U.S. Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention. https://www.regulations.gov/document/EPA-HQ-OPPT-2009-0154-0035 (accessed August 11, 2026).

U.S. EPA. (2017). Human Health Benchmarks for Pesticides: Updated 2017 Technical Document (pp. 5). (EPA 822-R -17 -001). Washington, DC: U.S. Environmental Protection Agency, Office of Water. https://www.epa.gov/sites/production/files/2015-10/documents/hh-benchmarks-techdoc.pdf.

U.S. EPA. (2018). Storage and retrieval (STORET) data warehouse and water quality exchange (WQX) [database] [Database]. Washington, DC. Retrieved from ftp://newftp.epa.gov/storet/exports/

U.S. EPA. (2019a). Chemistry Dashboard Information for 1,2-Dibromoethane. 106-93-4. Available online at https://comptox.epa.gov/dashboard/dsstoxdb/results?search=DTXSID3020415 (accessed August 11, 2026)

U.S. EPA. (2019b). Office of pesticide programs' Re-evaluation of the FQPA safety factor for pyrethroids: Updated literature and CAPHRA ProgramData review. (EPA-HQ-OPP-2008-0331-0084).

U.S. EPA. (2019c). User's Guide: Integrated Indoor-Outdoor Air Calculator (IIOAC). Washington, DC: U.S. EPA.

U.S. EPA. (2020a). Chemical Data Reporting (CDR): Reporting year 2020 [Database]. Washington, DC: U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics. Retrieved from https://www.epa.gov/chemical-data-reporting/access-cdr-data (accessed August 11, 2026).

U.S. EPA. (2020b). Final Scope of the Risk Evaluation for Ethylene Dibromide. (EPA-R-20-012). Washington, DC: U.S. Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention. https://www.epa.gov/sites/default/files/2020-09/documents/casrn_106-93-4_ethylene_dibromide_finalscope.pdf (accessed August 11, 2026).

U.S. EPA. (2020c). National Emissions Inventory (NEI): Ethylene dibromide (EDB), reporting years 2017 and 2020 [Database]. Washington, DC. Retrieved from https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei (accessed August 11, 2026).

U.S. EPA. (2021a). Draft systematic review protocol supporting TSCA risk evaluations for chemical substances, Version 1.0: A generic TSCA systematic review protocol with chemical-specific methodologies. (EPA Document #EPA-D-20-031). Washington, DC: Office of Chemical Safety and Pollution Prevention. https://www.regulations.gov/document/EPA-HQ-OPPT-2021-0414-0005 (accessed August 11, 2026).

U.S. EPA. (2021b). Use of chemicals in fuels and related products - Generic scenario for estimating occupational exposures and environmental releases (Methodology review draft). Washington, DC: Office of Pollution Prevention and Toxics, Risk Assessment Division.

U.S. EPA. (2022a). Chemical repackaging - Generic scenario for estimating occupational exposures and environmental releases (revised draft) [EPA Report]. Washington, DC.

U.S. EPA. (2022b). Draft TSCA screening level approach for assessing ambient air and water exposures to fenceline communities (version 1.0) [EPA Report]. (EPA-744-D-22-001). Washington, DC: Office of Chemical Safety and Pollution Prevention, U.S. Environmental Protection Agency. https://www.epa.gov/system/files/documents/2022-01/draft-fenceline-report_sacc.pdf (accessed August 11, 2026).

U.S. EPA. (2023a). Consumer Exposure Model (CEM) Version 3.2 User's Guide. Washington, DC. https://www.epa.gov/tsca-screening-tools/consumer-exposure-model-cem-version-32-users-guide (accessed August 11, 2026).

U.S. EPA. (2023b). Meeting minutes and final report for the Science Advisory Committee on Chemicals public virtual meeting "2023 Draft Supplement to the 1,4-Dioxane Risk Evaluation" held on September 12-14, 2023. Washington, DC.

U.S. EPA. (2023c). [REFER TO CORRECTED COPY] Use of laboratory chemicals - Generic scenario for estimating occupational exposures and environmental releases (Revised draft generic scenario) [EPA Report]. Washington, DC: U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, Existing Chemicals Risk Assessment Division. https://www.epa.gov/tsca-screening-tools/chemsteer-chemical-screening-tool-exposures-and-environmental-releases#genericscenarios (accessed August 11, 2026).

U.S. EPA. (2024a). 2024 CDR data [Database]. Washington, DC.

U.S. EPA. (2024b). Analysis of regulated contaminant occurrence data from public water systems in support of the Fourth Six-Year Review of national primary drinking water regulations: Chemical phase and radionuclides rules. (EPA- 815-R-24-014). Washington, DC: Office of Water. https://www.epa.gov/dwsixyearreview/support-documents-epas-fourth-review-existing-drinking-water-standards (accessed August 11, 2026).

U.S. EPA. (2024c). Discharge Monitoring Report (DMR) data: Ethylene dibromide (EDB), reporting years 2019-2023 [Database]. Washington, DC.

U.S. EPA. (2024d). General methodology for biofuel new chemical substance cases (revised draft). Washington, DC: Office of Pollution Prevention and Toxics, New Chemicals Division.

U.S. EPA. (2024e). National analysis TRI dataset (TRI): Data used for TSCA risk evaluations, reporting years 2019-2023 [Database]. Washington, DC. Retrieved from https://www.epa.gov/toxics-release-inventory-tri-program/tri-listed-chemicals (accessed August 11, 2026).

U.S. EPA. (2024f). Science advisory committee on chemicals meeting minutes and final report No. 2024-2, docket ID: EPA-HQ-OPPT-2024-0073: For the draft risk evaluation for di-isodecyl phthalate (DIDP) and draft hazard assessments for di-isononyl phthalate (DINP). Washington, DC: U.S. Environmental Protection Agency, Science Advisory Committee on Chemicals.

U.S. EPA. (2024g). Web-based Interspecies Correlation Estimation (Web-ICE) for Acute Toxicity: User Manual, Version 4.0. (EPA/600/B-24/158). Gulf Breeze, FL: Office of Research and Development, Gulf Ecosystem Measurement and Modeling Division. https://www3.epa.gov/webice/iceManual.html (accessed August 11, 2026).

U.S. EPA. (2025a). Draft Environmental Media and General Population Screening for Octamethylcyclotetrasiloxane (D4). Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2025b). Drinking Water Treatability Database (TDB): 1,2-Dibromoethane. Available online at https://tdb.epa.gov/tdb/contaminant?id=10981 (accessed August 11, 2026).

U.S. EPA. (2025c). Meeting with Professional Aviation Maintenance Association on Risk Evaluation Under TSCA Section 6 for Ethylene Dibromide. Washington, DC.

U.S. EPA. (2026a). Correspondence with the National Aerospace and Space Administration (NASA) on laboratory use of ethylene dibromide (EDB). Washington, DC: Office of Chemical Safety and Pollution Prevention.

U.S. EPA. (2026b). Draft Air Releases for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026c). Draft Calculations for Estimating Vapor Fraction of Ethylene Dibromide VOC in 100LL Avgas. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026d). Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026e). Draft Data Extraction Information for Environmental Hazard and Human Health Hazard Animal Toxicology and Epidemiology for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026f). Draft Data Extraction Information for General Population, Consumer, and Environmental Exposure for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026g). Draft Data Quality Evaluation and Data Extraction Information for Environmental Fate and Transport for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026h). Draft Data Quality Evaluation and Data Extraction Information for Environmental Release and Occupational Exposure for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026i). Draft Data Quality Evaluation and Data Extraction Information for Physical and Chemical Properties for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026j). Draft Data Quality Evaluation Information for Dermal Absorption for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026k). Draft Data Quality Evaluation Information for Environmental Hazard for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026l). Draft Data Quality Evaluation Information for General Population, Consumer, and Environmental Exposure for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026m). Draft Data Quality Evaluation Information for Human Health Hazard Animal Toxicology for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026n). Draft Data Quality Evaluation Information for Human Health Hazard Epidemiology for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026o). Draft Default Risk Calculator for Occupational and Consumer Exposures for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026p). Draft Estimates for Number of Workers and ONUs for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026q). Draft Exposure and Fate Assessment Screening Tool (E-FAST) Surface Water Concentrations for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026r). Draft Fish Ingestion Risk Calculator for General Population Exposure for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026s). Draft Fuels and Related Products Release Model for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026t). Draft Hazard Assessment for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA. (2026u). Draft Human Exposure Model (HEM) Exposure and Risk Calculator for General Population for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.
U.S. EPA. (2026v). Draft IH SkinPerm Dermal Absorption Modeling for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.
U.S. EPA. (2026w). Draft Import and Repackaging Release Model for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.
U.S. EPA. (2026x). Draft Integrated Indoor Outdoor Air Calculator (IIOAC) Exposure and Risk Calculator for General Population for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.
U.S. EPA. (2026y). Draft Number of Sites for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.
U.S. EPA. (2026z). Draft PBPK Model Code and Data for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.
U.S. EPA. (2026aa). Draft PBPK Reporting Document for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.
U.S. EPA. (2026ab). Draft PBPK Risk Calculator for Occupational Exposures for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.
U.S. EPA. (2026ac). Draft Point Source Calculator (PSC) Surface Water Concentrations for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.
U.S. EPA. (2026ad). Draft Risk Evaluation for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.
U.S. EPA. (2026ae). Draft Summary of AMTIC Data for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.
U.S. EPA. (2026af). Draft Surface Water Human Exposure Risk Calculator for General Population for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.
U.S. EPA. (2026ag). Draft Systematic Review Protocol for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.
U.S. EPA. (2026ah). Draft Water Releases for Ethylene Dibromide. Washington, DC: Office of Pollution Prevention and Toxics.
U.S. EPA. (2026ai). Risk Evaluation for 1,2-Dichloroethane. (EPA-740-R-26-017). Washington, DC: Office of Pollution Prevention and Toxics, Office of Chemical Safety and Pollution Prevention. https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/risk-evaluation-12-dichloroethane (accessed August 11, 2026).
U.S. PTO. 1,2-bis(3-methylphenoxy)ethane composition and thermal recording media made by using the same, (2010).
USGS. (2008). Anthropogenic organic compounds in source water of nine community water systems that withdraw from streams, 2002–05 (pp. 68). (Scientific Investigations Report 2008–5208). Reston, VA: U.S. Geological Survey. http://pubs.usgs.gov/sir/2008/5208/ (accessed August 11, 2026).
USGS. (2013). National Water Information System (NWIS) [Database]. Retrieved from http://waterdata.usgs.gov/nwis (accessed August 11, 2026).
Uthman, AP; Demlein, PJ; Allston, TD; Withiam, MC; McClements, MJ; Takacs, GA. (1978). Photoabsorption spectra of gaseous methyl-bromide, ethylene dibromide, nitrosyl bromide, thionyl chloride, and sulfuryl chloride. J Phys Chem 82: 2252-2257. https://dx.doi.org/10.1021/j100509a021 (accessed August 11, 2026).
Van Duuren, BL; Goldschmidt, BM; Loewengart, G; Smith, AC; Melchionne, S; Seidman, I; Roth, D. (1979). Carcinogenicity of halogenated olefinic and aliphatic hydrocarbons in mice. J Natl Cancer Inst 63: 1433-1439.

Van Duuren, BL; Melchionne, S; Seidman, I; Pereira, MA. (1986). Chronic bioassays of chlorinated humic acids in B6C3F1 mice. Environ Health Perspect 69: 109-117.

Van Duuren, BL; Seidman, I; Melchionne, S; Kline, SA. (1985). Carcinogenicity bioassays of bromoacetaldehyde and bromoethanol--potential metabolites of dibromoethane. Birth Defects Res B Dev Reprod Toxicol 5: 393-403. https://dx.doi.org/10.1002/tcm.1770050603 (accessed August 11, 2026).

Velsicol Chem Corp. (1978). Industrial hygiene survey, Velsicol Chemical Corporation, El Dorado, Ark Plant, Fire Master 680 Unit and semi-works summary with attachments and cover letter dated 07/19/78 [TSCA Submission]. (OTS0200544. 8EHQ-0778-0228. 88-7800228. TSCATS/408195). https://ntrl.ntis.gov/NTRL/dashboard/searchResults.xhtml?searchQuery=OTS0200544.

Vogel, TM; Reinhard, M. (1986). Reaction products and rates of disappearance of simple bromoalkanes 1,2-dibromopropane and 1,2-dibromoethane in water. Environ Sci Technol 20: 992-997. https://dx.doi.org/10.1021/es00152a004 (accessed August 11, 2026).

VP Racing Fuels. (2025). Safety Data Sheet (SDS): C12. Elmendorf, TX.

Walton, BT; Hendricks, MS; Anderson, TA; Griest, WH; Merriweather, R; Beauchamp, JJ; Francis, CW. (1992). Soil sorption of volatile and semivolatile organic compounds in a mixture. J Environ Qual 21: 552-558. https://dx.doi.org/10.2134/jeq1992.00472425002100040005x (accessed August 11, 2026).

Wegmann, F; Cavin, L; Macleod, M; Scheringer, M; Hungerbuhler, K. (2009). The OECD software tool for screening chemicals for persistence and long-range transport potential. Environ Modell Softw 24: 228-237. https://dx.doi.org/10.1016/j.envsoft.2008.06.014 (accessed August 11, 2026).

Weintraub, RA; Jex, GW; Moye, HA. (1986). Chemical and microbial-degradation of 1,2-dibromoethane (EDB) in Florida groundwater, soil, and sludge. In WY Garner; RC Honeycutt; HN Nigg (Eds.), Evaluation of Pesticides in Ground Water (pp. 294-310). Washington, DC: American Chemical Society. https://dx.doi.org/10.1021/bk-1986-0315.ch015 (accessed August 11, 2026).

Wells, BA; Wells, KL. (2014). Ethyl anti-knock gas. Available online at https://aoghs.org/products/tetraethyl-lead-gasoline/ (accessed August 11, 2026).

Whittaker, C; Rice, F; Mckernan, L; Dankovic, D; Lentz, T; Macmahon, K; Kuempel, E; Zumwalde, R; Schulte, P. (2016). Current Intelligence Bulletin 68: NIOSH Chemical Carcinogen Policy. US Department of Health and Human Services. https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/PB2017101413.xhtml (accessed August 11, 2026).

Yoon, M; Kedderis, GL; Yan, GZ; Clewell, HJ, III. (2015). Use of in vitro data in developing a physiologically based pharmacokinetic model: Carbaryl as a case study. Toxicology 332: 52-66. https://dx.doi.org/10.1016/j.tox.2014.05.006 (accessed August 11, 2026).

