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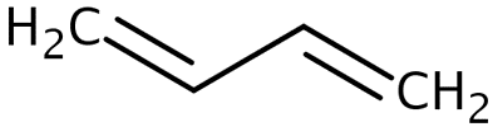
August 2020
Office of Chemical Safety and
Pollution Prevention

United States
Environmental Protection Agency

Final Scope of the Risk Evaluation for 1,3-Butadiene

CASRN 106-99-0



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ACKNOWLEDGEMENTS

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Docket

Supporting information can be found in public docket: [Docket ID: EPA-HQ-OPPT-2018-0451].

Disclaimer

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ABBREVIATIONS AND ACRONYMS

ABS	Acrylonitrile Butadiene Styrene resin plastics
ACC	American Chemistry Council
ADME	Absorption, Distribution, Metabolism, and Excretion
ATSDR	Agency for Toxic Substances and Disease Registry
BAF	Bioaccumulation Factor
BCF	Bioconcentration Factor
BMF	Biomagnification factor
CAA	Clean Air Act
CASRN	Chemical Abstracts Service Registry Number
CBI	Confidential Business Information
CCL	Contaminant Candidate List
CDR	Chemical Data Reporting
CEHD	Chemical Exposure Health Data
CEPA	Canadian Environmental Protection Act
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
COC	Concentration of Concern
CSCL	Chemical Substances Control Law
CSF	Cancer Slope Factor
EC	Engineering Controls
ECB	European Chemicals Bureau
ECHA	European Chemicals Agency
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
GACT	Generally Available Control Technology
ERG	Eastern Research Group
ESD	Emission Scenario Document
EU	European Union
FDA	Food and Drug Administration
FR	Federal Register
FYI	For Your Information
GDIT	General Dynamics Information Technology
GS	Generic Scenario
HAP	Hazardous Air Pollutant
HHE	Health Hazard Evaluation
HSDB	Hazardous Substances Data Bank
IARC	International Agency for Research on Cancer
ICES	International Council for the Exploration of the Sea
ICF	ICF is a global consulting services company
IECCU	Indoor Environmental Concentrations in Buildings with Conditioned and Unconditioned Zones
ILO	International Labour Organization
IMAP	Inventory Multi-Tiered Assessment and Prioritisation (Australia)
IUR	Inhalation Unit Risk
IRIS	Integrated Risk Information System

ISHA	Industrial Safety and Health Act
K_{OC}	Organic Carbon: Water Partition Coefficient
K_{OW}	Octanol: Water Partition Coefficient
LOEC	Lowest Observed Effect Concentration
MACT	Maximum Achievable Control Technology
MOA	Mode of Action
MOE	Margin of Error
MSW	Municipal Solid Waste
NAICS	North American Industry Classification System
NICNAS	National Industrial Chemicals Notification and Assessment Scheme (Australia)
NIOSH	National Institute for Occupational Safety and Health
NOEC	No Observed Effect Concentration
NPDES	National Pollutant Discharge Elimination System
NPDWR	National Primary Drinking Water Regulations
NPL	National Priorities List
NPRI	National Pollutant Release Inventory
NTP	National Toxicology Program
OCSPP	Office of Chemical Safety and Pollution Prevention
OECD	Organisation for Economic Co-operation and Development
OEHHA	Office of Environmental Health Hazard Assessment (California)
ONU	Occupational Non-User
OPPT	Office of Pollution Prevention and Toxics
OSF	Oral Slope Factor
OSHA	Occupational Safety and Health Administration
PBPK	Physiologically Based Pharmacokinetic
PEL	Permissible Exposure Limit
PECO	Populations, Exposures, Comparators, and Outcomes
PESO	Pathways and Processes, Exposure, Setting or Scenario, and Outcomes
PESS	Potentially Exposed or Susceptible Subpopulations
POD	Point of Departure
POTW	Publicly Owned Treatment Works
PPE	Personal Protective Equipment
RAD	Risk Assessment Division
RCRA	Resource Conservation and Recovery Act
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals (European Union)
RESO	Receptors, Exposure, Setting or Scenario, and Outcomes
SARA	Superfund Amendments and Reauthorization Act
SDS	Safety Data Sheet
SDWA	Safe Drinking Water Act
SRC	SRC Inc., formerly Syracuse Research Corporation
STEL	Short-term Exposure Limit
TBD	To be determined
TIAB	Title and Abstract
TSCA	Toxic Substances Control Act
TLV	Threshold Limit Value
TMF	Trophic Magnification Factors
TRI	Toxics Release Inventory

TWA	Time-weighted average
UCMR	Unregulated Contaminants Monitoring Rule
USGS	United States Geological Survey
VOC	Volatile Organic Compound
VP	Vapor Pressure
WWT	Wastewater Treatment

EXECUTIVE SUMMARY

In December 2019, EPA designated 1,3-butadiene (CASRN 106-99-0) as a high-priority substance for risk evaluation following the prioritization process as required by Section 6(b) of the Toxic Substances Control Act (TSCA) and implementing regulations (40 CFR Part 702) (Docket ID: EPA-HQ-OPPT-2019-0131). The first step of the risk evaluation process is the development of the draft scope document. EPA published the *Draft Scope of the Risk Evaluation for 1,3-Butadiene* (EPA Document No. 740-D-20-001) (U.S. EPA, 2020c) and provided a 45-day comment period on the draft scope per 40 CFR 702.41(c)(7). EPA has considered comments received (Docket ID: EPA-HQ-OPPT-2018-0451) during the public comment period to inform the development of this final scope document, and public comments received will continue to inform the development of the risk evaluation for 1,3-butadiene. This document fulfills the TSCA requirement to issue a final scope document per TSCA Section 6(b)(4)(D) and as described in 40 CFR 702.41(c)(8). The scope for 1,3-butadiene includes the following information: the conditions of use, potentially exposed or susceptible subpopulations (PESS), hazards, and exposures that EPA plans to consider in the risk evaluation, along with a description of the reasonably available information, conceptual model, analysis plan and science approaches, and plan for peer review for this chemical substance.