APPENDICES

Appendix A KEY ABBREVIATIONS AND ACRONYMS

7Q10	Lowest 7-day average flow that occurs (on average) once every 10 years
30Q5	Lowest 30-day average flow that occurs (on average) once every 5 years
AAD	Acute absorbed dose
ACGIH	American Conference of Governmental Industrial Hygienists
ACR	Acute-to-chronic ratio
ADAF	Age-dependent adjustment factor
ADD	Average daily dose
ADME	Absorption, distribution, metabolism, and excretion
ADR	Acute dose rate
AERMOD	American Meteorological Society (AMS)/EPA Regulatory Model
AF	Assessment factor
AMTIC	Ambient Monitoring Technology Information Center
APDR	Acute potential dose rate
APF	Assigned protection factor
ARD	Acute retain dose
BAF	Bioaccumulation factor
BCF	Bioconcentration factor
BLS	Bureau of Labor Service (U.S.)
BMC	Benchmark concentration
BMCL	Lower confidence limit of the BMC
BMD	Benchmark dose
BMDL	Lower confidence limit of the BMD
CASRN	Chemical Abstracts Service Registry Number
CBI	Confidential business information
CDR	Chemical Data Reporting
COC	Concentration of concern
COU	Condition of use
CSF	Cancer slope factor
CT	Central tendency
DEVL	Dermal Exposure to Volatile Liquids Model
DMR	Discharge Monitoring Report
EAA	Experimental Aircraft Association
EAGLE	Eliminate Aviation Gasoline Lead Emissions Initiative
ECEL	Existing chemical exposure limit
ECHA	European Chemicals Agency
E-FAST	Exposure and Fate Assessment Screening Tool
ELCR	Excess lifetime cancer risk
EPA	Environmental Protection Agency (U.S.)
ESD	Emission scenario document
FAA	Federal Aviation Adminstration (U.S.)
FBO	Fixed base operator
FT	Frequency of events
GI	Gastrointestinal
GS	Generic scenario
GST	Glutathione *S*-transferases

7376	HCx	Hazardous concentration for x% of species
7377	HEC	Human equivalent concentration
7378	HED	Human equivalent dose
7379	HEM	Human Exposure Model
7380	HERO	Health and Environmental Research Online (Database)
7381	HLC	Henry's Law constant
7382	HV	Hazard Value
7383	IIOAC	Integrated Indoor-Outdoor Air Calculator (Model)
7384	IRD	Intermediate retained dose
7385	IRIS	Integrated Risk Information System (EPA)
7386	IUR	Inhalation unit risk
7387	K_{OC}	Organic carbon:water partition coefficient
7388	K_{OW}	Octanol: water partition coefficient
7389	LADC	Lifetime average daily concentration
7390	LADD	Lifetime average daily dose
7391	LCD	Life cycle diagram
7392	LCx	Lethal concentration at which x% of test organisms die
7393	LDx	Lethal dose at which x% of test organisms die
7394	LOAEC	Lowest-observed-adverse-effect concentration
7395	LOAEL	Lowest-observed-adverse-effect level
7396	LOD	Limit of detection
7397	LOEC	Lowest-observed-effect concentration
7398	LOQ	Limit of quantification
7399	MCL	Maximum contaminant limit
7400	MOE	Margin of exposure
7401	MPH	Miles per hour
7402	NAICS	North American Industry Classification System
7403	ND	Non-detect
7404	NEI	National Emissions Inventory
7405	NESHAP	National Emission Standards for Hazardous Air Pollutants
7406	NHDPlus	National Hydrography Dataset Plus
7407	NIOSH	National Institute for Occupational Safety and Health
7408	NOAEL	No-observed-adverse-effect level
7409	NPDES	National Pollutant Discharge Elimination System
7410	NPDWR	National Primary Drinking Water Regulation
7411	NRC	National Response Center
7412	NTP	National Toxicology Program
7413	OCSPP	Office of Chemical Safety and Pollution Prevention (EPA)
7414	OECD	Organisation for Economic Co-operation and Development
7415	OEHHA	Office of Environmental Health Hazard Assessment (California)
7416	OEL	Occupational exposure limit
7417	OES	Occupational exposure scenario
7418	ONU	Occupational non-user
7419	OPPT	Office of Pollution Prevention and Toxics (EPA)
7420	OSF	Oral slope factor
7421	OSHA	Occupational Safety and Health Administration (U.S.)
7422	PAMA	Professional Aviation Maintenance Association
7423	PBPK	Physiologically-based pharmacokinetic
7424	PBZ	Personal breathing zone

PEL	Permissible exposure limit
PESS	Potentially exposed or susceptible subpopulations
PF	Protection factor
POD	Point of departure
POTW	Publicly owned treatment works
PPE	Personal protective equipment
PSC	Point Source Calculator
RCRA	Resource Conservation and Recovery Act
RQ	Risk quotient
SACC	Science Advisory Committee on Chemicals
SDS	Safety data sheet
SDWA	Safe Drinking Water Act
SEG	Similar exposure group
SIC	Standard Industrial Classification
SSD	Species sensitivity distribution
STEL	Short-term exposure limit
STIR	Screening Tool for Inhalation Risk
TLV	Threshold Limit Value
TRI	Toxics Release Inventory
TSCA	Toxic Substances Control Act
TSD	Technical support document
TWA	Time-weighted average
VOC	Volatile organic compound
VVWM	Variable Volume Water Model
WHO	World Health Organization
WQP	Water Quality Portal
WWT	Wastewater treatment
UF	Uncertainty factor
U.S.	United States

Appendix B REGULATORY AND ASSESSMENT HISTORY

The chemical substance, ethylene dibromide, is subject to federal and state laws and regulations in the United States (Table_Apx B-1 and Table_Apx B-2). Regulatory actions by other governments, tribes, and international agreements applicable to ethylene dibromide are listed in Table_Apx B-3.

B.1 Federal Laws and Regulations

Table_Apx B-1. Federal Laws and Regulations

Statute	General Description of Authority or Regulation	Chemical-Specific Summary
EPA authorities		
Toxic Substances Control Act (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.	Ethylene dibromide is one of the chemical substances designated as high-priority substances for risk evaluation (84 FR 71924, December 30, 2019).The final scope of the ethylene dibromide risk evaluation was published in September 2020 (85 FR 55281, September 4, 2020).
Toxic Substances Control Act (TSCA) – section 8(a)	The TSCA section 8(a) 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.	Ethylene dibromide manufacturing (including importing), processing and use information is reported under the CDR rule (40 CFR part 711).
Toxic Substances Control Act (TSCA) – section 8(b)	EPA must compile, keep current and publish a list (the TSCA Inventory) of each chemical substance manufactured (including imported), processed or imported in the United States.	Ethane, 1,2-dibromo- (CASRN 106-93-4) was listed on the initial TSCA Inventory and therefore was not subject to EPA's new chemicals review process under TSCA section 5 (89 FR 102773).
Toxic Substances Control Act (TSCA) – section 8(d)	Provides EPA with authority to issue rules requiring manufacturers (including importers), processors, and distributors of a chemical substance or mixture to submit lists and/or copies of ongoing and completed, unpublished health and safety studies. EPA's Health and Safety Data Reporting Rule at 40 CFR part 716 generally requires such submissions for manufacturers (including importers) and (if specified) processors of substances covered by part 716.	Thirteen health and safety studies were received for ethylene dibromide (2021) (U.S. EPA, ChemView, accessed August 11, 2026).
Toxic Substances Control Act (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.	Three substantial risk reports were received for ethylene dibromide in 1994, two of which had follow up submissions in 2011 and 2012 (U.S. EPA, ChemView, accessed August 11, 2026).
Emergency Planning and Community Right-To-Know Act	EPCRA section 313 – also known as the Toxic Release Inventory (TRI) – requires annual reporting from facilities in specific industry sectors that employ 10 or more full-time	Ethylene dibromide is a listed substance subject to reporting requirements under 40 CFR 372.65 effective as of January 01, 1987.

Statute	General Description of Authority or Regulation	Chemical-Specific Summary
(EPCRA) – section 313	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 (*e.g.,* 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.e.,* air, land and water).	
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) – sections 3 and 6	FIFRA governs the sale, distribution and use of pesticides. Section 3 of FIFRA generally requires that pesticide products be registered by EPA prior to distribution or sale. EPA assesses the whole formulation of pesticide products including active ingredients which have pesticidal effects and inert ingredients that do not. EPA keeps lists of inert ingredients that have been approved for use in pesticide products distinguishing between those that have been approved for use on food and those that have not. Pesticide products may only be registered if, among other things, they do not cause "unreasonable adverse effects on the environment." Section 6 of FIFRA provides EPA with the authority to cancel pesticide registrations if either (1) the pesticide, labeling, or other material does not comply with FIFRA; or (2) when used in accordance with widespread and commonly recognized practice, the pesticide generally causes unreasonable adverse effects on the environment.	Ethylene dibromide was registered as an antimicrobial and a conventional chemical in 1974. Antimicrobial uses were cancelled in 1993. Conventional uses have also been cancelled. (U.S. EPA. Pesticide Chemical Search, accessed August 11, 2026).
Clean Air Act (CAA) – section 111(b)	Requires EPA to establish new source performance standards (NSPS) for any category of new or modified stationary sources that EPA determines causes, or contributes significantly to, air pollution, which may reasonably be anticipated to endanger public health or welfare. The standards are based on the degree of emission limitation achievable through the application of the best system of emission reduction (BSER) which (taking into account the cost of achieving reductions and environmental impacts and energy requirements) EPA determines has been adequately demonstrated.	EPA has established NSPS for a number of source categories that regulate emissions of ethylene dibromide to air. (See-New Source Performance Standards, accessed August 11, 2026).
Clean Air Act (CAA) – section 112(b)	Contains the original list of 189 hazardous air pollutants (HAPs) that Congress added in 1990. Under 112(c) of the CAA, EPA must identify and list source categories that emit listed HAPs and then set emission standards for those listed	Ethylene dibromide is listed as a HAP (42 U.S. C. section 7412).

Statute	General Description of Authority or Regulation	Chemical-Specific Summary
	source categories under CAA section 112(d). CAA section 112(b)(3)(A) specifies that any person may petition the Administrator to modify the list of HAP by adding or deleting a substance. Since 1990, EPA has both removed HAPs from and added HAPs to the original list.	
Clean Air Act (CAA) – section 112(d)	Directs EPA to establish, by rule, NESHAPs for each category or subcategory of listed major sources and area sources of HAPs (listed pursuant to section 112(c)). For major sources, the standards must require the maximum degree of emission reduction that EPA determines is achievable by each particular source category. This is generally referred to as maximum achievable control technology (MACT). For areas sources, the standards must require generally achievable control technology (GACT) though may require MACT. Section 112(d)(6) requires EPA to review, and revise, as necessary, (taking into account developments in practices, processes and control technologies) the emission standards every 8 years.	EPA has established NESHAPs for a number of source categories that emit ethylene dibromide to air. (See National emission standards hazardous air pollutants, accessed August 11, 2026)
Clean Air Act (CAA) – sections 112(f)	Section 112(f)(2) requires EPA to conduct risk assessments for each source category subject to section 112(d) NESHAP that require maximum achievable control technology (MACT) and to determine if additional standards are needed to reduce remaining risks; this is required within 8 years of promulgating the NESHAP.	EPA has completed a significant number of Risk and Technology Reviews (RTR) of NESHAP and will do so, as required, for the remaining source categories regulated under section 112.
Clean Air Act (CAA) – section 231(a)	Requires EPA to issue emission standards if the EPA Administrator determines that the emission of any air pollutant from any class or classes of aircraft engines causes, or contributes to, air pollution which may reasonably be anticipated to endanger public health or welfare. Pursuant to CAA section 231(b), the effective date of the standards is based on the length of time the Administrator determines is necessary to permit the development and application of the requisite technology, giving appropriate consideration to the cost of compliance within such period. Pursuant to CAA section 232 and 49 CFR 1.83(c), after EPA sets emission standards, the U.S. Federal Aviation Administration ("FAA") enforces those standards by establishing certification requirements requiring compliance with the EPA's emission standards.	EPA issued a final determination that lead emissions from aircraft engines that operate on leaded fuel (primarily used in piston engine aircraft) cause or contribute to lead air pollution that may reasonably be anticipated to endanger public health and welfare under section 231(a) of the Clean Air Act (88 FR 72372, October 20, 2023) ("endangerment finding"). Section II. A of the endangerment finding, "Background Information Helpful to Understanding This Final Action," explains that lead is added to aviation gasoline in the form of tetraethyl lead along with ethylene dibromide, which acts as a lead scavenger in the fuel. In the same section, the endangerment finding also notes that "[l] leaded avgas discharged to the ground and water includes other hazardous fuel components such as ethylene dibromide." The finding itself does not ban or impose restrictions on the use, sale, distribution, dispensing, and general availability of leaded fuel, nor does

Statute	General Description of Authority or Regulation	Chemical-Specific Summary
		it establish any new control measures regarding aircraft lead emissions. Per CAA section 231(a), the endangerment finding established a duty for EPA to promulgate lead emission standards applicable to aircraft engines covered by the endangerment finding. EPA has not yet issued such standards. Pursuant to 49 U.S.C. 44714, FAA has a statutory mandate to prescribe standards for the composition or chemical or physical properties of an aircraft fuel or fuel additive to control or eliminate aircraft emissions which the EPA has found endanger public health or welfare under section 231(a) of the Clean Air Act. FAA has not yet established such standards for lead. FAA's authorized use of a fuel for a given aircraft or engine is accomplished through a reference to a fuel specification. The most widely used leaded aviation gasoline, 100 low lead avgas (100LL), meets ASTM D910, "Standard Specification for Leaded Aviation Gasolines," which specifies the fuel contains a prescribed amount of lead and enough ethylene dibromide to provide two atoms of bromine per atom of lead.
Clean Water Act (CWA) – section 311(b) (2)(A) and 501(a) of the Federal Water Pollution Control Act.	Requires EPA to develop, promulgate, and revise as may be appropriate, regulations designating as hazardous substances, other than oil, which, when discharged present an imminent and substantial danger to the public health or welfare, including, but not limited to, fish, shellfish, wildlife, shorelines, and beaches.	Ethylene dibromide is a designated hazardous substance in accordance with section 311(b)(2)(A) of the Federal Water Pollution Control Act. (40 FR 116.4, see 43 FR 10474 March 13, 1978).
Safe Drinking Water Act (SDWA) – section 1412	Requires EPA to publish a non-enforceable maximum contaminant level goal (MCLG) for a contaminant for which EPA makes the determination that the contaminant: 1. may have an adverse effect on the health of persons; 2. is known to occur or there is a substantial likelihood that the contaminant will occur in public water systems with a frequency and at levels of public health concern; and 3. in the sole judgement of the Administrator, regulation of the contaminant presents a meaningful opportunity for health risk reductions for persons served by public water systems. When EPA publishes an MCLG, EPA must also promulgate a National Primary Drinking Water Regulation (NPDWR) which includes either an enforceable maximum contaminant level (MCL), or a required treatment technique. Public water systems are required to comply with NPDWRs.	Ethylene dibromide is subject to NPDWR under the SDWA with a MCLG of zero (40 CFR 141.50) and an enforceable MCL of 0.00005 mg/L (section 1412) (52 FR 25690, January 30, 1991).

Statute	General Description of Authority or Regulation	Chemical-Specific Summary
Resource Conservation and Recovery Act (RCRA) – section 3001	Directs EPA to develop and promulgate criteria for identifying the characteristics of hazardous waste, and for listing hazardous waste, taking into account toxicity, persistence, and degradability in nature, potential for accumulation in tissue and other related factors such as flammability, corrosiveness, and other hazardous characteristics.	Ethylene dibromide is included on the list of hazardous wastes pursuant to RCRA 3001. RCRA Hazardous Waste Code: U067 (40 CFR 261.33). Ethylene dibromide is a U-listed hazardous waste under code U067 under RCRA; therefore, discarded, unused pure and commercial grades of ethylene dibromide are regulated as a hazardous waste under RCRA (40 CFR 261.33(f)).
Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) – sections 102(a) and 103	Authorizes EPA to promulgate regulations designating as hazardous substances, in addition to those referred to in section 101(14) of CERCLA, those elements, compounds, mixtures, solutions, and substances which, when released into the environment, may present substantial danger to the public health or welfare or the environment. EPA must also promulgate regulations establishing the quantity of any hazardous substance the release of which must be reported under section 103. Section 103 requires persons in charge of vessels or facilities to report to the National Response Center if they have knowledge of a release of a hazardous substance above the reportable quantity threshold. CERCLA Hazardous substances listed under 40 CFR 302.4 are subject to EPCRA section 304 notification requirements.	Ethylene dibromide is a hazardous substance under CERCLA. Releases of ethylene dibromide in excess of 1 pound must be reported (40 CFR 302.4).
Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) – section 104(i), as amended by the Superfund Amendments and Reauthorization Act (SARA)	Requires the Agency to revise the hazardous ranking system and update the National Priorities List of hazardous waste sites, increases state and citizen involvement in the superfund program and provides new enforcement authorities and settlement tools.	Ethylene dibromide is listed on SARA, an amendment to CERCLA and the CERCLA Priority List of Hazardous Substances. This list includes substances most commonly found at facilities on the CERCLA National Priorities List (NPL) (accessed August 11, 2026) that have been deemed to pose the greatest threat to public health.
Other federal authorities		
Occupational Safety and Health Act (OSHA)	Requires employers to provide their workers with a place of employment free from recognized hazards to safety and health, such as exposure to toxic chemicals, excessive noise levels, mechanical dangers, heat or cold stress or unsanitary conditions (29 U.S.C section 651 et seq.). Under the Act, OSHA can issue occupational safety and health standards including such provisions as Permissible Exposure Limits	OSHA occupational exposure limit for ethylene dibromide is 20 ppm TWA, with an acceptable ceiling concentration of 30 ppm and an acceptable maximum peak above the acceptable ceiling concentration for an 8 hour shift of 50 ppm with a maximum duration of 5 min (29 CFR 1910.1000).

Statute	General Description of Authority or Regulation	Chemical-Specific Summary
	(PELs), exposure monitoring, engineering and administrative control measures, and respiratory protection.	
Federal Hazardous Materials Transportation Act (HMTA)	Section 5103 of the Act directs the Secretary of Transportation to: • Designate material (including an explosive, radioactive material, infectious substance, flammable or combustible liquid, solid or gas, toxic, oxidizing or corrosive material, and compressed gas) as hazardous when the Secretary determines that transporting the material in commerce may pose an unreasonable risk to health and safety or property. • Issue regulations for the safe transportation, including security, of hazardous material in intrastate, interstate and foreign commerce.	The Department of Transportation (DOT) has designated ethylene dibromide as a hazardous material, and there are special requirements for marking, labeling and transporting it (49 CFR 172.101).

B.2 State Laws and Regulations

Table_Apx B-2. State Laws and Regulations

General Description of Authority or Regulation		Chemical-Specific Summary
State Air Regulations	California (Cal. Title 17, CCR, section 93000).	Ethylene dibromide has been designated by the State Board to be a toxic air contaminant pursuant to Health and Safety Code section 39657.
	Maryland (MD Title 26, Part 2, Subtitle 11, Chapter 26.11.16)	State Class I Toxic Air Pollutants Requiring Ambient Impact Analysis by Existing Sources
	Michigan (MI Administrative Code R.336.1229)	State Initial Threshold Screening Level (ITSL): 9 µg/m^3 State Initial Risk Screening Level (IRSL): 0.002 µg/m^3 State Secondary Risk Screening Level (SRSL): 0.02 µg/m^3
	New Hampshire Toxicity Class 1 Allowable Ambient Levels (AAL) and *de minimis* (NH Env-A 1400: Regulated Toxic Air Pollutants).	State 24-hour and annual AAL: 0.05 µg/m^3 State 24-hour *de minimis*: 0.00059 lb/day State annual *de minimis*: 0.22 lb/yr
	New York Annual Guideline Concentration (AGC) (6 NYCRR Part 212)	State AGC: 0.0017 µg/m^3
	North Carolina Acceptable Annual Average (AAL) (15A NCAC 02D.1100)	State AAL: 4×10^{-4} mg/m^3 (annual carcinogen)
	Rhode Island Acceptable Ambient Level (AAL) (RI Air Pollution Regulation No. 22)	State 24-hour AAL: 9 µg/m^3 State annual AAL: 0.2 µg/m^3
	Texas Air Monitoring Comparison Values (AMCV)	Short-term AMCV Health: 510 ug/m^3 (66ppb) Long-term AMCV Health: 0.22 ug/m^3 (0.029 ppb)

General Description of Authority or Regulation		Chemical-Specific Summary
	(Tex. Administrative Code Title 30, Chapter 101)	
State Drinking Water Standards and Guidelines	California (Cal Code Regs. Title 26, section 22-64444)	Maximum Contaminant Level (MCL): 0.05 µg/L Detection Limit for Reporting (DLR): 0.02 µg/L Public Health Goal (PHG): 0.01 µg/L
	Connecticut (Conn. Agencies Regs. 19-13-B102), Delaware (Del. Admin. Code Title 16, 4462), Maine (10 144 Me. Code R. Chap. 231), Michigan (Mich. Admin. Code r.299.44 and r.299.49, 2017), New Jersey (7:10 N.J Admin. Code 5.2), Pennsylvania (25 Pa. Code 109.202), Rhode Island (216-RICR-50-05-1), Texas (30 Tex. Admin. Code 290.104)	State MCL: 0.05 µg/L
	Florida (Fla. Admin. Code R. Chap. 62-550), Massachusetts (310 Code Mass. Regs. 22.00)	State MCL: 0.02 µg/L
	Minnesota (Minn R. Chap. 4720)	State MCL: 0.03 µg/L
State PELs	California (Cal Code Regs. Title 8, 5155)	State PEL: 0.13ppm (ceiling)
	Hawaii (Hawaii Administrative Rules section 12-60-50)	State PEL: 20 ppm State ceiling: 30 ppm
	Massachusetts (Massachusetts Department of Environmental Protection; Ambient Air Toxic Guidelines)	Threshold Effects Exposure Limit (24-hr average): 2 ug/m3 Non-Threshold Effects Exposure Limit (annual average): 0.003 µg/m^3 Allowable Ambient Limit (annual average): 0.003 µg/m3
	Oregon (Administrative Rules 437-002-0382)	State PEL: 20 ppm State ceiling: 25 ppm Acceptable Max. Peak Above the Acceptable Ceiling Concentration for an 8-hour Shift: 5 ppm; Skin notation
	Washington (Admin. Code WAC 296-841-20025)	State TWA: 0.1 ppm State STEL: 0.5 ppm
State Right-to-Know Acts		Massachusetts (105 Code Mass. Regs. § 670.000 Appendix A), New Jersey (8:59 N.J. Admin. Code 9.1) and Pennsylvania (P.L. 734, No. 159 and 34 Pa. Code 323).
Chemicals of High Concern to Children		Several states have adopted reporting laws for chemicals in children's products containing ethylene dibromide, including Maine (38 MRSA Chapter 16-D), and Minnesota (Toxic Free Kids Act Minn. Stat. 116.9401 to 116.9407).
Other		California listed ethylene dibromide on Proposition 65 in 1987 due to cancer and in 1998 due to reproductive toxicity (including developmental toxicity and male reproductive toxicity), (Cal Code Regs. Title 27, 27001).

General Description of Authority or Regulation	Chemical-Specific Summary
	Ethylene dibromide is listed as a Candidate Chemical under California's Safer Consumer Products Program (Health and Safety Code 25252 and 25253). Ethylene dibromide is on the MA Toxic Use Reduction Act (TURA) list of 2019 (301 CMR 41.00). Maine (CMR 01.001 Chapter 349 limits the presence of residual ethylene dibromide in Milled grain products intended to receive further cooking to 30 ppb; Ready-to-eat products containing grains to 5 ppb; and Baby foods to 0 ppb.

B.3 International Laws and Regulations

Table_Apx B-3. International Laws and Regulations

Country/ Organization	General Description of Authority or Regulation	Chemical-Specific Summary
Canada	Ethylene dibromide appears on the Canadian Domestic Substances List. (Government of Canada. Managing substances in the environment. Substances search, accessed August 11, 2026).	TWA: 0.5 ppm, skin notation; confirmed carcinogen 2A
European Union	Ethylene dibromide is registered for use in the EU. (European Chemicals Agency (ECHA) database, accessed August 11, 2026).	8 hours limit value: 0.1 ppm Long term occupational exposure limit: 0.5 ppm, skin notation; carcinogen
Australia	Ethylene dibromide was assessed under the Human Health and Environment Tier II of the Inventory Multi-Tiered Assessment and Prioritization (IMAP). Uses reported include: preparations for dyes and waxes; production of some plastics and latex, manufacture of leaded petro; treatment of logs for pests; fumigant in soils, grains, fruits and vegetables. (NICNAS, 2013, Human Health Tier II assessment for ethylene dibromide, accessed August 11, 2026).	TWA: 0.5 ppm or 3.9 mg/m^3, skin notation; confirmed carcinogen
Japan	Ethylene dibromide is regulated in Japan under the following legislation: • Act on the Evaluation of Chemical Substances and Regulation of Their Manufacture, *etc.* (Chemical Substances Control Law; CSCL) • Act on Confirmation, *etc.* of Release Amounts of Specific Chemical Substances in the Environment and Promotion of Improvements to the Management Thereof • Industrial Safety and Health Act (ISHA) • Air Pollution Control Law • Poisonous and Deleterious Substances Control Act (National Institute of Technology and Evaluation [NITE] Chemical Risk Information Platform [CHIRP, accessed August 11, 2026],	-Carcinogen -Skin notation -Hazardous Air Pollutant
World Health Organization (WHO)	IARC (1977, 1982, 1987) concluded, from biological data relevant to the evaluation of carcinogenic risk, that 1,2-dibromoethane is carcinogenic in mice and rats after oral administration, and by inhalation, producing squamous cell carcinomas of the forestomach.	Group 2A carcinogen (probably carcinogenic to humans).

Country/ Organization	General Description of Authority or Regulation	Chemical-Specific Summary
	1,2-Dibromoethane was evaluated by the Joint FAO/WHO Expert Committee on Pesticide Residues in 1965 (FAO/WHO, 1965) and 1966 (FAO/WHO, 1967). The 1965 evaluation concluded that 1,2-dibromoethane should be used for fumigation of food only on the condition that no residue of the unchanged compound reached the consumer. In the 1966 evaluation an Acceptable Daily Intake (ADI) of 1 mg/kg body weight as bromide was established. In 1991 the Codex Alimentarius Commission deleted the Guideline Levels for 1,2-dibromoethane in food commodities (FAO/WHO, 1992; accessed August 11, 2026)	
Institute for Occupational Safety and Health of the German Social Accident Insurance (GESTIS) International Limit Values for Chemical Agents Database (accessed August 11, 2026).	Austria	TWA: 0.1 ppm STEL: 0.4 ppm Skin notation
	Belgium, Finland, France, Hungary, Ireland, Italy, Latvia, Spain	TWA: 0.1 ppm Skin notation
	Denmark	TWA: 0.0002 ppm STEL: 0.2 ppm Carcinogen Skin notation
	Germany	TWA: 0.1 ppm Skin notation Formal implementation of Directive 2019/130/EU.
	Israel	TWA: 1 ppm STEL: 3 ppm
	New Zealand	TWA: 0.0003 ppm
	Norway	TWA: 0.01 ppm Skin notation
	Poland	TWA: 0.001 ppm Skin notation
	Romania	TWA: 0.1 ppm STEL: 0.3 ppm
	South Africa, United Kingdom	TWA: 0.5 ppm Skin notation
	Sweden, Switzerland	TWA: 0.1 ppm
	The Netherlands	TWA: 0.0002 ppm Skin notation

B.4 Assessment History

Table_Apx B-4. Assessment History of Ethylene Dibromide

Authoring Organization	Publication
EPA publications	
California Environmental Protection Agency (CalEPA), California Office of Environmental Health Hazard Assessment (OEHHA)	CalEPA's *TSD for noncancer RELs – Appendix D.3 Chronic RELs and toxicity summaries using the previous version of the Hot Spots Risk Assessment guidelines* (2001) (CalEPA, 2001)
California Environmental Protection Agency (CalEPA), California Office of Environmental Health Hazard Assessment (OEHHA), Air Resources Board (ARB)	CalEPA's *Table 1: Consolidated table of OEHHA/ARB approved risk assessment health values* (2023) (CalEPA, 2023)
United States Environmental Protection Agency (U.S. EPA), Office of Pesticide Programs (OPP)	U.S. EPA's *Ethylene dibromide (EDB): Position document 4* (1983) (U.S. EPA, 1983)
United States Environmental Protection Agency (U.S. EPA), Office of Health and Environmental Assessment (OEHA)	U.S. EPA's *Dermal exposure assessment: Principles and applications (interim report)* (1992) (U.S. EPA, 1992a)
United States Environmental Protection Agency (U.S. EPA), Integrated Risk Information System (IRIS)	U.S. EPA's *Reference Dose (RfD): description and use in health risk assessments background document 1A* (1993) (U.S. EPA, 1993a)
United States Environmental Protection Agency (U.S. EPA), Office of Research and Development (ORD)	U.S. EPA's *Wildlife exposure factors handbook [EPA Report]* (1993) (U.S. EPA, 1993b)
United States Environmental Protection Agency (U.S. EPA)	U.S. EPA's *Methods for derivation of inhalation reference concentrations and application of inhalation dosimetry* [EPA Report] (1994) (U.S. EPA, 1994b)
United States Environmental Protection Agency (U.S. EPA), Risk Assessment Forum	U.S. EPA's *Guidelines for ecological risk assessment [EPA Report]* (1998) (U.S. EPA, 1998)
United States Environmental Protection Agency (U.S. EPA)	U.S. EPA's *A review of the reference dose and reference concentration processes [EPA Report]* (2002) (U.S. EPA, 2002a)
United States Environmental Protection Agency (U.S. EPA)	U.S. EPA's *Short-term methods for estimating the chronic toxicity of effluents and receiving water to freshwater organisms [EPA Report]* (2002) (U.S. EPA, 2002b)
United States Environmental Protection Agency (U.S. EPA), Office of Pesticide Programs (OPP)	U.S. EPA's *Docket EPA-HQ-OPP-2004-0005: Refined (Level II) terrestrial and aquatic models for probabilistic and ecological assessment of pesticides* (2004) (U.S. EPA, 2004a)
United States Environmental Protection Agency (U.S. EPA), Office of Research and Development (ORD), National Center for Environmental Assessment (NCEA)	U.S. EPA's *Toxicological review of 1,2-dibromoethane (CAS no. 106-93-4)* (2004) (U.S. EPA, 2004b)
United States Environmental Protection Agency (U.S. EPA)	U.S. *EPA's Guidelines for carcinogen risk assessment [EPA Report]* (2005) (U.S. EPA, 2005a)
United States Environmental Protection Agency (U.S. EPA), Risk Assessment Forum	U.S. EPA's *Supplemental guidance for assessing susceptibility from early-life exposure to carcinogens [EPA Report]* (2005) (U.S. EPA, 2005b)

Authoring Organization	Publication
United States Environmental Protection Agency (U.S. EPA), National Risk Management Research Laboratory (NRMRL)	U.S. EPA's *Natural attenuation of the lead scavengers 1,2-dibromoethane (EDB) and 1,2-dichloroethane (1,2-DCA) at motor fuel release sites and implications for risk management* (2008) (U.S. EPA, 2008b)
United States Environmental Protection Agency (U.S. EPA), Environmental Fate and Effects Division, Office of Pesticide Programs (OPP) [website]	U.S. EPA's *STIR Version 1.0 User's Guide for Pesticide Inhalation Risk: Screening tool for inhalation risk* (2010) (U.S. EPA, 2010)
United States Environmental Protection Agency (U.S. EPA), Office of Research and Development (ORD), National Center for Environmental Assessment (NCEA)	U.S. EPA's *Exposure factors handbook: 2011 edition [EPA Report]* (2011) (U.S. EPA, 2011a)
United States Environmental Protection Agency (U.S. EPA)	U.S. EPA's *Recommended use of body weight 3/4 as the default method in derivation of the oral reference dose* (2011) (U.S. EPA, 2011b)
United States Environmental Protection Agency (U.S. EPA)	U.S. EPA's *Advances in inhalation gas dosimetry for derivation of a reference concentration (RfC) and use in risk assessment* (2012) (U.S. EPA, 2012a)
United States Environmental Protection Agency (U.S. EPA), Risk Assessment Forum	U.S. EPA's *Benchmark dose technical guidance [EPA Report]* (2012) (U.S. EPA, 2012b)
United States Environmental Protection Agency (U.S. EPA), Office of Chemical Safety and Pollution Prevention (OCSPP)	U.S. EPA's *Ecological effects test guidelines: OCSPP 850.2400: Wild mammal toxicity testing [EPA Report]* (2012) (U.S. EPA, 2012c)
United States Environmental Protection Agency (U.S. EPA)	U.S. EPA's *Interpretive assistance document for assessment of discrete organic chemicals. Sustainable futures summary assessment [EPA Report]* (2013) (U.S. EPA, 2013)
United States Environmental Protection Agency (U.S. EPA), Risk Assessment Forum	U.S. EPA's *Framework for human health risk assessment to inform decision making. Final [EPA Report]* (2014) (U.S. EPA, 2014a)
United States Environmental Protection Agency (U.S. EPA), Risk Assessment Forum, Office of the Science Advisor	U.S. EPA's *Guidance for applying quantitative data to develop data-derived extrapolation factors for interspecies and intraspecies extrapolation [EPA Report]* (2014) (U.S. EPA, 2014b)
United States Environmental Protection Agency (U.S. EPA), Office of Chemical Safety and Pollution Prevention (OCSPP)	U.S. EPA's *Ecological effects test guidelines: OCSPP 850.1075: Freshwater and saltwater fish acute toxicity test [EPA Report]* (2016) (U.S. EPA, 2016b)
United States Environmental Protection Agency (U.S. EPA), Office of Pesticide Programs (OPP)	U.S. EPA's *Office of pesticide programs' Re-evaluation of the FQPA safety factor for pyrethroids: Updated literature and CAPHRA Program Data review* (2019) (U.S. EPA, 2019b) (2019)
United States Environmental Protection Agency (U.S. EPA), Office of Chemical Safety and Pollution Prevention (OCSPP)	U.S. EPA's *Draft systematic review protocol supporting TSCA risk evaluations for chemical substances, Version 1.0: A generic TSCA systematic review protocol with chemical-specific methodologies* (2021) (U.S. EPA, 2021a)
United States Environmental Protection Agency (U.S. EPA), Science Advisory Committee on Chemicals (SACC)	U.S. EPA's *Science advisory committee on chemicals meeting minutes and final report No. 2024-2, docket ID: EPA-HQ-OPPT-2024-0073: For the draft risk evaluation for di-isodecyl phthalate (DIDP) and*