General Information. 1,3-Butadiene is a colorless gas with a total production volume in the United States between 1 and 5 billion pounds.

Reasonably Available Information. EPA leveraged the data and information sources already described in *Proposed Designation of 1,3-Butadiene (CASRN 106-99-0) as a High-Priority Substance for Risk Evaluation* (U.S. EPA, 2019d) to inform the development of this scope document. Furthermore, EPA conducted a comprehensive search to identify and screen multiple evidence streams (*i.e.*, chemistry, fate, release and engineering, exposure, hazard) and the search and screening results are provided in Section 2.1. EPA used the systematic review process described in Appendix A to search for and screen reasonably available information, including information already in EPA's possession, for inclusion in the risk evaluation. This information includes the hazards, exposures, PESS, and conditions of use that may help inform the risk evaluation for 1,3-butadiene. EPA has focused on the data collection phase (consisting of data search, data screening, and data extraction) during the preparation of the scope document, whereas the data evaluation and integration stages will occur during the development of the risk evaluation and thus are not part of the scoping activities described in this document. EPA plans to consider additional information identified following publication of this scope document, as appropriate, in developing the risk evaluation, including the Chemical Data Reporting (CDR) information that the Agency will receive by the end of November 2020.

Conditions of Use. EPA plans to evaluate manufacturing (including importing); processing; distribution in commerce; industrial, commercial, and consumer uses; and disposal of 1,3-butadiene in the risk evaluation. 1,3-Butadiene is manufactured (including imported) in the United States. The chemical is processed as a reactant, incorporated into a formulation, mixture, or reaction product, and incorporated into articles. The identified processing activities also include the repackaging and recycling of 1,3-butadiene. Several industrial and commercial uses were identified that ranged from use in plastic and rubber products to use in lubricants. Only one consumer use was reported in plastic and rubber products. EPA identified these conditions of use from information reported to EPA through CDR and Toxics Release Inventory (TRI) reporting, published literature, public comments, and consultation with stakeholders both for uses currently in production and uses whose production may have ceased. EPA revised the conditions of use in the final scope of the risk evaluation based on additional information and

public comments (Docket ID: EPA-HQ-OPPT-2018-0451) on the draft scope document for 1,3-butadiene. EPA is aware of information reporting use of 1,3-butadiene in smoke from tobacco and smoke from wildfires; however, they are not conditions of use for the chemical substance as defined in TSCA § 3(2) and (4). Section 2.2 provides details regarding the conditions of use within the scope of the risk evaluation.

Conceptual Model. The conceptual models for 1,3-butadiene are presented in Section 2.6. Conceptual models are graphical depictions of the actual or predicted relationships of conditions of use, exposure pathways (*e.g.*, media), exposure routes (*e.g.*, inhalation, dermal, oral), hazards and receptors throughout the life cycle of the chemical substance. EPA considered reasonably available information as well as public comments received on the draft scope document for 1,3-butadiene in finalizing the exposure pathways, exposure routes, and hazards EPA plans to evaluate in the risk evaluation. As a result, EPA plans to focus the risk evaluation for 1,3-butadiene on the following exposures, hazards and receptors:

- *Exposures (Pathways and Routes), Receptors and PESS.* EPA plans to evaluate releases to the environment as well as both human and environmental exposures resulting from the conditions of use of 1,3-butadiene that EPA plans to consider in risk evaluation. Exposures to 1,3-butadiene are discussed in Section 2.3. Additional information gathered through systematic review searches will also inform expected exposures.

  EPA's plan for evaluating environmental exposure pathways in the scope of the risk evaluation considers whether and how other EPA administered statutes and regulatory programs cover 1,3-butadiene in media pathways falling under the jurisdiction of those authorities. Section 2.6.3.1. discusses pathways under the jurisdiction of other EPA-administered laws. In Section 2.6.3.2, EPA presents the conceptual model describing the identified exposures (pathways and routes), receptors and hazards associated with the conditions of use of 1,3-butadiene within the scope of the risk evaluation.

  EPA considered reasonably available information and comments received on the draft scope for 1,3-butadiene in determining the human and environmental exposure pathways, routes, receptors and PESS for inclusion in the final scope. EPA plans to evaluate the following human and environmental exposure pathways, routes, receptors and PESS in the scope of the risk evaluation:

  - *Occupational exposure:* EPA plans to evaluate exposures to workers and occupational non-users (ONUs) via the inhalation route and exposures to workers via the dermal route associated with the manufacturing, processing, distribution, use and disposal of 1,3-butadiene.
  - *Consumer and bystander exposure:* EPA plans to evaluate inhalation exposures to 1,3-butadiene vapor for consumers and bystanders during use of plastics and rubber products.
  - *General population exposure:* EPA plans to evaluate general population exposures to 1,3-butadiene from ingestion of fish, and from dermal and oral exposure to surface water.
  - *PESS:* EPA plans to include children, women of reproductive age (*e.g.*, pregnant women), workers and consumers as PESS in the risk evaluation.
  - *Environmental exposures:* EPA plans to evaluate exposure to 1,3-butadiene for aquatic and terrestrial receptors.

- *Hazards*. Hazards for 1,3-butadiene are discussed in Section 2.4. EPA completed preliminary reviews of information (*e.g.,* federal and international government chemical assessments) to identify potential environmental and human health hazards for 1,3-butadiene as part of the prioritization (U.S. EPA, 2019d) and scoping process (U.S. EPA, 2020c). EPA also considered reasonably available information collected through systematic review methods as outlined in Appendix A and public comments received on the draft scope for 1,3-butadiene in determining the broad categories of environmental and human health hazard effects to be evaluated in the risk evaluation. EPA plans to use systematic review methods to evaluate the epidemiological and toxicological literature for 1,3-butadiene.