Authoring Organization	Publication
	draft hazard assessments for di-isononyl phthalate (DINP) (2024) (U.S. EPA, 2024f)
United States Environmental Protection Agency (U.S. EPA), Office of Research and Development (ORD), Gulf Ecosystem Measurement and Modeling Division	U.S. EPA's *Web-based Interspecies Correlation Estimation (Web-ICE) for Acute Toxicity: User Manual, Version 4.0* (2024) (U.S. EPA, 2024g)
United States Environmental Protection Agency (U.S. EPA), Office of Chemical Safety and Pollution Prevention (OCSPP)	U.S. EPA's *Ecological effects test guidelines: OCSPP 850.2400: Wild mammal toxicity testing* (2024) (U.S. EPA, 2012c)
United States Environmental Protection Agency (U.S. EPA)	U.S. EPA's *Meeting with Professional Aviation Maintenance Association on Risk Evaluation Under TSCA section 6 for Ethylene Dibromide* (2025) (U.S. EPA, 2025c)
Other U.S.-based organizations	
Agency for Toxic Substances and Disease Registry (ATSDR)	ATSDR's *Toxicological profile for 1,2-dibromoethane* (2018) (ATSDR, 2018)
American Society for Testing and Materials (ASTM)	ASTM's Standard guide for conducting acute toxicity tests on test materials with fishes, macroinvertebrates, and amphibians (2014) (ASTM, 2014)
Agency for Toxic Substances and Disease Registry (ATSDR)	ATSDR's *Medical Management Guidelines (MMG) for Ethylene dibromide* (2007) (ATSDR, 2007)
Equitable Environmental Health Inc.	Equitable Environment Health Inc's *A retrospective study of inferred fertility of married men occupationally exposed to ethylene dibromide (EDB)* (1977) (Equitable Environmental Health Inc, 1977)
Lab Research Ltd, Chemtura Corporation	LAB Research Ltd's *Acute immobilisation test with Ethylene Dibromide Industrial (EDB) on Daphnia (Daphnia magna)* (2010) (LAB Research, 2010a)
Lab Research Ltd, Chemtura Corporation	LAB Research Ltd's *Acute toxicity test with Ethylene Dibromide Industrial (EDB) on rainbow trout (Oncorhynchus mykiss)* (2010) (LAB Research, 2010b)
Lab Research Ltd, Chemtura Corporation	LAB Research Ltd's *Growth inhibition test with Ethylene Dibromide Industrial (EDB) on algae (Pseudokirchneriella subcapitata)* (2010) (LAB Research, 2010c)
National Cancer Institute (NCI), National Institute of Health (NIH)	NCI's *Bioassay of 1,2-dibromoethane for possible carcinogenicity* (1978) (NCI, 1978)
National Toxicology Program (NTP)	NTP's *Carcinogenesis bioassay of 1,2-dibromoethane (CAS no 106-93-4) in F344 rats and B6C3F1 mice (inhalation study)* (1982) (NTP, 1982)
National Toxicology Program (NTP)	NTP's *Report on carcinogens, fourteenth edition: 1,2-dichloroethane* (2016) (NTP, 2016)
International	
National Industrial Chemicals Notification and Assessment Scheme (NICNAS)	National Industrial Chemicals Notification and Assessment Scheme's *Ethane, 1,2-dibromo-: Environment tier II assessment* (2013) (NICNAS, 2013)

Authoring Organization	Publication
National Industrial Chemicals Notification and Assessment Scheme (NICNAS)	National Industrial Chemicals Notification and Assessment Scheme's *Ethane, 1,2-dibromo-: Environment tier II assessment* (2014) (NICNAS, 2014)
American Society for Testing and Materials (ASTM)	ASTM's *Standard guide for conducting acute toxicity tests on test materials with fishes, macroinvertebrates, and amphibians* (2014) (ASTM, 2014)
International Agency for Research on Cancer (IARC), World Health Organization (WHO)	IARC's *Ethylene dibromide (1,2-dibromoethane) [IARC Monograph]. In Re-evaluation of some organic chemicals, hydrazine and hydrogen peroxide, pt 2* (1999) (IARC, 1999)
International Agency for Research on Cancer (IARC), World Health Organization (WHO)	IARC's *Some antiviral and antineoplastic drugs, and other pharmaceutical agents [IARC Monograph]* (2000) (IARC, 2000)
Interdepartmental Group on Health Risks from Chemicals (IGHRC), Institute of Environment and Health	IGHRC,s *Guidelines on route-to-route extrapolation of toxicity data when assessing health risks of chemicals* (2006) (IGHRC, 2006)

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Appendix C LIST OF TECHNICAL SUPPORT AND SUPPLEMENTAL DOCUMENTS

This appendix provides a list and citations for all TSDs and supplemental files included in the draft risk evaluation for ethylene dibromide. These include discipline-specific assessments, systematic review results, risk calculations, and modeling outputs documents. Files are numbered to correspond with the filenames uploaded to the docket ("01" is for this risk evaluation): EPA-HQ-OPPT-2018-0488.

1. *Draft Risk Evaluation for Ethylene Dibromide* (U.S. EPA, 2026ad)

Associated **Technical Support and Supplemental Information Documents** – Provide additional details and information on exposure, hazard, and risk assessments.

2. *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d)
3. *Draft Hazard Assessment for Ethylene Dibromide* (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.

4. *Draft Systematic Review Protocol for Ethylene Dibromide* (U.S. EPA, 2026ag) – In lieu of an update to the 2021 Draft Systematic Review Protocol (U.S. EPA, 2021a), this systematic review protocol for the *Draft Risk Evaluation for Ethylene Dibromide* 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 "Ethylene Dibromide Systematic Review Protocol."
5. *Draft Data Quality Evaluation and Data Extraction Information for Physical and Chemical Properties for Ethylene Dibromide* (U.S. EPA, 2026i) – Provides a compilation of tables for the data extraction and data quality evaluation information for ethylene dibromide. 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 "Ethylene Dibromide Data Quality Evaluation and Data Extraction Information for Physical and Chemical Properties."
6. *Draft Data Quality Evaluation and Data Extraction Information for Environmental Fate and Transport for Ethylene Dibromide* (U.S. EPA, 2026g) – Provides a compilation of tables for the data extraction and data quality evaluation information for ethylene dibromide. 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 for Environmental Fate and Transport. This supplemental file may also be referred to as the "Ethylene Dibromide Data Quality Evaluation and Data Extraction Information for Environmental Fate and Transport."
7. *Draft Data Quality Evaluation and Data Extraction Information for Environmental Release and Occupational Exposure for Ethylene Dibromide* (U.S. EPA, 2026h) – Provides a compilation of tables for the data extraction and data quality evaluation information for ethylene dibromide. 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 environmental release and occupational exposure. This supplemental file may also be referred to as the "Ethylene

Dibromide Data Quality Evaluation and Data Extraction Information for Environmental Release and Occupational Exposure."

8. *Draft Data Quality Evaluation Information for Dermal Absorption for Ethylene Dibromide* (U.S. EPA, 2026j) – Provides a compilation of tables for the data quality evaluation information for ethylene dibromide. 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 for Dermal Absorption. This supplemental file may also be referred to as the "Ethylene Dibromide Data Quality Evaluation Information for Dermal Absorption."
9. *Draft Data Quality Evaluation Information for General Population, Consumer, and Environmental Exposure for Ethylene Dibromide* (U.S. EPA, 2026l) – Provides a compilation of tables for the data extraction for ethylene dibromide. 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 general population, consumer, and environmental exposure. This supplemental file may also be referred to as the "Ethylene Dibromide Data Evaluation Information for General Population, Consumer, and Environmental Exposure."
10. *Draft Data Extraction Information for General Population, Consumer, and Environmental Exposure for Ethylene Dibromide* (U.S. EPA, 2026f) – Provides a compilation of tables for the data extraction information for ethylene dibromide. 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 general population, consumer, and environmental exposure. This supplemental file may also be referred to as the "Ethylene Dibromide Data Extraction Information for General Population, Consumer, and Environmental Exposure."
11. *Draft Data Quality Evaluation Information for Human Health Hazard Epidemiology for Ethylene Dibromide* (U.S. EPA, 2026n) – Provides a compilation of tables for the data quality evaluation information for ethylene dibromide. Each table shows the data point, set, or element that was evaluated from a data source that has information relevant for the evaluation of epidemiological information. This supplemental file may also be referred to as the "Ethylene Dibromide Data Quality Evaluation Information for Human Health Hazard Epidemiology."
12. *Draft Data Quality Evaluation Information for Human Health Hazard Animal Toxicology for Ethylene Dibromide* (U.S. EPA, 2026m) – Provides a compilation of tables for the data quality evaluation information for ethylene dibromide. 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 "Ethylene Dibromide Data Quality Evaluation Information for Human Health Hazard Animal Toxicology."
13. *Draft Data Quality Evaluation Information for Environmental Hazard for Ethylene Dibromide* (U.S. EPA, 2026k) – Provides a compilation of tables for the data quality evaluation information for ethylene dibromide. Each table shows the data point, dataset, 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 "Ethylene Dibromide Data Quality Evaluation Information for Environmental Hazard."
14. *Draft Data Extraction Information for Environmental Hazard and Human Health Hazard Animal Toxicology and Epidemiology for Ethylene Dibromide* (U.S. EPA, 2026e) – Provides a compilation of tables for the data extraction for ethylene dibromide. Each table shows the data point, set, or information element that was extracted from a data source that has information relevant for the evaluation human health hazard animal toxicology, epidemiology, and environmental hazard toxicology information. This supplemental file may also be referred to as the "Ethylene Dibromide Data Extraction Information for Environmental Hazard and Human Health Hazard Animal Toxicology and Epidemiology."

Associated **Supplemental Information Document** – Provide additional details and information on fate, exposure, hazard, and risk assessments.

15. *Draft Exposure and Fate Assessment Screening Tool (E−FAST) Surface Water Concentrations for Ethylene Dibromide* (U.S. EPA, 2026q)
16. *Draft Point Source Calculator (PSC) Surface Water Concentrations for Ethylene Dibromide* (U.S. EPA, 2026ac)
17. *Draft Number of Sites for Ethylene Dibromide* (U.S. EPA, 2026y)
18. *Draft Water Releases for Ethylene Dibromide* (U.S. EPA, 2026ah)
19. *Draft Air Releases for Ethylene Dibromide* (U.S. EPA, 2026b)
20. *Draft Default Risk Calculator for Occupational and Consumer Exposures for Ethylene Dibromide* (U.S. EPA, 2026o)
21. *Draft PBPK Risk Calculator for Occupational Exposures for Ethylene Dibromide* (U.S. EPA, 2026ab)
22. *Draft Calculations for Estimating Vapor Fraction of Ethylene Dibromide VOC in 100LL Avgas* (U.S. EPA, 2026c)
23. *Draft Estimates for Number of Workers and ONUs* (U.S. EPA, 2026p)
24. *Draft Human Exposure Model (HEM) Exposure and Risk Calculator for General Population for Ethylene Dibromide* (U.S. EPA, 2026u)
25. *Draft Integrated Indoor Outdoor Air Calculator (IIOAC) Exposure and Risk Calculator for General Population for Ethylene Dibromide* (U.S. EPA, 2026x)
26. *Draft Surface Water Human Exposure Risk Calculator for General Population for Ethylene Dibromide* (U.S. EPA, 2026af)
27. *Draft Fish Ingestion Risk Calculator for General Population Exposure for Ethylene Dibromide* (U.S. EPA, 2026r)
28. *Draft Summary of AMTIC Data for Ethylene Dibromide* (U.S. EPA, 2026ae)
29. *Draft PBPK Reporting Document for Ethylene Dibromide* (U.S. EPA, 2026aa)
30. *Draft Import and Repackaging Release Model for Ethylene Dibromide* (U.S. EPA, 2026w)
31. *Draft Fuels and Related Products Release Model for Ethylene Dibromide* (U.S. EPA, 2026s)
32. *Draft IH SkinPerm Dermal Absorption Modeling for Ethylene Dibromide* (U.S. EPA, 2026v)
33. *Draft PBPK Model Code and Data for Ethylene Dibromide* (U.S. EPA, 2026z)

Appendix D ETHYLENE DIBROMIDE CONDITIONS OF USE

D.1 Additions and Name Changes to Conditions of Use Based on Updated 2020 and 2024 CDR Reported Data

After publication of the final scope (U.S. EPA, 2020b), EPA received updated submissions under the 2020 and 2024 CDR reported data. In addition to new submissions received under the 2020 and 2024 CDR, EPA's improved understanding of the COUs based on further outreach, public comments, and some industry code names were updated for the 2020 and 2024 CDR cycles. Therefore, EPA is amending the description of certain ethylene dibromide conditions of use based on that outreach and those new submissions. Also, EPA received information from stakeholders clarifying certain conditions of use of ethylene dibromide. Table_Apx D-1 summarizes the changes to the conditions of use based on the new reporting codes in the 2020 and 2024 CDR and any other new information since the publication of the final scope.

D.2 Changes to Conditions of Use Table

Table_Apx D-1. Additions and Name Changes to Categories and Subcategories of Conditions of Use Based on CDR Reporting and Stakeholder Engagement

Life Cycle Stage and Category	Original Subcategory in the Final Scope Document	Occurred Change	Revised Life Cycle Stage, Category, and Subcategory in the 2025 Draft Risk Evaluation
Manufacturing – Import	Import	Changed Manufacturing to Manufacture and Subcategory to N/A for consistency with other chemicals.	Manufacture – Import – N/A
Processing – Incorporation into formulation, mixture, or reaction product	Petroleum refineries	Added product functional code of "Fuels and fuel additives in" to both subcategories consistent with CDR reporting.	Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in petroleum refineries
	All other petroleum and coal products manufacturing		Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in all other petroleum and coal products manufacturing
Processing – Processing as a reactant	Not included	Added COU for "Processing as a reactant – *E.g.,* in Pigment and dye manufacturing; Plastic material and resin manufacturing" based on patents and stakeholder outreach.	Processing – Processing as a reactant – *E.g.,* in Pigment and dye manufacturing; Plastic material and resin manufacturing
Processing – Repackaging	Not included	Added "Processing: Repackaging" COU to account for repackaging for laboratory use.	Processing – Repackaging – N/A
Distribution in commerce – Distribution in commerce	Distribution in commerce	Revised category and subcategory to "N/A" because it was duplicative and therefore unnecessary for identifying the condition of use.	Distribution in commerce – N/A – N/A
Industrial Use – Fuel agents in petroleum refineries	Not included	Added COUs based on CDR reporting and stakeholder outreach.	Industrial Use – Fuel agents in petroleum refineries – N/A

Life Cycle Stage and Category	Original Subcategory in the Final Scope Document	Occurred Change	Revised Life Cycle Stage, Category, and Subcategory in the 2025 Draft Risk Evaluation
Industrial Use – Other Use			Industrial Use – Other Use – Processing aid not otherwise specified; Pigment and dye manufacturing
Commercial Use – Other Use	*E.g.,* Laboratory chemical	Removed "*E.g.*" as research did not indicate additional commercial uses.	Commercial Use – Other Use – Laboratory chemical
Commercial use – Fuels and related products	Fuels additives (*e.g.,* in aviation and racing fuels)	Revised subcategory to "N/A" because it was duplicative and therefore unnecessary for identifying the condition of use.	Commercial use – Fuels and related products – N/A
Consumer use – Fuels and related products	Fuels and related products	Revised subcategory to "N/A" because it was duplicative and therefore unnecessary for identifying the condition of use.	Consumer use – Fuels and related products – N/A
Disposal – Disposal	Disposal	Revised category and subcategory to "N/A" because it was duplicative and therefore unnecessary for identifying the condition of use.	Disposal – N/A – N/A

D.3 Descriptions of Ethylene Dibromide Conditions of Use

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 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 ethylene dibromide. To better describe the COUs, EPA considered CDR submissions for ethylene dibromide from the last three CDR cycles and other reasonably available information, including stakeholder engagements, published literature, company websites, government and commercial trade databases and publications. For CDR submissions, 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 which are referenced, *e.g.,* "plastic products manufacturing," or "fabric, textile, and leather products." EPA will clarify as needed when these references are included throughout the COU descriptions below.