  EPA plans to evaluate all potential environmental and human health hazard effects identified for 1,3-butadiene in Section 2.4.1 and 2.4.2, respectively. EPA did not identify any potential environmental hazard effects or related information during prioritization or through the data screening phase of systematic review for 1,3-butadiene. The potential human health hazard effects and related information identified through prioritization and the data screening phase of systematic review for 1,3-butadiene that EPA plans to consider for the risk evaluation include: ADME, PBPK, cancer, cardiovascular, developmental, endocrine, gastrointestinal, hematological and immune, hepatic, mortality, musculoskeletal, neurological, nutritional and metabolic, ocular and sensory, renal, reproductive, respiratory, skin and connective tissue.

Analysis Plan. The analysis plan for 1,3-butadiene is presented in Section 2.7. The analysis plan outlines the general science approaches that EPA plans to use for the various evidence streams (*i.e.*, chemistry, fate, release and engineering, exposure, hazard) supporting the risk evaluation. The analysis plan is based on EPA's knowledge of 1,3-butadiene to date which includes a, review of identified information as described in Section 2.1. Should additional data or approaches become reasonably available, EPA may consider them for the risk evaluation.

Peer Review. The draft risk evaluation for 1,3-butadiene will be peer reviewed. Peer review will be conducted in accordance with relevant and applicable methods for chemical risk evaluations, including using EPA's Peer Review Handbook (U.S. EPA, 2015c) and other methods consistent with Section 26 of TSCA (see 40 CFR 702.45).

1 INTRODUCTION

This document presents the scope of the risk evaluation to be conducted for 1,3-butadiene under the Frank R. Lautenberg Chemical Safety for the 21st Century Act. The Frank R. Lautenberg Chemical Safety for the 21st Century Act amended TSCA on June 22, 2016. The new law includes statutory requirements and deadlines for actions related to conducting risk evaluations of existing chemicals.

Under TSCA § 6(b), the Environmental Protection Agency (EPA) must designate chemical substances as high-priority substances for risk evaluation or low-priority substances for which risk evaluations are not warranted at the time, and upon designating a chemical substance as a high-priority substance, initiate a risk evaluation on the substance. TSCA § 6(b)(4) directs EPA to conduct risk evaluations for existing chemicals, to "*determine whether a chemical substance presents an unreasonable risk of injury to health or the environment, without consideration of costs or other nonrisk 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 § 6(b)(4)(D) and implementing regulations require that EPA publish the scope of the risk evaluation to be conducted, including the hazards, exposures, conditions of use and PESS that the Administrator expects to consider, within 6 months after the initiation of a risk evaluation. In addition, a draft scope is to be published pursuant to 40 CFR 702.41. In December 2019, EPA published a list of 20 chemical substances that have been designated high priority substances for risk evaluations (Docket ID: EPA-HQ-OPPT-2019-0131) (84 FR 71924, December 30, 2019), as required by TSCA § 6(b)(2)(B), which initiated the risk evaluation process for those chemical substances. 1,3-Butadiene is one of the chemicals designated as a high-priority substance for risk evaluation. On April 9, 2020, EPA published the *Draft Scope of the Risk Evaluation for 1,3-Butadiene* (EPA Document No. 740-D-20-011) (85 FR 19941, April 9, 2020) (U.S. EPA, 2020c) for a 45-day public comment period. After reviewing and considering the public comments (Docket ID: EPA-HQ-OPPT-2018-0451) received on the draft scope document, EPA is now publishing this final scope document pursuant to 40 CFR 702.41(c)(8).

2 SCOPE OF THE EVALUATION

2.1 Reasonably Available Information

EPA conducted a comprehensive search for reasonably available information[1] to support the development of this scope document for 1,3-butadiene. EPA leveraged the data and information sources already collected in the documents supporting the chemical substance's high-priority substance designation. In addition, EPA searched for additional data and information on physical and chemical properties, environmental fate, engineering, exposure, environmental and human health hazards that could be obtained from the following general categories of sources:

1. Databases containing publicly available, peer-reviewed literature;
2. Gray literature, which is defined as the broad category of data/information sources not found in standard, peer-reviewed literature databases;

[1] *Reasonably available information* means information that EPA possesses or can reasonably generate, obtain, and synthesize for use in risk evaluations, considering the deadlines specified in TSCA Section 6(b)(4)(G) for completing such evaluation. Information that meets the terms of the preceding sentence is reasonably available information whether or not the information is confidential business information, that is protected from public disclosure under TSCA Section 14 (40 CFR 702.33).

3. Data and information submitted under TSCA Sections 4, 5, 8(e), and 8(d), as well as "for your information" (FYI) submissions.

Following the comprehensive search, EPA performed a title and abstract screening to identify information potentially relevant for the risk evaluation process. This step also classified the references into useful categories or tags to facilitate the sorting of information through the systematic review process.

Search terms were used to search each of the literature streams and gather 1,3-butadiene studies. These terms and the methods used to develop them are listed in Appendix A. The studies resulting from the search process were loaded into the EPA Health and Environmental Research Online (HERO) database and then prioritized to screen first the literature likely relevant for each of the disciplines: fate, physical and chemical properties, engineering, exposure and hazard. The tools and methods used to manage the screening process are also outlined in Appendix A. The studies resulting from the search underwent a title/abstract screening process, which tagged them by topic or category. Following this, a determination was made to move studies forward into full-text screening. The criteria used in the screening process for each discipline are found in the population, exposure, comparator, outcome (PECO) statements listed in Appendix A. The screening process results are presented in the form of literature inventory trees and heat maps in Section 2.1.2. The screening process was conducted based on EPA's planning, execution and assessment activities outlined in Appendix A.

EPA has focused on the data collection phase (consisting of data search, data screening, and data extraction) during the preparation of the scope document, whereas the data evaluation and integration stages will occur during the development of the risk evaluation and thus are not part of the scoping activities described in this document.

The subsequent sections summarize the data collection activities completed to date for the general categories of sources and topic areas (or disciplines) using systematic review methods.

2.1.1 Search of Gray Literature

EPA surveyed the gray literature[2] and identified 267 search results relevant to EPA's risk evaluation needs for 1,3-butadiene. Appendix A.3.4 lists the gray literature sources that yielded 267 discrete data or information sources relevant to 1,3-butadiene. EPA further categorized the data and information into the various topic areas (or disciplines) supporting the risk evaluation (*e.g.*, physical and chemical properties, environmental fate, environmental hazard, human health hazard, exposure, engineering) and the breakdown is shown in Figure 2-1. EPA plans to consider additional reasonably available information from gray literature if it becomes available during the risk evaluation phase.

[2] Gray literature is defined as the broad category of data/information sources not found in standard, peer-reviewed literature databases (*e.g.*, PubMed and Web of Science). Gray literature includes data/information sources such as white papers, conference proceedings, technical reports, reference books, dissertations, information on various stakeholder websites, and other databases.

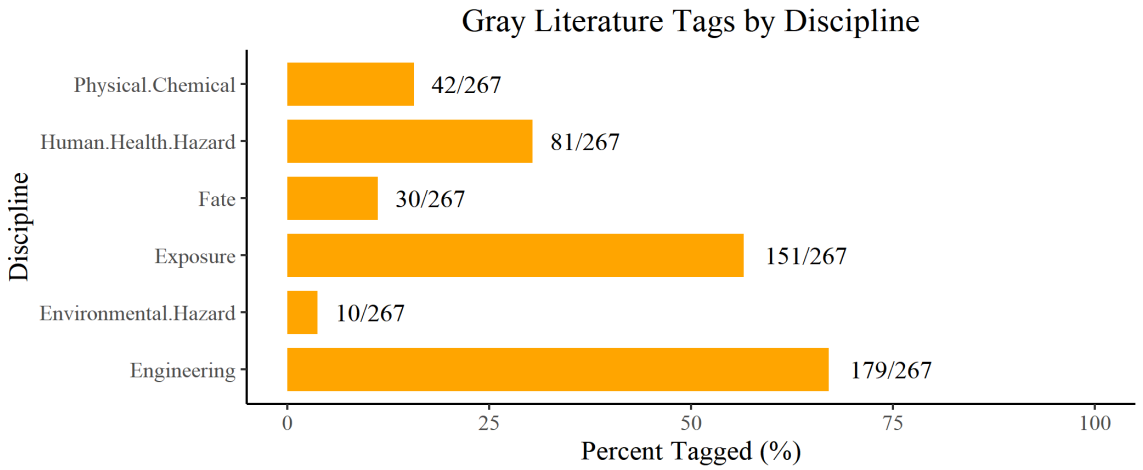


Figure 2-1. Gray Literature Search Results for 1,3-Butadiene
The percentages across disciplines do not add up to 100%, as each source may provide data or information for various topic areas (or disciplines).

2.1.2 Search of Literature from Publicly Available Databases (Peer-Reviewed Literature)

EPA has begun the systematic review process and has conducted searching and screening of the reasonably available literature using the process outlined in Appendix A. This includes performing a comprehensive search of the reasonably available peer review literature on physical and chemical properties, environmental fate and transport, engineering (environmental release and occupational exposure), exposure (environmental, general population and consumer) and environmental and human health hazards of 1,3-butadiene. Eligibility criteria were applied in the form of PECO statements (see Appendix A). Included references met the PECO criteria, whereas excluded references did not meet the criteria (*i.e.*, not relevant), and supplemental material was considered as potentially relevant (see Appendix A.2). EPA plans to evaluate the reasonably available information identified for each discipline during the development of the risk evaluation.

EPA created literature inventory trees to graphically illustrate the flow of data and information sources following full-text screening (see Figure 2-2, Figure 2-3, Figure 2-5, Figure 2-7, and Figure 2-9). EPA used the Health Assessment Workplace Collaborative (HAWC) tool to develop web-based literature inventory trees illustrating, through interactive links, studies that were included or excluded. These literature inventory trees enhance the transparency of the decisions resulting from the screening process described in Appendix A. For each of the corresponding disciplines, the literature was tagged to be included for evaluation during the risk evaluation. Literature inventory trees for physical and chemical properties are provided as static diagrams (Figure 2-2). For all other disciplines, static screen captures are provided in addition to links within each figure's caption to the interactive trees. The links show individual studies that were tagged as included, excluded, or supplemental. Supplemental studies did not meet all inclusion criteria, but may be considered during the risk evaluation as supporting information (see Appendix A). These studies can be accessed through the hyperlink provided in the associated caption below each figure. Note that in some figures the sum of the numbers for the various sub-categories may be larger than the broader category because some studies may be included under multiple sub-categories. In other cases, the sum of the various sub-categories may be smaller than the main category because some studies may not be depicted in the sub-categories if their relevance to the risk evaluation was unclear.

In addition, EPA tabulated the number and characteristics of the data and information sources included in the full-text screening process in the form of literature inventory heat maps for the fate, engineering, exposure and hazard disciplines (see Figure 2-4, Figure 2-6, Figure 2-8, Figure 2-10). For each of these four disciplines, a static image of the literature inventory heat map is provided, and a link to the interactive version presented in HAWC is included in the caption below each diagram.