D.3.1 Manufacture – Import

This COU refers to the import of ethylene dibromide, including ethylene dibromide-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 ethylene dibromide. In general, chemicals may be imported into the United States in bulk via water, air, land, and intermodal shipments.

D.3.2 Processing – Incorporation into a Formulation, Mixture, or Reaction Product – Fuels and Fuel Additives in All Other Petroleum and Coal Products Manufacturing

This COU refers to the preparation of a product; that is, the incorporation of ethylene dibromide into a 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, ethylene dibromide is added to a formulation, mixture, or reaction product (*e.g.,* ethylene dibromide-containing liquid, semi-solid, powder, or solid material) as a fuel or fuel additive or in all other petroleum and coal products manufacturing. The primary use of ethylene dibromide that may require incorporation into a formulation is leaded aviation fuel (avgas).

While the Final Scope of the Risk Evaluation (U.S. EPA, 2020b) identified use of ethylene dibromide in racing fuel, reasonably available information suggests that this use is largely phased out because Indy cars burn methanol; top fuel dragsters and funny cars burn nitromethane; and NASCAR switched to unleaded gas in 2008.

D.3.3 Processing – Incorporation into a Formulation, Mixture, or Reaction Product – Fuels and Fuel Additives in Petroleum Refineries

This COU refers to the preparation of a product; that is, the incorporation of ethylene dibromide into a 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 ethylene dibromide in fuels and fuel additives in petroleum refineries. In particular, ethylene dibromide is a component of the fuel additive typically known as TEL-B that contains tetraethyl lead (TEL) and ethylene dibromide. This TEL-B product contains 35.6% ethylene dibromide by weight, and this COU includes the blending of TEL-B into fuels at petroleum refineries, with an end percentage of ethylene dibromide in the fuel typically at 0.07%.

Examples of CDR Submissions

This use was reported during the 2016 CDR cycle. It was not reported during the 2020 or 2024 CDR cycles. The updated corresponding CDR code, "Fuel agents" was reported an Industrial use during the 2020 and 2024 CDR cycle (U.S. EPA (2024a, 2020a, 2016a)).

D.3.4 Processing – As a Reactant – *E.g.* in Pigment and Dye Manufacturing; Plastic Material and Resin Manufacturing

This COU refers to the use of ethylene dibromide in the production of another chemical via a chemical reaction in which ethylene dibromide is consumed to form the product, although trace amounts may be present in the product as an impurity. Processing of ethylene dibromide as a reactant may occur, for example, in pigment and dye manufacturing, as a solvent in plastic material and resin manufacturing, and as an alkylating agent in the manufacturing of dimeric benzylidene malonates.

D.3.5 Processing – Repackaging

This COU refers to preparation of ethylene dibromide for distribution in 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 chemical manufacturing. This COU includes transferring ethylene dibromide 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.

D.3.6 Distribution in Commerce

For purposes of assessment in this risk evaluation, distribution in commerce consists of the transportation associated with the moving of ethylene dibromide or ethylene dibromide-containing products and/or articles between sites manufacturing, processing or recycling ethylene dibromide or ethylene dibromide-containing products and/or articles, or to final use sites, or for final disposal of

ethylene dibromide or ethylene dibromide-containing products and/or articles. More broadly under TSCA, "distribution in commerce" and "distribute in commerce" are defined under TSCA section 3(5).

D.3.7 Industrial Use – Fuel Agents in Petroleum Refineries

This COU refers to the industrial use of ethylene dibromide as a fuel agent in petroleum refineries. This is a use of ethylene dibromide after it has already been incorporated into the fuel agent, as opposed to when it is used upstream, (*e.g.,* when ethylene dibromide is processed into the fuel agent). In particular, ethylene dibromide is a component of the fuel additive typically known as TEL-B that contains tetraethyl lead (TEL) and ethylene dibromide. This TEL-B product contains 35.6% ethylene dibromide by weight, and this COU includes the blending of TEL-B into fuels at petroleum refineries, with an end percentage of ethylene dibromide in the fuel typically at 0.07%.

Examples of CDR Submissions

This is an updated CDR code that was reported during the 2020 and 2024 CDR cycles. It was not reported during the 2016 CDR cycle. The corresponding CDR code, "Fuels and fuel additives" was reported a Processing use during the 2016 CDR cycle U.S. EPA (2024a, 2020a, 2016a).

D.3.8 Industrial Use – Other Use – Processing Aid Not Otherwise Specified; Pigment and Dye Manufacturing

This COU refers to the industrial use of ethylene dibromide as a processing aid and in pigment and dye manufacturing. This includes use of ethylene dibromide as an entrainment reagent to activate magnesium or zinc, depending on the reaction being performed. It also includes use of ethylene dibromide to digest excess unreacted magnesium from Grignard reactions. This is a use of ethylene dibromide after it has already been incorporated into the processing aid, pigment, or dye product or mixture, as opposed to when it is used upstream, (*e.g.,* when ethylene dibromide is processed into the processing aid, pigment, or dye formulation).

Examples of CDR Submissions

This use was not reported to CDR. Bedoukian Research Inc. self-identified as a small business for the TSCA Fees Rule and additional stakeholder outreach confirmed the details of this use (EPA-HQ-OPPT-2018-0488-0060).

D.3.9 Commercial Use – Fuels and Related Products

This COU refers to the commercial use of ethylene dibromide in fuels and fuel additives. This includes use as a lead scavenger in leaded fuels to reduce the accumulation of lead deposits in engines. Lead and lead scavengers were phased out of conventional automobile gasoline by the end of the 1980s, but aviation gasoline (avgas) containing ethylene dibromide and other lead scavengers is still used. EPA recognizes that piston-engine aircraft play a significant role in transportation in the United States. Avgas is critical for communities in remote locations, not otherwise served by road systems.

While the Final Scope of the Risk Evaluation (U.S. EPA, 2020b) identified use of ethylene dibromide in racing fuel, reasonably available information suggests that this use is largely phased out because Indy cars burn methanol; top fuel dragsters and funny cars burn nitromethane; and NASCAR switched to unleaded gas in 2008.

This is a use of ethylene dibromide after it has already been incorporated into the fuel or fuel additive product or mixture, as opposed to when it is used upstream, (*e.g.,* when ethylene dibromide is processed into the fuel or fuel additive formulation). The percentage of ethylene dibromide in the fuel is typically 0.07%.

Examples of CDR Submissions

This use was reported during the 2016 and 2020 CDR cycles. It was reported under the updated corresponding code, "Fuel agents" during the 2024 CDR cycle (U.S. EPA (2024a, 2020a, 2016a)).

D.3.10 Commercial Use – Other Use – Laboratory Chemical

This COU refers to the industrial and commercial use of ethylene dibromide as a laboratory chemical, such as for chemical standards, research, equipment calibration and sample preparation, including as a reference material during analysis. This COU refers to ethylene dibromide as it is used in the commercial sector, opposed to when it is processed upstream (*e.g.,* when ethylene dibromide is repackaged for laboratory use). EPA emphasizes that commercial use of ethylene dibromide as a laboratory chemical applies to research, government, and academic institutions, as well as to industrial and commercial laboratories. This COU also includes activities identified as critical by NASA.

D.3.11 Consumer Use – Fuels and Related Products

This COU refers to the consumer use of ethylene dibromide in fuels and fuel additives. This includes use as a lead scavenger in leaded fuels to reduce the accumulation of lead deposits in engines. Lead and lead scavengers were phased out of conventional automobile gasoline by the end of the 1980s, but aviation gasoline (avgas) containing ethylene dibromide and other lead scavengers is still used. EPA recognizes that piston-engine aircraft play a significant role in transportation in the United States. Avgas is critical for communities in remote locations, not otherwise served by road systems.

While the Final Scope of the Risk Evaluation (U.S. EPA, 2020b) identified use of ethylene dibromide in racing fuel, reasonably available information suggests that this use is largely phased out because Indy cars burn methanol; top fuel dragsters and funny cars burn nitromethane; and NASCAR switched to unleaded gas in 2008.

This is a use of ethylene dibromide after it has already been incorporated into the fuel or fuel additive product or mixture, as opposed to when it is used upstream, (*e.g.,* when ethylene dibromide is processed into the fuel or fuel additive formulation). The percentage of ethylene dibromide in the fuel is typically 0.07%.

Examples of CDR Submissions

This use was reported during the 2016 CDR cycle. It was reported under the updated corresponding code, "Fuel agents" during the 2024 CDR cycle (U.S. EPA (2024a, 2016a)).

D.3.12 Disposal

Each of the conditions of use of ethylene dibromide 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 ethylene dibromide risk evaluation, this COU refers to the ethylene dibromide in a waste stream that is collected from facilities and commercial sites and is unloaded at and treated or disposed at third-party sites. This COU also encompasses ethylene dibromide contained in wastewater discharged by occupational users to a POTW or other, non-POTW for treatment, as well as other wastes. Ethylene dibromide is expected to be released to other environmental media, such as migration to water sources, or through waste disposal (*e.g.,* disposal of formulations containing ethylene dibromide or transport containers). Disposal may also include destruction and removal by incineration. Recycling of ethylene dibromide and ethylene dibromide-containing products would be considered a different COU, however there is no reasonably available information to suggest that recycling is occurring. Environmental releases from manufacturing and processing sites that treat or dispose onsite waste are assessed in each COU.

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

Based on the available hazard and exposure profile for ethylene dibromide, EPA has calculated a draft 8-hour TWA existing chemical occupational exposure value (OEV) and a draft 15-minute short-term occupational exposure value (STEV). The calculated values may be used to support risk management efforts for ethylene dibromide under TSCA section 6(a), 15 U.S.C. 2605. EPA calculated the value rounded to 9.7×10^{-4} ppm or 7.5×10^{-3} mg/m^3 for inhalation exposures to ethylene dibromide as an 8-hour TWA and for consideration in workplace settings (see Appendix E.1 below) based on the hazard value for lifetime cancer unit risk (IUR) for a combined/multi-tumor model. The current OSHA permissible exposure limit (PEL) is 20 ppm as an 8-hour TWA for ethylene dibromide. The short-term exposure limit (STEL) is 30 ppm for any 15 minutes period, and a 50 ppm maximum peak for any 5 minutes within an 8-hour shift (OSHA, 2018).

EPA has determined that the most sensitive occupational exposure value is already protective of any hazards specific to short-term exposure (see Appendix E.3 for details).

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

This draft calculated occupational exposure value for ethylene dibromide represents the exposure concentration at which the cancer risk related to exposure and hazard for workers and ONUs under each COU is above the benchmark cancer risk of 1×10^{-6}.

The draft value is derived based on HECs described in Section 4.2.4, reflecting the best available science and are protective of human health effects. The calculated value is intended to be protective of carcinogenicity (an HEC based on lifetime IUR) and male reproductive effects. This 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 hazard values used in these calculations are based on non-cancer, human equivalent concentrations (HECs), associated UF derivations, and the IUR value from the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t).

EPA expects that at the occupational exposure value of 9.7×10^{-4} ppm or 7.5×10^{-3} mg/m^3 for lifetime exposure, workers and ONUs also would be protective against non-cancer health effects for acute, intermediate, and chronic durations. EPA has also calculated a draft short-term occupational exposure value (STEV) for ethylene dibromide (see Appendix E.3 for details). The acute exposure value is unchanged for all durations of a single exposure and also serves as the short-term exposure value (STEV) to protect against 15-minute exposures.

Of the identified occupational monitoring data for ethylene dibromide, there have been measured workplace air concentrations below the calculated short-term exposure value. A summary table of

available monitoring methods from OSHA, NIOSH, and EPA are included in Table_Apx E-1. That table presents validated methods from governmental agencies and is not intended to be a comprehensive list of available air monitoring methods for ethylene dibromide. The calculated exposure value is above the limit of detection (LOD) and limit of quantification (LOQ) using at least one of the monitoring methods identified.

OSHA set a PEL as an 8-hour TWA for ethylene dibromide of 20 ppm (OSHA, 2018). The OSHA also set a ceiling limit of 30 ppm for any 15 minutes period, and a 50 ppm maximum peak for any 5 minutes within an 8-hour shift (OSHA, 2018). The OSHA PEL for ethylene dibromide was adopted in 1971. However, as noted on OSHA's website, "OSHA recognizes that many of its permissible exposure limits (PELs) are outdated and inadequate for ensuring protection of worker health. Most of OSHA's PELs were issued shortly after adoption of the Occupational Safety and Health (OSH) Act in 1970 and have not been updated since that time." In addition, OSHA's PEL must undergo both risk assessment and feasibility assessment analyses before selecting a level that will substantially reduce risk under the Occupational Safety and Health Act. EPA's calculated exposure value is a lower value and is based on newer information and analysis from this risk evaluation.

Table_Apx E-1. EPA's Draft OEV, STEV and Existing Recommended Exposure Limits Established for Ethylene Dibromide

Organization	Type of Limit / Classification	Value	Exposure Duration / Notes	Timeline of the Value Derived or Established
EPA	Draft Occupational Exposure Value (OEV)	9.7E−04 ppm	Time-weighted average for a 8-hour workday	2026 (Draft)
EPA	Draft 15-Minute Short Term Exposure Value (STEV)	0.92 ppm	Must not be exceeded during any 15-minute period	2026 (Draft)
NIOSH	Recommended Exposure Limit (REL) – TWA	0.045 ppm	Time-weighted average for up to a 10-hour workday	1977
NIOSH	Ceiling Limit	0.13 ppm	Must not be exceeded during any 15-minute period	1977
NIOSH	IDLH (Immediately Dangerous to Life or Health)	100 ppm	Based on a 30-minute exposure	1994
ACGIH	Threshold Limit Value (TLV)	Not established	No TLV set for ethylene dibromide	N/A
NIOSH and ACGIH; accessed August 11, 2026				

E.1 Occupational Exposure Value Calculations

This section presents the calculations used to estimate the occupational exposure values using inputs derived in this draft risk evaluation. Multiple values are presented below for hazard endpoints based on different exposure durations. The most sensitive occupational exposure value for ethylene dibromide is an inhalation multi-tumor unit risk (IUR) of 5.60×10^{-2} per mg/m^3 or 0.43 per ppm based on chronic, cancer for carcinomas and adenocarcinomas of the nasal cavity, based on an 8-hour TWA assuming a typical 40-hour work week. The resulting chronic, cancer (lifetime) 8-hour TWA is rounded to 7.5×10^{-3} mg/m^3 (9.7×10^{-4} ppm). The draft occupational exposure value is derived based on IUR described in Section 4.2.4. The human health hazard values (HECs, IUR) used in the equations are derived in this draft risk evaluation and the *Draft Hazard Assessment for Ethylene Dibromide* (U.S. EPA, 2026t).

EPA also reviewed and summarized information on recommended occupational exposure limits previously derived and established for ethylene dibromide by other government agencies and independent groups.

Most Sensitive Occupational Exposure Value (Lifetime Cancer)

The EV_{cancer} is the concentration at which the extra cancer risk is equivalent to the benchmark cancer risk of 1.0×10^{-4}:

$$EV_{cancer} = \frac{Benchmark_{Cancer}}{IUR} \times \frac{AT_{IUR}}{ED \times EF \times WY} \times \frac{IR_{resting}}{IR_{workers}}$$

$$= \frac{1\times10^{-4}}{0.43\ per\ ppm} \times \frac{24\frac{h}{d}\times\frac{365d}{y}\times78y}{8\frac{h}{d}\times\frac{250d}{y}\times40y} \times \frac{0.6125\frac{m^3}{h}}{1.25\frac{m^3}{h}} = \mathbf{9.7\times10^{-4}\ ppm}$$

$$EV_{cancer}\left(\frac{mg}{m^3}\right) = \frac{EV\ ppm \times MW}{Molar\ Volume} = \frac{9.73\times10^{-4}\ \text{ppm} \times 187.86\frac{g}{mol}}{24.45\frac{L}{mol}} = \mathbf{7.5\times10^{-3}\ mg/m^3}$$

Where:

Molar Volume	=	24.45 L/mol, the volume of a mole of gas at 1 atm and 25 °C
MW	=	Molecular weight of ethylene dibromide (187.86 g/mole)

Acute Non-Cancer Occupational Exposure Value

The acute occupational exposure value (EV_{acute}) was calculated as the concentration at which the acute MOE would equal the benchmark MOE for acute occupational exposures using the following equation:

$$EV_{acute} = \frac{HEC_{acute}}{Benchmark\ MOE_{acute}} \times \frac{AT_{HEC_{acute}}}{ED} \times \frac{IR_{resting}}{IR_{workers}}$$

$$= \frac{19.52\ \text{ppm}}{100} \times \frac{\frac{24h}{d}}{\frac{8h}{d}} \times \frac{0.6125\ \frac{m^3}{h}}{1.25\frac{m^3}{h}} = \mathbf{0.28\ ppm}$$

$$EV_{acute}\left(\frac{mg}{m^3}\right) = \frac{EV\ ppm\ \times\ MW}{Molar\ Volume} = \frac{0.28\ \text{ppm}\ \times\ 187.86\frac{g}{mol}}{24.45\ \frac{L}{mol}} = \mathbf{2.2\ mg/m^3}$$

Intermediate Non-Cancer Occupational Exposure Value

The hazard value (an HEC of 150 $mg/^3$ or, 19.52 ppm) is the same for the acute and intermediate OESs. The intermediate occupational exposure value ($EV_{intermediate}$) can be calculated as the concentration at which the intermediate MOE would equal the benchmark MOE for intermediate occupational exposures. However, EPA has determined that because the same critical health effect applies to both acute and intermediate exposure contexts, the relevant averaging time should be considered equivalent across both exposure scenarios. Therefore, the resulting $EV_{intermediate}$ would be the same as the EV_{acute} based on acute exposures and EPA is presenting only the EV_{acute}.