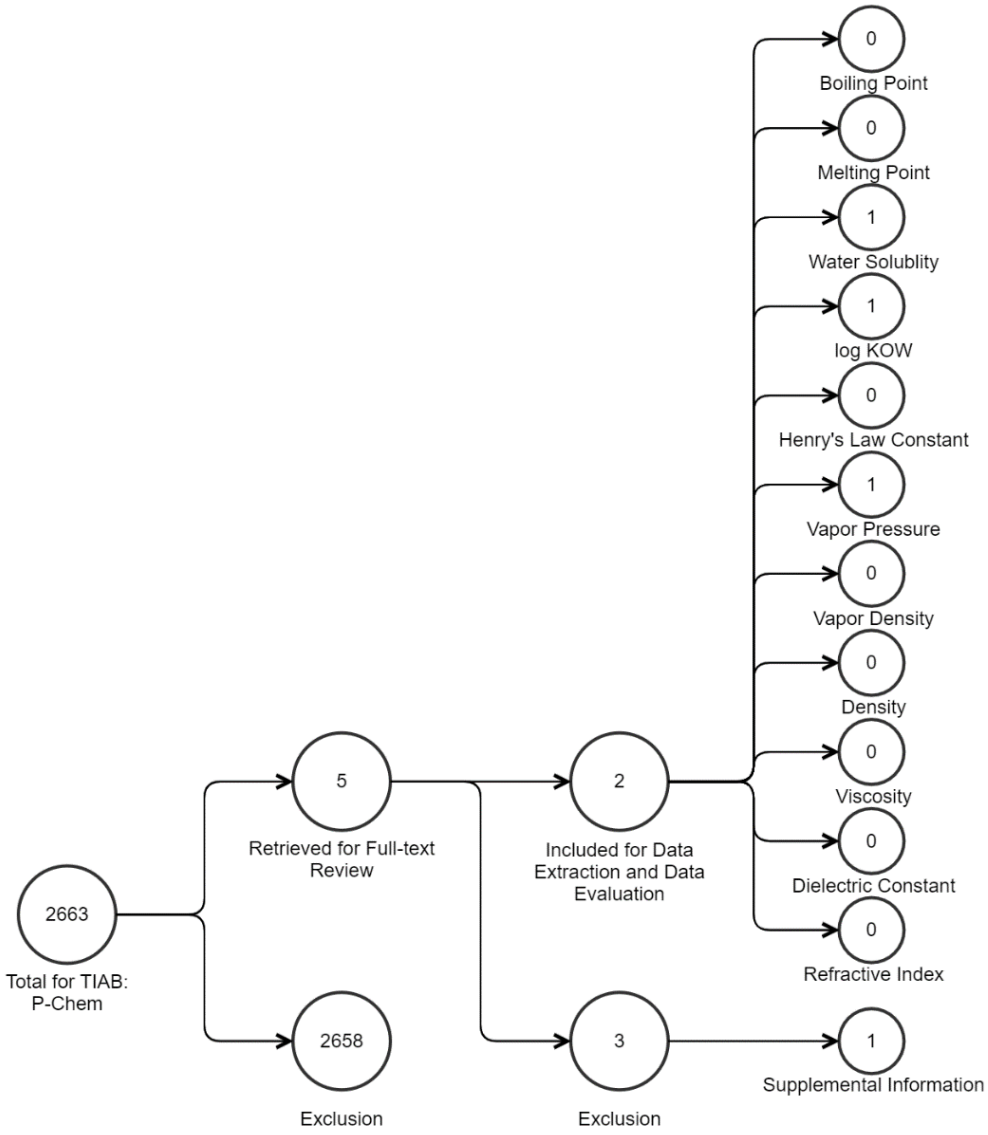


Figure 2-2. Peer-reviewed Literature Inventory Tree – Physical and Chemical Properties Search Results for 1,3-Butadiene

Data in this static figure represent references obtained from the publicly available databases search (see Appendix A.1.2) that were included during full-text screening as of June 2, 2020. TIAB refers to "title and abstract" screening.