Chronic Non-Cancer Occupational Exposure Value

The chronic occupational exposure value ($EV_{chronic}$) was calculated as the concentration at which the chronic MOE would equal the benchmark MOE for 8-hour chronic occupational exposures with the following equation:

$$EV_{chronic} = \frac{HEC_{chronic}}{Benchmark\ MOE_{chronic}} \times \frac{AT_{HEC_{chronic}}}{ED \times EF \times WY} \times \frac{IR_{resting}}{IR_{workers}}$$

$$= \frac{1.56 \text{ ppm}}{30} * \frac{\frac{24h}{d} \times \frac{365d}{y} \times 40\,y}{\frac{8h}{d} \times \frac{250d}{y} \times 40\,y} \times \frac{0.6125\ \frac{m^3}{h}}{1.25\ \frac{m^3}{h}} = \mathbf{0.11\ ppm}$$

$$EV_{chronic}\left(\frac{mg}{m^3}\right) = \frac{EV\ ppm\ \times\ MW}{Molar\ Volume} = \frac{0.11 \text{ ppm} \times 187.86 \frac{g}{mol}}{24.45\ \frac{L}{mol}} = \mathbf{1.4\ mg/m^3}$$

The parameters used in the above equations are summarized below. Numerical values chosen for the parameters are described in relevant sections of this risk evaluation and the *Draft Human Health Hazard Assessment for Ethylene Dibromide.*

Where:

- $AT_{HECchronic}$ = Averaging time for the POD/HEC used for evaluating non-cancer, chronic occupational risk, based on study conditions and/or HEC adjustments (24 hours/day for 365 days/yr) and assuming the number of years matches the high-end working years (WY, 40 yrs) for a worker
- $AT_{HECintermediate}$ = Averaging time for the POD/HEC used for evaluating non-cancer, intermediate occupational risk, based on study conditions and/or any HEC adjustments (24 hours/day for 30 days)
- $AT_{HECacute}$ = Averaging time for the POD/HEC used for evaluating non-cancer, acute occupational risk, based on study conditions and/or any HEC adjustments (24 hours/day)
- AT_{IUR} = Averaging time for the cancer IUR, based on study conditions and any adjustments (24 hours/day for 365 days/year) and averaged over a lifetime (78 years)
- 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 100
- Benchmark MOE_{acute} = Acute non-cancer benchmark margin of exposure, based on the total uncertainty factor of 100
- $Benchmark_{cancer}$ = Benchmark for excess lifetime cancer risk
- EV_{acute} = Draft occupational exposure value based on mouse fetal skeletal malformations, resorptions
- $EV_{intermediate}$ = Draft occupational exposure value based on mouse fetal skeletal malformations, resorptions
- $EV_{chronic,\ non\text{-}cancer}$ = Draft occupational exposure value based on hepatic necrosis
- $EV_{chronic,\ cancer}$ = Draft occupational exposure value based on excess cancer risk
- ED = Exposure duration (8 hours/day)
- EF = Exposure frequency (1 day/year for acute, 22 days/year for intermediate, 250 days/year for chronic and lifetime)
- $HEC_{acute,\ intermediate,\ or\ chronic}$ = Human equivalent concentration for acute, intermediate, or chronic occupational exposure scenarios
- IUR = Inhalation unit risk (per mg/m^3 and per ppm)
- IR = Inhalation rate (default is 1.25 m^3/hour for workers and 0.6125 m^3/hour for the general population at rest; 0.6125 m^3/hour is also

assumed for animals in toxicity studies if they are "at rest" vs. exercising)

WY = Working years per lifetime at the 95th percentile (40 years)

Molar Volume = 24.45 L/mol, the volume of a mole of gas at 1 atm and 25 °C

MW = Molecular weight of ethylene dibromide (187.86 g/mole)

Unit conversion:

1 ppm = 7.68 mg/m^3 (based on the molecular weight of 187.86 g/mol for ethylene dibromide)

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 ethylene dibromide 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 ethylene dibromide. The sources used for the search included the following:

1. NIOSH Manual of Analytical Methods (NMAM; accessed August 11, 2026); 5th Edition
2. NIOSH NMAM 4th Edition (accessed August 11, 2026)
3. OSHA Index of Sampling and Analytical Methods (accessed August 11, 2026)
4. EPA Environmental Test Method and Monitoring Information (accessed August 11, 2026)

Table_Apx E-2. Limit of Detection (LOD) and Limit of Quantification (LOQ) Summary for Air Sampling Analytical Methods Identified

Air Sampling Analytical Methods	Year Published	LOD [a]	LOQ	Notes	Source
NIOSH Method 1008 OSHA Method 02	1994 (issue 2)	6.5E−04 ppm, or 5.0E−03 mg/m^3	N/A	Method reports the LOD as 0.01 µg per sample and provides procedures for collecting air samples between 0.1 and 0.5 µg with a flow rate of 0.02 to 0.2 L/min. The method reports that the working range is 0.0003 to 1 ppm (0.002 to 8 mg/m^3) for a 25L air sample. Multiple media change-outs will be required in order to achieve the minimum LOD based on a maximum sampling volume of 25L.	NIOSH NMAM 4th Edition OSHA Index of Sampling and Analytical Methods

ppm = parts per million

[a] These sources cover a range of LODs both below and above the most sensitive occupational exposure value.

The OSHA 02 analytical method can be used for detecting ethylene dibromide in occupational air sampling. The lower limit of the working range for the OSHA Method 02 is 5.0×10^{-3} mg/m^3. The draft 8-hour TWA occupational exposure value 7.5×10^{-3} mg/m^3 is above the reliable quantitative limits of the NIOSH method 1008, and OSHA 02 method.

E.3 Draft Short-Term Occupational Exposure Value Derivation

According to *Current Intelligence Bulletin 69: NIOSH Practices in Occupational Risk Assessment* (NIOSH, 2020; accessed August 11, 2026), a short-term occupational exposure value (described as a short-term exposure limit (STEL) in (NIOSH, 2020; accessed August 11, 2026)) should be derived if there is a concern for effects following short-term exposure at 15-minute concentrations. The 8-hour TWA most sensitive occupational exposure value would prevent 15-minute exposures above 32 times that value (based on 32, 15-minute periods in an 8-hour shift), assuming only a single 15-minute chemical exposure in 1 day. Therefore, if short-term health effects are expected and can be quantified

with a derived short-term occupational exposure value (STEV) lower than 32 times the most sensitive EV, implementing a short-term exposure value could be justified.

EPA derived an acute exposure value (EV_{acute}) of 0.28 ppm or 2.2 mg/m^3 for ethylene dibromide based on fetal skeletal malformations, resorptions in mouse resulting from acute exposure (Short et al., 1978) with an UF of 100. Mouse fetal developmental abnormalities and increased late resorptions was selected as the basis for the acute exposure value for ethylene dibromide due to its sensitive LOAEC of 20 ppm and the severity of outcomes. According to principles of (ten Berge et al., 1986), Haber's Law is adjusted by the use of an exponent to create a shallower slope, resulting in a more health-protective value when extrapolating to shorter durations. Due to lack of a published chemical-specific exponent value in (ten Berge et al., 1986) or other study for ethylene dibromide, use of the default exponent of 3.0, as per NIOSH IDLH guidance (NRC, 2001) and the Standard Operating Procedure for AEGLs (NIOSH, 2013), and a benchmark MOE of 100, the 15-minute HEC is 92 ppm and the STEV is 0.92 ppm or 7.1 mg/m^3 (see calculations below). This value was based on the reported analytical exposure LOAEC of 20 ppm (Short et al., 1978).

Below are the calculations used to derive the short-term occupational exposure value. EPA used study data from (Short et al., 1978), which is also the basis of the EV_{acute}. The initial step in adjusting an acute HEC for a shorter duration is to derive the ten Berge constant (k) based on the POD and exposure duration from the study along with the ten Berge exponent (n) for ethylene dibromide as follows:

$$C^n \times t = k$$

$$20^{3.0} \times 24 = k$$

$$k = 192000$$

Where:

- C = Air concentration / study POD at duration *t* in ppm (20 ppm in (Short et al., 1978))
- n = Ten Berge exponent (3.0; default based on (NRC, 2001) and (NIOSH, 2013).
- t = Timepoint of the measured concentration, in hours (24 hours in (Short et al., 1978))
- k = Calculated ten Berge constant

The new HEC is then calculated using the same equation, where k and n remain constant.

$$C^n \times t = k$$

$$C^{3.0} \times 0.25 = 192000$$

$$C = \left(\frac{192000}{0.25}\right)^{0.33}$$

$$C_{STEV} = \mathbf{92\ ppm}$$

Where:

- C_{STEV} = HEC at short-term exposure value duration *t* in ppm
- t = Relevant exposure duration for a short-term exposure value (15 minutes, or 0.25 hours)

Finally, the short-term exposure value is calculated from the C_{STEV} by applying the benchmark MOE used for non-cancer acute risk estimates and the EV_{acute} derivation.

$$STEV = C_{STEV} / \text{benchmark MOE}$$

$$STEV = 92 / 100 = \mathbf{0.92\ ppm = 7.1\ mg/m^3}$$

Where:

STEV	=	Short-term exposure value
Benchmark MOE	=	Acute non-cancer benchmark margin of exposure, based on the total uncertainty factor of 100

Appendix F Aggregate Hazard, Exposure and Risk Characterization

As explained in Section 4.3.2, U.S. EPA considered aggregate exposure and risk across various exposure routes for workers, consumers and the general population. This appendix describes aggregate exposure considerations for non-cancer and cancer, pertaining to each population (Appendix F.1), as well as hazard considerations for aggregate non-cancer and cancer risk (Appendix F.2), and aggregate risk characterization for workers (Appendices F.3 and F.4). Table_Apx F-1 provides an overview of hazard considerations that may be relevant to specific exposure routes considered for aggregate non-cancer and cancer risk, as well as whether aggregate non-cancer and/or cancer risk was assessed for the respective worker, consumer and/or general populations.

For workers and consumers, EPA considered aggregate non-cancer and cancer risk across inhalation and dermal routes of exposure for each COU. Aggregate non-cancer and cancer risk was quantified for workers for both routes of exposure as described below in Appendix F.3 and mapped to OESs and COUs in Appendix F.4. For consumers, aggregate non-cancer and cancer risk was unable to be quantified. For non-cancer risk to consumer, the MOEs far exceeded the benchmark MOEs for all exposure durations considered, therefore it was deemed unlikely that there would be aggregate non-cancer risk. In regard to aggregate cancer risk for consumers, as described above in 4.3.4.2, PBPK modeling was unable to estimate exposure-scenario specific HEDs, therefore dermal cancer risk was determined to be unlikely, resulting in the determination that it would be unlikely that there would be aggregate cancer risk resulting from inhalation and dermal exposure.

For the general population, although aggregate exposure and risk were considered for both non-cancer and cancer for the exposure scenario-relevant pathways, aggregate non-cancer and cancer risk was ultimately not quantified. Specifically, for the swimming scenario, although both acute dermal and incidental ingestion may occur, due to the acute oral POD being based off of portal of entry effects and the acute dermal POD being based off route-to-route extrapolation from the acute inhalation POD which was a developmental effect, it was determined to not be appropriate to aggregate acute non-cancer risk for this exposure scenario. In regards to potentially aggregating non-cancer chronic and cancer risk for oral exposure resulting from fish ingestion and drinking water, EPA does not expect that the source of drinking water and fish are co-incident. Additionally for non-cancer chronic aggregate oral considerations, the MOE exceeds the benchmark MOE. Due to these reasons, it was determined that it was extremely unlikely for there to be aggregate oral non-cancer chronic risk from this scenario and therefore EPA did not quantify non-cancer chronic aggregate risk for fish ingestion and drinking water for the general population. Finally, although EPA considered aggregating non-cancer chronic and cancer risk due to surface water release-related oral exposures (*e.g.,* fish ingestion and drinking water) and air releases (inhalation), the release points were not geographically close and therefore it is unlikely that the general population will be exposed to ethylene dibromide via oral and inhalation exposure.

Table_Apx F-1. Overview of Compatible Hazard PODs for Aggregate Risk Considerations

Hazard Category	Exposure Routes Considered	Aggregate Reasonable Due to Hazard Considerations	Exposure Population	Aggregate Risk Assessed by EPA [a]
Acute and Intermediate Non-Cancer	Oral, Inhalation	No, no shared outcome types across exposures	–	–
	Oral, Dermal	No, no shared outcome types across exposures	–	–
	Inhalation, Dermal	Yes, shared outcome types across exposures	Workers	Assessed (described in Appendix F.3.1.2)

Hazard Category	Exposure Routes Considered	Aggregate Reasonable Due to Hazard Considerations	Exposure Population	Aggregate Risk Assessed by EPA [a]
		(reproductive/ developmental) Short et al. (1978), Short et al. (1979)	Consumers	Not Assessed (calculated inhalation and dermal MOEs are above benchmark MOEs)
			General Population	Not Assessed (no general population exposure scenarios apply to these routes of exposure)
Chronic Non-Cancer	Oral, Inhalation, Dermal	Yes, shared outcome types across exposures (liver) NTP (1982), NCI (1978)	Workers	Assessed (described in Appendix F.3.1.3)
			Consumers	Not Assessed (chronic non-cancer for these exposure routes were not assessed for consumer)
			General Population	Not Assessed (MOEs for each route of exposure were several magnitudes above the benchmark MOE)
Cancer	Oral, Inhalation, Dermal	Yes, tumor outcomes supported by a mutagenic MOA NTP (1982), NCI (1978)	Workers	Assessed (described in Appendix F.3.2 for inhalation and dermal exposure)
			Consumers	Not Assessed (dermal risk is unlikely therefore aggregate cancer risk across inhalation and dermal was not quantified)
			General Population	Not Assessed (unlikely exposure via oral and inhalation due to lack of geographical proximity of surface water and air releases of ethylene dibromide)

[a] Rationale for why aggregate non-cancer and/or cancer risk was not quantified are provided in parentheticals, and further described in Appendices F.1, F.2 and F.3, as applicable to specific populations.

F.1 Aggregate Exposure Approach and Results

F.1.1 Non-Cancer

For the draft risk evaluation of ethylene dibromide, EPA used the below equation to quantify the aggregate non-cancer MOEs for various durations considered for workers, which are presented in Appendix F.1.1 for acute, intermediate and chronic exposure durations. The aggregate MOEs are compared to the benchmark MOEs which are 100 for acute and intermediate durations, and 30 for chronic durations.

$$MOE_{duration,aggregate} = \left(\frac{1}{MOE_{duration,dermal}} + \frac{1}{MOE_{duration,inhalation}} \right)^{-1}$$

F.1.1.1 Acute

Workers

EPA considered aggregate acute exposure to ethylene dibromide via inhalation dermal routes for workers and presented aggregate acute risk resulting from exposure. EPA did not present aggregate acute risk for ONUs as the Agency does not expect ONUs to have any dermal exposure to ethylene dibromide based on the ongoing use information EPA identified. The Agency considers both inhalation and dermal routes to be the primary routes of exposure and the driver for risk depending on the COU where risk was identified based on aggregate acute exposure.

Consumers

For consumers, EPA evaluated acute non-cancer exposure to ethylene dibromide via inhalation and dermal routes during avgas refueling and pre-flight fuel sampling. In the consumer refueling scenario, route-specific acute MOEs were far above the benchmark MOE (100), with MOE-to-benchmark ratios ranging from 130 to 12,000. Therefore, aggregation across routes was not performed because risk is not expected. The maximum impact of aggregating inhalation and dermal risk is a factor of 2 (this occurs when inhalation and dermal risks are exactly equal) but given the ratio of the MOEs to the benchmark were several orders of magnitude, aggregation would not change the conclusion of no unreasonable non-cancer risk for these scenarios.

General Population

There can be simultaneous acute oral and dermal acute exposure to the general population during the swimming scenario. Though these pathways were only evaluated as a screening analysis and calculated risks from each of these pathways were magnitudes away from risk to the general population (Table 4-35)—even when utilizing water concentrations from the OES with the highest resulting water concentration in E-FAST modeling. The incidental oral and incidental dermal analyses are discussed in Sections 4.1.3.4.2 and 4.1.3.3. The risks were not aggregated because there is no reasonably available hazard information that allows for aggregated oral and dermal acute exposure to be quantified as the health effects observed are not shared outcomes across exposure routes.

The highest resulting risk from the water pathway, including incidental ingestion from swimming, incidental dermal, and fish ingestion is from the Incorporation into formulations, mixtures, or reaction products OES. The acute MOEs from these pathways are 1.9×10^4, 6.2×10^4, and 4.0×10^3, respectively (see Table 4-35). The benchmark MOE for acute oral exposure is 30 and the benchmark MOE for acute dermal exposure is 300. Each of these MOEs are several magnitudes above their benchmark MOEs, therefore EPA did not find it necessary to aggregate these risks.

F.1.1.2 Intermediate

Workers

EPA considered aggregate intermediate exposure to ethylene dibromide via inhalation dermal routes for workers and presented aggregate intermediate risk resulting from exposure in Appendix F.3.1.2. EPA did not present aggregate intermediate risk for ONUs as the Agency does not expect ONUs to have any dermal exposure to ethylene dibromide based on the ongoing use information the Agency identified. EPA considers inhalation route to be the primary route of exposure and the driver for risk for COUs where risk was identified based on aggregate intermediate exposure.

Consumer

For consumers, EPA evaluated intermediate non-cancer exposure to ethylene dibromide via inhalation and dermal routes during avgas refueling and pre-flight fuel sampling. In the consumer refueling scenario, route-specific acute and intermediate MOEs were far above the benchmark MOE (100), with MOE-to-benchmark ratios ranging from 890 to 390,000. Therefore, aggregation across routes was not performed because risk is not expected.

General Population

The general population did not evaluate intermediate exposures for any pathway due to the lack of intermediate exposure scenarios.

F.1.1.3 Chronic

Workers

EPA considered aggregate chronic, non-cancer exposure to ethylene dibromide via inhalation dermal routes for workers and presented aggregate chronic, non-cancer risk resulting from exposure in Appendix F.3.1.3. EPA did not present aggregate chronic, non-cancer risk for ONUs as the Agency does not expect ONUs to have any dermal exposure to ethylene dibromide based on the ongoing use information EPA identified.

Consumer

EPA did not present non-cancer chronic exposure and risk estimates because the maximum assumed exposure frequency is 52 days per year on an intermittent schedule. Toxicokinetics data, including the PBPK model for this chemical, clearly demonstrates that ethylene dibromide is rapidly eliminated from the body. Therefore, EPA expects that ethylene dibromide does not accumulate in the body with intermittent exposure and these scenarios can be modeled as a series of acute and/or intermediate exposures. The Agency concludes that it is sufficient to use the acute and intermediate PODs for estimating MOEs for consumer exposure scenarios, therefore, aggregation across routes for non-cancer chronic exposure was not performed.

General Population

EPA evaluated general population chronic exposure to ethylene dibromide via ambient air inhalation and drinking water ingestion. However, it was not appropriate to aggregate across these routes because exposures to these TSCA releases did not geographically co-occur.

EPA evaluated chronic drinking water exposure and performed a screening analysis for fish ingestion using the highest estimates surface water concentration of ethylene dibromide. The highest chronic risk from drinking water ingestion and fish ingestion came from different OESs (See Table 4-35). This was because the highest surface water concentration was a coastal release, and therefore was relevant for fish ingestion but not drinking water. EPA only analyzed the highest surface water concentration for fish ingestion as a part of their screening assessment. In its consideration of aggregate oral exposure for the general population, the Agency does not expect that the source of drinking water and fish are coincident. The lowest MOE for chronic drinking water exposure was 3.58×10^{4} from the Import and repackaging OES, while the lowest chronic fish ingestion MOE was 4.92×10^{3} from the Incorporation into Formulations, Mixtures, or Reaction Products OES. The benchmark MOE for chronic ingestion is 30. Because each of these exposure routes had MOEs several magnitudes above the benchmark and these highest exposures do occur together geographically, EPA did not find it necessary to aggregate risk across fish ingestion and drinking water chronic exposure.

F.1.2 Cancer

Workers

EPA considered aggregate chronic, cancer exposure to ethylene dibromide via inhalation and dermal routes for workers and presented aggregate chronic, cancer risk resulting from exposure in Appendix F.3.2. EPA did not present aggregate chronic, cancer risk for ONUs as the Agency does not expect ONUs to have any dermal exposure to ethylene dibromide based on the ongoing use information that EPA considers both inhalation and dermal routes to be the primary routes of exposure and the driver for risk depending on the COU where risk was identified based on aggregate chronic, cancer exposure.

Consumer

EPA considered aggregate cancer risk to consumers from dermal and inhalation exposure to ethylene dibromide because both pathways are likely to occur simultaneously during refueling and sampling

(sumping) activities associated with this COU. However, PBPK simulations showed exposures were too low to reach the internal dose metric, so no dermal CSF could be predicted. The details about dermal risk estimation using both default and PBPK approaches are described in Section 4.3.4.2. Accordingly, EPA did not aggregate cancer risk for inhalation and dermal exposure for this COU. The Agency considers inhalation to be the primary route of exposure and the driver for this consumer COU as non-cancer acute and intermediate risk was not identified.

General Population

The two general population exposure scenarios where cancer risk was assessed were ambient air inhalation and drinking water ingestion from TSCA facility releases to air and water. These cancer risks were not aggregated because EPA did not identify NEI or TRI facilities releasing to air with high enough risk that aligned geographically with the facilities releasing to surface water. EPA evaluated facilities releasing to air with risks as low as 1.0×10^{-7} alongside the facilities releasing to water, and no facilities were located near each other (within 50 km). Therefore, there would not be general population exposures to ethylene dibromide for both routes and cancer risk was not aggregated.

The HEM inherently aggregates risks across facilities with releases to TRI and NEI that are located within 50 km of each other. Therefore, EPA did evaluate aggregate cancer risk across multiple facilities for Census blocks within the inhalation route (Section 4.1.3.2). When evaluating air concentrations across facilities, no risk above 10^{-6} was identified from aggregating air releases in HEM.

The Agency did not consider aggregate inhalation exposures to people who both work at and live near facilities releasing ethylene dibromide because EPA does not have data showing that this is a likely exposure scenario. Aggregate risks did not impact the overall risk determination for the general population.

F.2 Aggregate Hazard Considerations

F.2.1 Non-Cancer

F.2.1.1 Acute and Intermediate

Due to the oral acute and intermediate POD being based on a portal of entry effect (forestomach epithelial cell proliferation and hyperkeratosis), and the lack of systemic effects being reported in Ghanayem et al., (1986), aggregate non-cancer acute and/or intermediate risk are unable to be conducted regarding any combination of exposure routes being considered for a given exposure scenario concerning oral exposure. Uncertainties related to the oral acute and intermediate POD are further discussed in Section 4.2.6. The inhalation acute and intermediate POD is based on reproductive and developmental effects (fetal developmental abnormalities and increased late resorptions), as reported in Short et al., (1978), which is also the basis of the dermal POD via route-to-route extrapolation, as described in Section 4.2.7. Non-cancer acute and/or intermediate aggregate risk may be considered and quantified regarding inhalation and dermal exposure since the dermal POD is based on the route-to-route extrapolation from the inhalation acute and intermediate PODs.

F.2.1.2 Chronic

For non-cancer chronic effects, risk could be aggregated across oral, inhalation, and dermal exposure routes. The selected POD references for chronic inhalation (liver necrosis) (NTP, 1982) and oral exposure (liver peliosis) (NCI, 1978) are based on related liver endpoints, and the dermal POD is based

on route-to-route extrapolation from inhalation and are therefore based on the same effect from the same critical study.

F.2.2 Cancer

As described in Section 2.6.1 of the *Draft Hazard Assessment for Ethylene Dibromide*, aggregation of cancer risk was conducted for some populations because there is a mutagenic MOA that contributes to systemic tumor development. Tumors were seen at multiple sites in animal bioassays via oral, dermal, and inhalation exposure, allowing EPA to conclude that cancer is a hazard regardless of route. Certain conditions of use and occupational scenarios include inhalation and dermal exposures for the same use/scenario, leading to increased exposure vs. exposure by a single route. Furthermore, the dermal cancer analysis slope factor was derived through route-to-route extrapolation based off extrapolation from the inhalation data unit risk; therefore, it represents the same cancer risk but adjusted via the PBPK model for route-specific ADME behavior. Considering cancer risk across multiple routes of exposure for a given exposure scenario was considered a health-protective estimate of carcinogenic potential (U.S. EPA, 2026t).

F.3 Aggregate Risk Characterization and Results

F.3.1 Non-Cancer

F.3.1.1 Non-Cancer – Acute

Workers

The aggregate acute-duration occupational risk evaluation integrates exposures across inhalation and dermal routes to determine whether combined exposures alter risk conclusions for any COU. Across all assessed COUs, aggregate non-cancer acute risk did not change overall risk determinations. For most COUs, the inhalation and dermal contributions to exposure and risk are already dominated by a single route, and summing across routes does not significantly decrease MOE compared to benchmark MOE for acute duration.

However, aggregation did influence risk for Commercial use – Other use – Laboratory chemicals COU. For this OES, individual routes did not independently exceed benchmark acute MOE thresholds, but combined exposures narrowed MOEs enough to indicate that shorter acute exposure became contributors to potential risk. The calculated route specific MOEs (*i.e.,* inhalation and dermal) for this COU exceeded the benchmark MOE of 100 for non-cancer exposure durations when considered individually. However, when the risks were aggregated for acute inhalation and dermal exposures, the calculated MOE was below the benchmark MOE, based on high-end estimates. There was no risk found at the central tendency for any of the non-cancer durations considered individually and aggregated across exposure routes for this COU.

For workers, the aggregate risk estimates in comparison with route-specific risk estimates for acute duration for each COU are presented in Table_Apx F-2.

Table_Apx F-2. Summary of Acute Aggregate Risks for Workers

COU	Acute Inhalation MOE (HE) Benchmark MOE = 100	Acute Dermal MOE (HE) Benchmark MOE = 100	Aggregate MOE (HE) Benchmark MOE = 100	Acute Risk Interpretation
Manufacturing – Import (2-Hands)	**41**	148	**32**	Risk is driven by inhalation route
Processing – Repackaging (2-Hands)	**41**	**84**	**27**	Risk is driven by both inhalation and dermal routes
Processing – Incorporation into formulation, mixture, or reaction product (2-Hands)	796	148	125	No risk from inhalation or dermal route
Processing as a Reactant (2-Hands)	796	**84**	**76**	Risk is driven by dermal route
Industrial use – Other use – Processing aid not otherwise specified	796	**84**	**76**	Risk is driven by dermal route
Industrial Use – Fuel Agent in Refineries (2-Hands)	2,168	N/A	N/A	No risk from inhalation or dermal route
Commercial Use – Fuels and Related Products (2-Hands)	2,656	N/A	N/A	No risk from inhalation or dermal route
Commercial Use – Other use – Laboratory chemicals (1-Hand)	131	171	**74**	No risk from any individual route, but aggregate exposure through both routes result in risk for high-end exposures only
Disposal (Landfill)	73,000	**84**	**84**	Risk is driven by dermal route
Disposal (Wastewater)	7,941	**84**	**84**	Risk is driven by dermal route
Distribution in Commerce	No quantitative risk assessment was performed for this OES as occupational exposures covered are not reasonably expected to occur			

COU = condition of use; HE = high-end; MOE = margin of exposure
Bolded/shaded cells indicate MOEs lower than the benchmark MOE.

Consumer

Aggregate acute exposure is relevant to consumers across inhalation and dermal routes, however these risks were not aggregated because the MOEs resulting from inhalation and dermal exposure were two orders of magnitude greater than the benchmark MOEs. Aggregate non-cancer acute risk is not expected for consumers.

General Population

Aggregate acute exposure is relevant to the general population across the oral and dermal routes, however these risks were not aggregated due to hazard evidence. Aggregate non-cancer acute risk is not expected for the general population. Acute risk was evaluated for incidental ingestion from swimming, fish ingestion, and drinking water ingestion; however, the MOEs were several magnitudes above the benchmark, therefore aggregating risk was not necessary because risk would not exceed the benchmark.

F.3.1.2 Non-Cancer – Intermediate

Workers

The aggregate intermediate duration occupational risk evaluation integrates exposures across inhalation and dermal routes to determine whether combined exposures alter risk conclusions for any COU. Across all assessed COUs, aggregate non-cancer intermediate risk did not change overall risk determinations.

For most COUs, the inhalation and dermal contributions are already dominated by a single route, and summing across routes does not significantly decrease MOE compared to benchmark MOE for intermediate duration. For workers, the aggregate risk estimates in comparison with route-specific risk estimates for intermediate duration for each COU are presented in Table_Apx F-3.

Table_Apx F-3. Summary of Intermediate Aggregate Risks for Workers

COU	Intermediate Inhalation MOE (HE) Benchmark MOE = 100	Intermediate Dermal MOE (HE) Benchmark MOE = 100	Aggregate MOE (HE) Benchmark MOE = 100	Intermediate Risk Interpretation
Manufacturing – Import (2-Hands)	**56**	202	**44**	Risk is driven by inhalation route
Processing – Repackaging (2-Hands)	**56**	115	**38**	Risk is driven by inhalation route
Processing – Incorporation into formulation, mixture, or reaction product (2-Hands)	1,085	202	170	No risk from inhalation or dermal route
Processing as a reactant (2-Hands)	1,085	115	104	No risk from inhalation or dermal route
Industrial use – Other use – Processing aid not otherwise specified	1,085	115	104	No risk from inhalation or dermal route
Industrial use – Fuel agent in refineries (2-Hands)	2,957	N/A	N/A	No risk from inhalation or dermal route
Commercial use – Fuels and related products (2-Hands)	3,629	NA	N/A	No risk from inhalation or dermal route
Commercial use – Other use – Laboratory chemicals (1-Hand)	178	233	101	No risk from inhalation or dermal route
Disposal (Landfill)	30,341	115	115	No risk from inhalation or dermal route
Disposal (Wastewater)	2,985	115	111	No risk from inhalation or dermal route
Distribution in commerce	No quantitative risk assessment was performed for this OES as occupational exposures covered are not reasonably expected to occur			

COU = condition of use; HE = high-end; MOE = margin of exposure
Bolded/shaded cells indicate MOEs lower than the benchmark MOE.

Consumer

Aggregate intermediate exposure is relevant to consumers across inhalation and dermal routes, however these risks were not aggregated due to the MOEs resulting from inhalation and dermal exposure far surpassing the benchmark MOEs by three to five magnitudes. Aggregate non-cancer intermediate risk is not expected for consumers.

General Population

There are no intermediate general population exposure scenarios assessed; therefore, aggregate non-cancer intermediate risk is not expected for the general population.

F.3.1.3 Non-Cancer – Chronic

Workers

The aggregate chronic, non-cancer duration occupational risk evaluation integrates exposures across inhalation and dermal routes to determine whether combined exposures alter risk conclusions for any COU. Across all assessed COUs, aggregate chronic, non-cancer risk did not change overall risk determinations. For most COUs, the inhalation and dermal contributions are already dominated by a single route, and summing across routes does not significantly decrease MOEs compared to benchmark MOE for chronic, non-cancer duration. For workers, the aggregate risk estimates in comparison with route-specific risk estimates for chronic, non-cancer duration for each COU are presented in Table_Apx F-4.