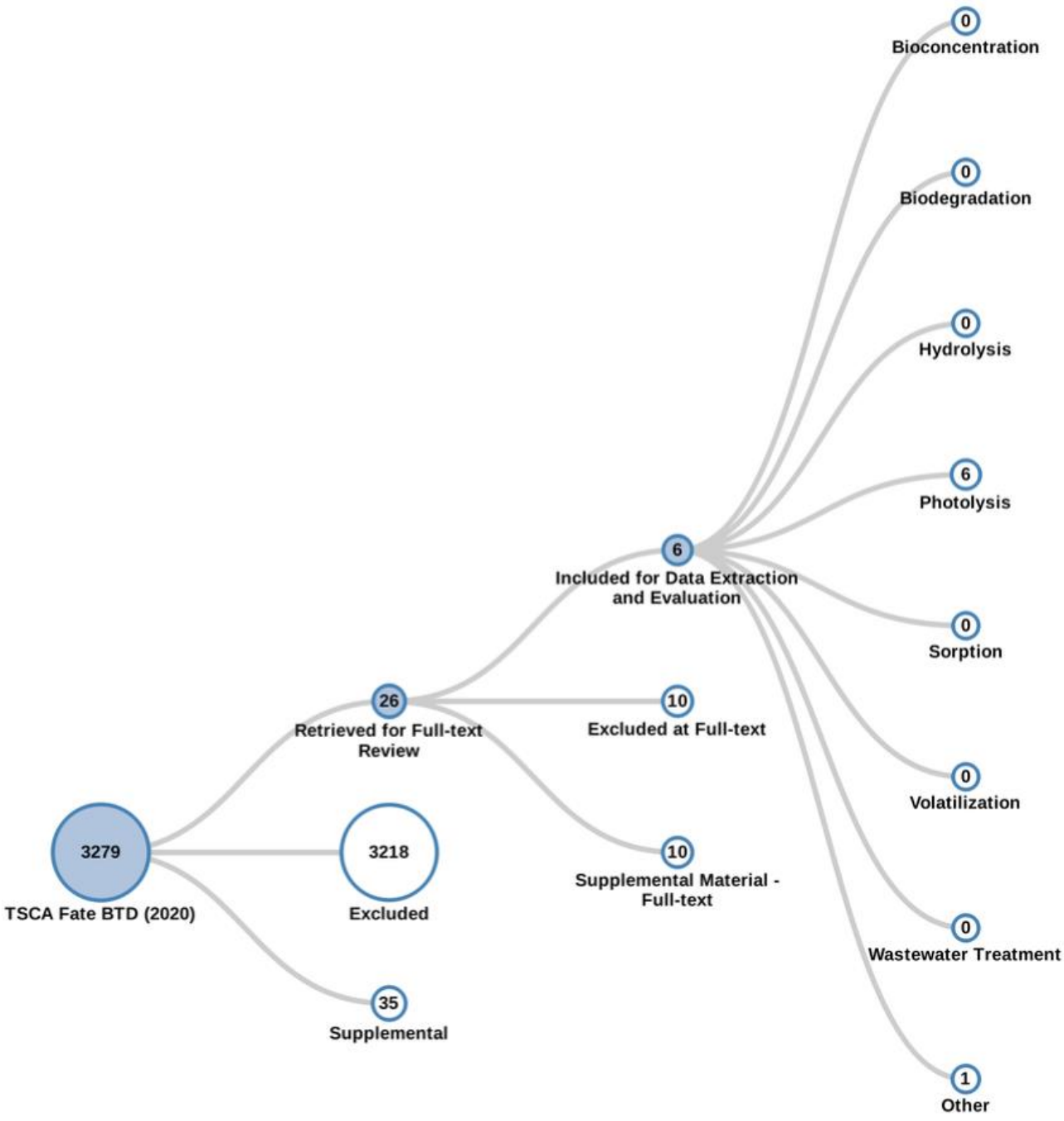


Figure 2-3. Peer-reviewed Literature Inventory Tree – Fate and Transport Search Results for 1,3-Butadiene

Click here to view the interactive literature inventory tree. Data in this figure represent references obtained from the publicly available databases search (see Appendix A.1.2) that were included during full-text screening as of June 2, 2020. Additional data may be added to the interactive version as they become available.

	Media					
Endpoint	Air	Soil, Sediment	Wastewater, Biosolids	Water	Other	Grand Total
Bioconcentration						
Biodegradation						
Hydrolysis						
Photolysis	6					6
Sorption						
Volatilization						
Wastewater Treatment						
Other	1					1
Grand Total	6					6

Figure 2-4. Peer-reviewed Literature Inventory Heat Map - Fate and Transport Search Results for 1,3-Butadiene

Click here to view the interactive version for additional study details. The column totals, row totals, and grand totals indicate total numbers of unique references, as some references may be included in multiple cells. The various shades of color visually represent the number of relevant references identified by media or endpoint. The various shades of color visually represent the number of relevant references identified by media or endpoint. The darker the color, the more references are available for a given media or endpoint. Data in this figure represents references obtained from the publicly available databases search (see Appendix A.1.2) that were included during full-text screening as of June 2, 2020. Additional data may be added to the interactive version as they become available.

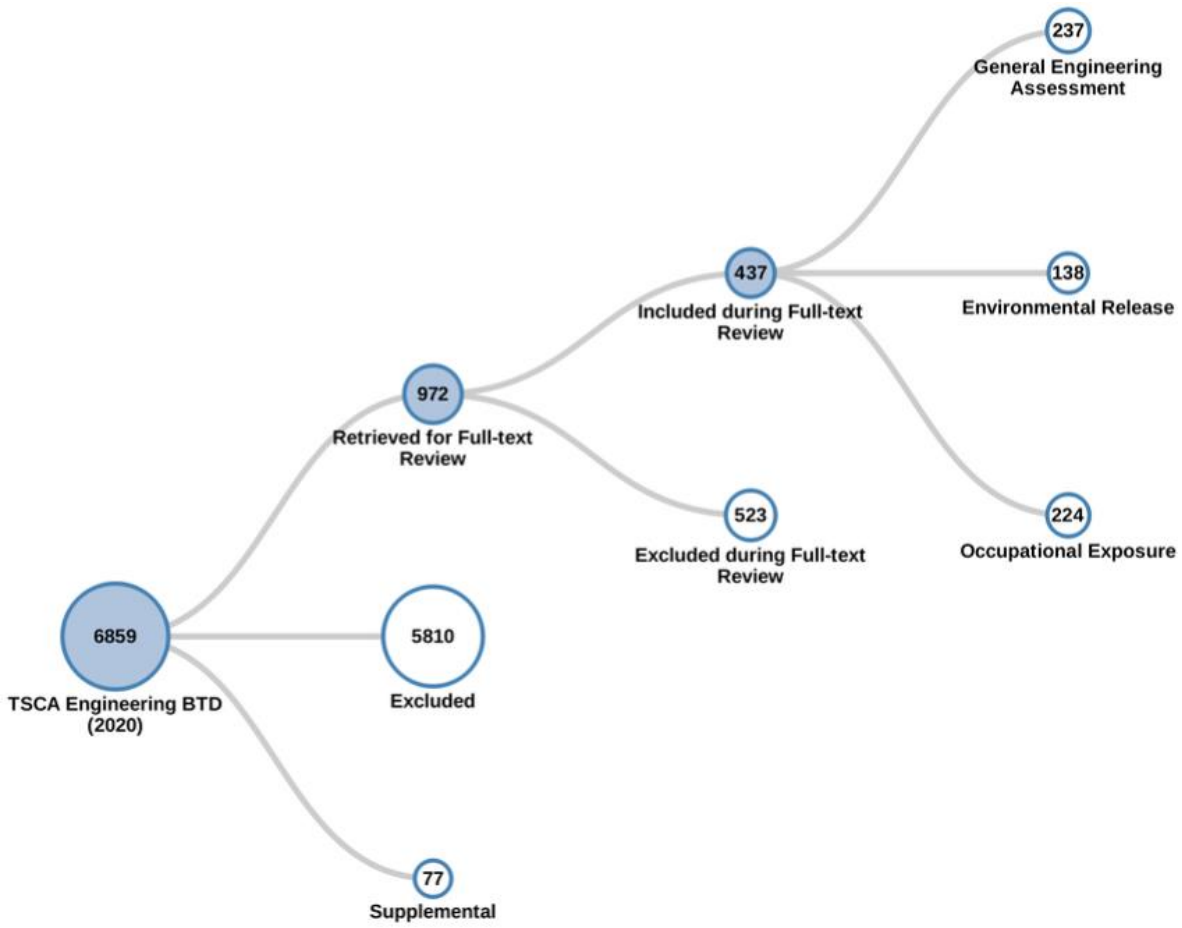


Figure 2-5. Peer-reviewed Literature Inventory Tree - Engineering Search Results for 1,3-Butadiene

Click here to view the interactive literature inventory tree. Data in this figure represent references obtained from the publicly available databases search (see Appendix A.1.2) that were included during full-text screening as of August 5, 2020. Additional data may be added to the interactive version as they become available.