Table_Apx F-4. Summary of Chronic, Non-Cancer Aggregate Risks for Workers

COU	Chronic, Non-Cancer Inhalation MOE (CT) Benchmark MOE = 30	Chronic, Non-Cancer Dermal MOE (CT) Benchmark MOE = 30	Aggregate MOE (CT) Benchmark MOE = 30	Chronic, Non-Cancer Risk Interpretation
Manufacturing – Import (2-Hands)	129	654	108	No risk from inhalation or dermal route
Processing – Repackaging (2-Hands)	129	581	106	No risk from inhalation or dermal route
Processing – Incorporation into formulation, mixture, or reaction product (2-Hands)	610	1,005	380	No risk from inhalation or dermal route
Processing as a Reactant (2-Hands)	610	521	281	No risk from inhalation or dermal route
Industrial use – Other use – Processing aid not otherwise specified	610	521	281	No risk from inhalation or dermal route
Industrial Use – Fuel Agent in Refineries (2-Hands)	757	N/A	N/A	No risk from inhalation or dermal route
Commercial Use – Fuels and Related Products (2-Hands)	2,481	N/A	N/A	No risk from inhalation or dermal route
Commercial Use – Other use – Laboratory chemicals (1-Hand)	479	1,206	343	No risk from inhalation or dermal route
Disposal (Landfill)	3.0E04	581	570	No risk from inhalation or dermal route
Disposal (Wastewater)	2,985	581	486	No risk from inhalation or dermal route
Distribution in Commerce	No quantitative risk assessment was performed for this OES as occupational exposures covered are not reasonably expected to occur			
COU = condition of use; CT = central tendency; MOE = margin of exposure				

Consumer

Aggregate chronic exposure is relevant to consumers across inhalation and dermal routes, however these risks were not aggregated because EPA did not assess non-cancer chronic exposure as explained in Section 4.3.4.1, 4.3.4.2 and F.1.1.3. Aggregate non-cancer chronic risk is not expected for consumers.

General Population

The general population assessment did not aggregate non-cancer chronic risk because there were no general population scenarios where the aggregation of inhalation and oral exposures would be appropriate due to the location of facilities releasing ethylene dibromide to air and water. Additionally, aggregate non-cancer chronic risk resulting from two oral routes was not conducted for both fish ingestion and drinking water; however, the MOEs were several magnitudes above the benchmark MOE. Aggregate non-cancer chronic risk is not expected for the general population.

F.3.2 Cancer

Workers

For aggregate cancer risks, the process of aggregating across routes increased the estimated risk (given that it involved summing two non-0 values) but did not affect which risks were above the benchmark for cancer risk of 1×10^{-4}. One uncertainty considered in aggregating cancer risks across routes of exposure is that, though ethylene dibromide is a direct-acting mutagen and systemic tumor effects are possible, the most sensitive findings are portal-of-entry effects that are less suitable for cross-route aggregation. Additionally, the supporting animal data are based on relatively high doses, which introduces some uncertainty in how well those data support aggregation across routes at lower exposure levels. EPA also acknowledges that the current PBPK model does not account for dose loss at the route of entry, which may overestimate systemic internal dose during route-to-route extrapolation.

Uncertainties associated with risk estimates for each route of exposure on its own contribute to uncertainties in this aggregate analysis. Section 4.1.1.8 provides a summary of the weight of evidence for the exposure estimates underlying these risk estimates for each OES. The *Draft Chemistry, Fate, Release, and Exposure Assessment for Ethylene Dibromide* (U.S. EPA, 2026d) provides additional details on the assumptions and key sources of uncertainty underlying the occupational exposure estimates used as the basis for risk estimates presented in this section. There is significant uncertainty in aggregating cancer risks from inhalation and dermal exposures. For instance, though ethylene dibromide is a direct-acting mutagen and systemic tumor effects are possible, when aggregating cancer risks across routes of exposure the most sensitive findings are portal of entry effects, which are less suitable for cross-route aggregation. Additionally, the supporting animal data are based on relatively high doses, which introduces some uncertainty in how well those data support aggregation across routes at lower exposure levels. EPA acknowledges that the current PBPK model does not account for dose loss at the route of entry, which may overestimate systemic internal dose during route-to-route extrapolation. Thus, the Agency EPA considers the resulting aggregate estimates to have a high level of uncertainty.

Below, Table_Apx F-5 summarizes the inhalation, dermal, and aggregate cancer risks used to characterize cancer risks from chronic exposure to ethylene dibromide for workers. EPA presents these values for each OES and their mapped COU(s). For some OESs, EPA presents multiple COUs in the same assessment when the COU-specific assumptions on dermal exposure (*e.g.,* ethylene dibromide concentration, skin surface area) are the same for the COUs.

8339 **Table_Apx F-5. Summary of Aggregate Cancer Risk Estimates for Workers**

COU	OES	Population	Inhalation Cancer Risk [f] (Benchmark = 10E−04)			PBPK Dermal Cancer Risk [f] (Benchmark = 10E−04) No PPE		PBPK Aggregate Cancer Risk [f] (Benchmark = 10E−04) No PPE		
			CT	HE	APF [g]	CT	HE	CT	HE	APF [g]
Manufacture – Import	Import and Repackaging (2-Hands, 45–60 wt%) [a]	Worker	**2.1E−03**	**7.2E−02**	25 (CT), 1,000 (HE)	**3.9E−03**	**2E−02**	**5.9E−03**	**9.2E−02**	25 (CT), 1,000 (HE)
Processing – Repackaging	Import and Repackaging (2-Hands, 50–100 wt%) [a]	Worker	**2.1E−03**	**7.2E−02**	25 (CT), 1,000 (HE)	**4.3E−03**	**3.3E−02**	**6.4E−03**	**11E−02**	25 (CT), 1,000 (HE)
Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in all other petroleum and coal products manufacturing Processing – Incorporation into formulation, mixture, or reaction product – Fuels and fuel additives in petroleum refineries	Incorporation into Formulation, Mixture or Reaction Product (2-Hands, 30–60 wt%) [a]	Worker	**4.4E−04**	**3.7E−03**	10 (CT),50 (HE)	**2.6E−03**	**2.0E−02**	**3.0E−03**	**2.4E−02**	10 (CT),50 (HE)
Processing – As a reactant Industrial use – Other use –Processing aid not otherwise specified; Pigment and dye manufacturing	Incorporation into Formulation, Mixture or Reaction Product [a] (2-Hands, 55–100 wt%)	Worker	**4.4E−04**	**3.7E−03**	10 (CT),50 (HE)	**4.7E−03**	**3.3E−02**	**5.2E−03**	**3.7E−02**	10 (CT),50 (HE)
Industrial use – Fuel agents in petroleum refineries	Fuels and Related Products – Bulk terminals (2-Hands, 0.09–0.1 wt%) [b]	Worker	**3.5E−04**	**1.4E−03**	10 (CT), 25 (HE)	-	-	**3.5E−04**	**1.4E−03**	10 (CT), 25 (HE)

COU	OES	Population	Inhalation Cancer Risk [f] (Benchmark = 10E−04)			PBPK Dermal Cancer Risk [f] (Benchmark = 10E−04) No PPE		PBPK Aggregate Cancer Risk [f] (Benchmark = 10E−04) No PPE		
			CT	HE	APF [g]	CT	HE	CT	HE	APF [g]
Commercial use – Fuels and related products [h]	Fuels and Related Products – Refueling, Low Exposure (2-Hands, 0.09–0.1 wt%) [c]	Worker	7.2E−05	**7.5E−04**	N/A, 10 (HE)	-	-	7.2E−05	**7.5E−04**	N/A, 10 (HE)
	Fuels and Related Products – Refueling, Low Exposure (1-Hand, 0.09–0.1 wt%) [c]	Worker	7.2E−05	**7.5E−04**	N/A, 10 (HE)	-	-	7.2E−05	**7.5E−04**	N/A, 10 (HE)
	Fuels and Related Products – Refueling, Medium Exposure (2-Hands, 0.09–0.1 wt%) [c]	Worker	**1.1E−04**	**1.1E−03**	10 (LE), 25 (HE)	-	-	**1.1E−04**	**1.1E−03**	10 (LE), 25 (HE)
	Fuels and Related Products – Refueling, Medium Exposure (1-Hand, 0.09–0.1 wt%) [c]	Worker	**1.1E−04**	**1.1E−03**	10 (LE), 25 (HE)	-	-	**1.1E−04**	**1.1E−03**	10 (LE), 25 (HE)
	Fuels and Related Products – Refueling, High Exposure (2-Hands, 0.09–0.1 wt%) [c]	Worker	**1.8E−04**	**1.9E−03**	10 (LE), 25 (HE)	-	-	**1.8E−04**	**1.9E−03**	10 (LE), 25 (HE)
	Fuels and Related Products – Refueling, High Exposure (1-Hand, 0.09–0.1 wt%) [c]	Worker	**1.8E−04**	**1.9E−03**	10 (LE), 25 (HE)	-	-	**1.8E−04**	**1.9E−03**	10 (LE), 25 (HE)

COU	OES	Population	Inhalation Cancer Risk [f] (Benchmark = 10E−04)			PBPK Dermal Cancer Risk [f] (Benchmark = 10E−04) No PPE		PBPK Aggregate Cancer Risk [f] (Benchmark = 10E−04) No PPE		
			CT	HE	APF [g]	CT	HE	CT	HE	APF [g]
Commercial use – Other use – Laboratory chemical	Laboratory Use [a] (2-Hands, 50–100 wt%)	Worker	**5.6E−04**	**2.3E−02**	10 (CT), 1,000 (HE)	**4.3E−03**	**3.3E−02**	**5.9E−03**	**5.6E−02**	10 (CT), 1,000 (HE)
	Laboratory Use [a] (1-Hand, 50–100 wt%)	Worker	**5.6E−04**	**2.3E−02**	10 (CT), 1,000 (HE)	**2.2E−03**	**1.6E−02**	**2.7E−03**	**3.9E−02**	10 (CT), 1,000 (HE)
Disposal	Waste Handling, Treatment, and Disposal – Landfill [e] (2-Hands, 50–100 wt%)	Worker	8.8E−06	4E−05	N/A	**4.3E−03**	**3.3E−02**	**4.3E−03**	**3.3E−02**	N/A
	Waste Handling, Treatment, and Disposal – Wastewater [a,d] (2-Hands, 50–100 wt%)	Worker	8.9E−05	**3.7E−04**	N/A,10 (HE)	**4.3E−03**	**3.3E−02**	**4.3E−03**	**3.3E−02**	N/A,10 (HE)
Distribution in Commerce	No quantitative risk assessment was performed for this OES as occupational exposures covered are not reasonably expected to occur									

Bolded/shaded cells indicate risks greater than the benchmark.
APF = assigned protection factor; COU = condition of use; CT = central tendency exposure; HE = high-end exposure; OES = occupational exposure scenario; "-" = Not calculated because PBPK could not predict HED values for this OES
[a] Based on exposure estimates derived from chemical-specific PBZ monitoring data from literature
[b] Based on exposure estimates derived from surrogate data from generic scenario
[c] Based on exposure estimates derived from modeled concentrations using CEM
[d] Based on exposure estimates derived from surrogate PBZ monitoring data from risk evaluation of 1,2-dichloroethane
[e] Based on exposure estimates derived from surrogate area monitoring data from risk evaluation of 1,2-dichloroethane
[f] Risk estimates that exceed the benchmark (*i.e.,* cancer risks exceeding the cancer risk benchmark) are bolded and shaded
[g] APF listed in parentheses is the minimum level of protection needed for estimated cancer risks to be below the cancer benchmark of 10E−04 for workers
[h] For refueling scenario, EPA assessed low-end (LE) instead of CT using the lower end value of exposure frequency with an assumption of one refueling or exposure event per day. EPA did not identify sufficient information to accurately characterize the statistical distribution of exposure frequencies in a day; and therefore, based inhalation exposure assessment on the lower bound (*i.e.,* one event/day) and upper bound (*i.e.,* eight events/day) values of exposure frequencies.

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Consumer

EPA did not aggregate consumer cancer risk across inhalation and dermal routes and characterized risk based primarily on inhalation cancer risk estimates because dermal risk could not be calculated and was determined to be unlikely using the PBPK approach. The Agency considers inhalation the primary route of exposure and the driver of cancer risk for this consumer COU. Aggregate cancer risk is not expected for consumers.

General Population

The general population assessment did not aggregate cancer risk because there were no general population scenarios where this aggregation would be appropriate due to the location of facilities releasing ethylene dibromide to air and water. HEM inherently aggregates cancer risk across co-located NEI and TRI facilities, however this did not cause any facility to exceed the cancer risk range. Aggregate cancer risk is not expected for the general population.

F.4 Workers Non-Cancer and Cancer Aggregate Risk Characterization

This section describes non-cancer (*i.e.,* acute, intermediate and chronic) and cancer risk characterization of each OES for aggregate exposure to ethylene dibromide from inhalation and dermal routes for workers. Similar to route-specific characterization, for most OESs, EPA expects the high-end estimates to be more representative of acute and intermediate exposure for all OESs, and central tendency estimates to be more representative of chronic exposure.

F.4.1 Import and Repackaging OES

Aggregation of inhalation and dermal exposures led to the same order of magnitude in both non-cancer and cancer risks when compared to non-cancer, and cancer risk estimates from inhalation exposure or dermal exposure alone, respectively. For aggregate risk estimates, EPA expects, putting aside all the uncertainties associated with aggregating these exposures, the high-end estimates to be more representative for short-term durations (*i.e.,* acute, intermediate) and central tendency estimates to be more representative for chronic durations (*i.e.,* non-cancer and cancer) for the same reasons described in route-specific risk characterization of this OES in Sections 4.3.3.1.1 and 4.3.3.2.1, respectively.

F.4.2 Incorporation into Formulation, Mixture, or Reaction Product OES

Aggregation of inhalation and dermal exposures led to the same order of magnitude in both non-cancer and cancer risks when compared to non-cancer, and cancer risk estimates from inhalation exposure or dermal exposure alone, respectively. Putting aside all the uncertainties associated with aggregating these exposures, EPA expects the high-end estimates to be more representative for short-term durations (*i.e.,* acute, intermediate) and central tendency estimates to be more representative for chronic durations (*i.e.,* non-cancer and cancer) for the same reasons described in route-specific risk characterization of this OES in Section 4.3.3.1.2 and Section 4.3.3.2.2, respectively.

F.4.3 Fuels and Related Products OES

Aggregation of inhalation and dermal exposures led to negligible differences in both non-cancer and cancer risks when compared to non-cancer and cancer risk estimates from inhalation exposure alone. As PBPK model could not predict any human equivalent health hazard value for dermal route for this COU, EPA expects that inhalation is the primary route of exposure and risk for this COU. Therefore, the aggregate risks only represents risks from inhalation route for this OES.

F.4.4 Laboratory Use OES

Aggregation of inhalation and dermal exposures led to a lower order of magnitude in non-cancer, acute risk when compared to non-cancer, acute risk estimates from inhalation exposure or dermal exposure

alone. However, aggregation of inhalation and dermal exposures led to negligible differences in other durations (*i.e.,* non-cancer, intermediate, non-cancer, chronic, and cancer) when compared to risk estimates for same durations from inhalation or dermal exposure alone. For aggregate risk estimates, EPA expects, putting aside all the uncertainties associated with aggregating these exposures, the high-end estimates, to be more representative for short-term durations (*i.e.,* acute, intermediate) and central tendency estimates to be more representative for chronic durations (*i.e.,* non-cancer and cancer) for the same reasons described in route-specific risk characterization of this OES in Sections 4.3.3.1.5 and 4.3.3.2.4, respectively.

F.4.5 Waste Handling, Treatment, and Disposal OES

Aggregation of inhalation and dermal exposures led to the same order of magnitude in both non-cancer and cancer risks when compared to non-cancer and cancer risk estimates from inhalation exposure or dermal exposure alone, respectively. Putting aside all the uncertainties associated with aggregating these exposures, EPA expects the high-end estimates to be more representative for short-term durations (*i.e.,* acute, intermediate) and central tendency estimates to be more representative for chronic durations (non-cancer and cancer) for the same reasons described in route-specific risk characterization of this OES in Sections 4.3.3.1.6 and 4.3.3.2.5, respectively.

F.4.6 Distribution in Commerce OES

No quantitative aggregate risk assessment was performed for this OES, as occupational exposures covered are not reasonably expected to occur.