Data Type	Evidence Tags	
Environmental Releases	Description of release source	74
	No evidence tag	4
	Release frequency	10
	Release or emission factors	87
	Release quantity	73
	Waste treatment methods and pollution control	27
	Total	138
General Engineering Assessment	Chemical concentration	37
	Life cycle description	35
	No evidence tag	5
	Number of sites	33
	Process description	85
	Production, import, or use volume	160
	Throughput	31
	Total	237
Occupational Exposures	Area sampling data	126
	Dermal exposure data	7
	Engineering control	8
	Exposure duration	85
	Exposure frequency	49
	Exposure route	135
	No evidence tag	4
	Number of workers	89
	Particle size characterization	
	Personal protective equipment	12
	Personal sampling data	125
	Physical form	73
	Worker activity description	112
	Total	224
Grand Total		437

Figure 2-6. Peer-reviewed Literature Inventory Heat Map - Engineering Search Results for 1,3-Butadiene

Click here to view the interactive version for additional study details. Data in this figure represent references obtained from the publicly available databases search (see Appendix A.1.2) that were included during full-text screening as of August 5, 2020. Additional data may be added to the interactive version as they become available.

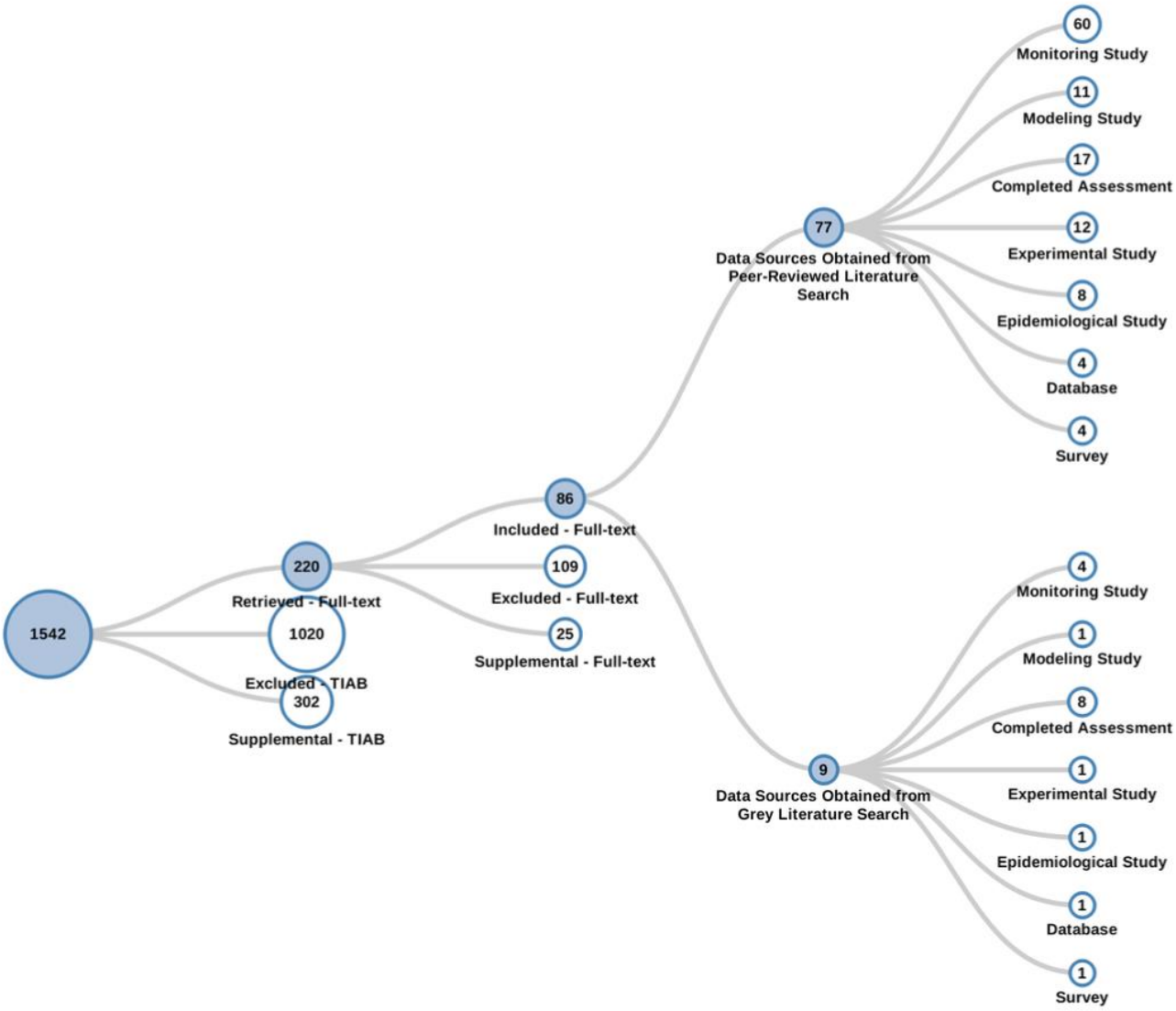


Figure 2-7. Peer-reviewed and Gray Literature Inventory Tree - Exposure Search Results for 1,3-Butadiene

Click here to view the interactive literature inventory tree. Data in this figure represent all references obtained from the publicly available databases search (see Appendix A.1.2.), and gray literature references search (see Appendix A.3) that were included during full-text screening as of July 31, 2020. Additional data may be added to the interactive version as they become available.

Media (group)	Data Type							
	Monitoring Study	Modeling Study	Completed Assessment	Experimental Study	Epidemiological Study	Database	Survey	Grand Total
Ambient Air								
Biosolids/Sludge	1		1					1
Drinking Water								
Groundwater	1		1					1
Land Disposal/ Landfill			1					1
Sediment	1		1					1
Soil	1		2					2
Surface Water	2		3			1		4
Wastewater								
Aquatic Species								
Terrestrial Species								
Consumer	4	2	4	7		1	1	13
Dietary	1		4	1		1		5
Dust								
Exposure Factors	6	5	5	2	2	1	3	10
Exposure Pathway	8	3	6	2	1	1	2	12
Human Biomonitoring	20	3	5	5	2	1	1	22
Indoor Air	51	10	18	6	6	2	4	65
Isomers								
Use Information	6	2	8	2	1	1	1	12
No Evidence Type	1		1		1		1	1
Grand Total	65	12	25	13	9	5	5	87

Figure 2-8. Peer-reviewed and Gray Literature Inventory Heat Map - Exposure Search Results for 1,3-Butadiene

Click here to view the interactive version for additional study details. The column totals, row totals, and grand totals indicate total numbers of unique references, as some references may be included in multiple cells. The various shades of color visually represent the number of relevant references identified by exposure media or data type. The darker the color, the more references are available for a given exposure media or data type. Data in this figure represent all references obtained from the publicly available databases search (see Appendix A.1.2), and gray literature references search (see Appendix A.3) that were included during full-text screening as of July 31, 2020. Additional data may be added the interactive version as they become available.

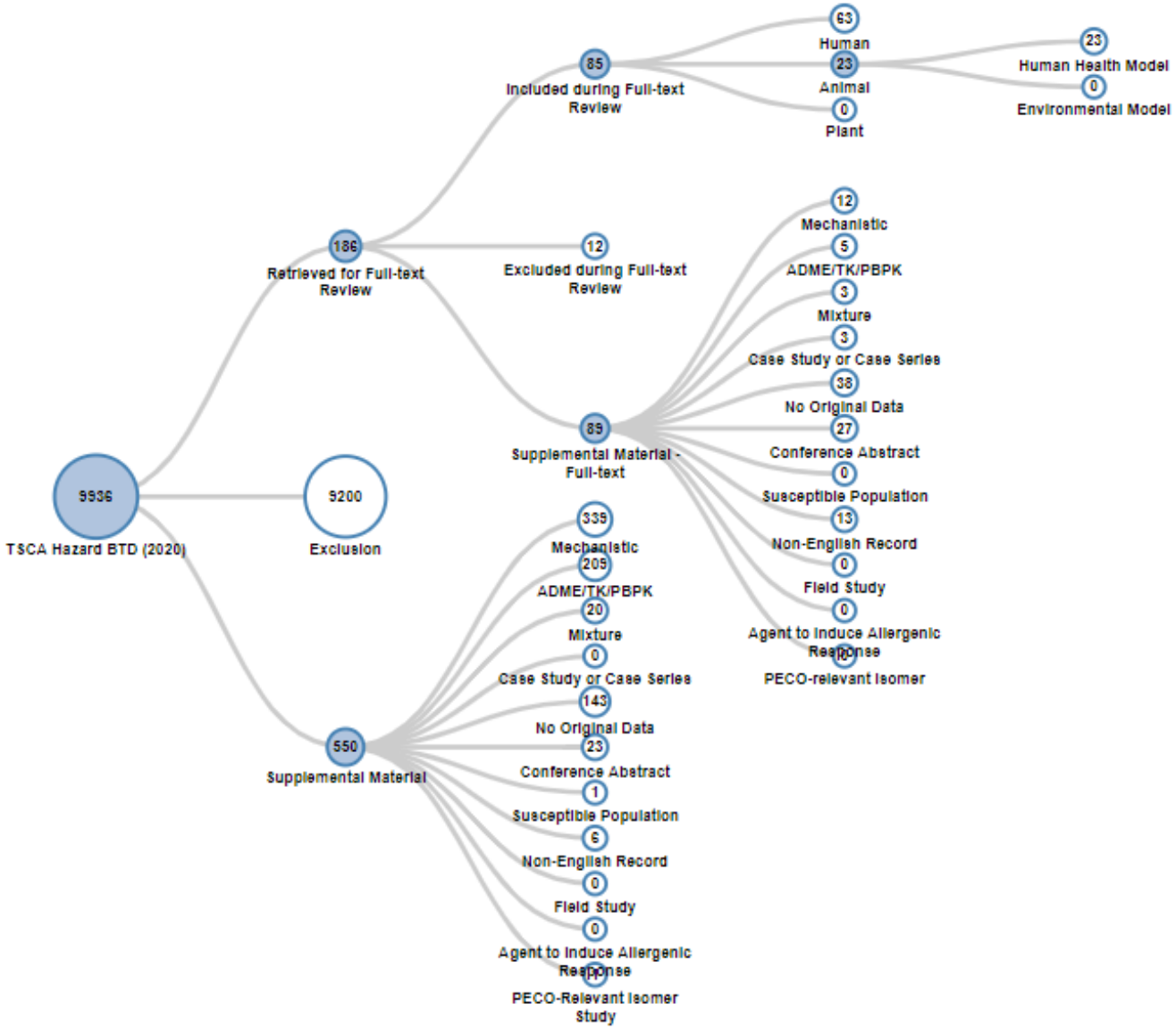


Figure 2-9. Peer-reviewed Literature Inventory Tree - Human Health and Environmental Hazards Search Results for 1,3-Butadiene

Click here to view the interactive literature inventory tree. Data in this figure represent references obtained from the publicly available databases search (see Appendix A.1.2) that were included during full-text screening as of June 17, 2020. Additional data may be added to the interactive version as they become available.

	Evidence Type				
Health Outcomes	Human	Animal - Human Health Model	Animal - Environmental Model	Plant	Grand Total
ADME	10	18			27
Cancer	54	16			69
Cardiovascular	7	6			13
Developmental	13	7			20
Endocrine	2	9			11
Gastrointestinal	6	2			8
Hematological and Immune	40	12			52
Hepatic	2	6			8
Mortality	34	8			42
Musculoskeletal	4	3			7
Neurological	4	4			8
Nutritional and Metabolic	2	1			3
Ocular and Sensory	2				2
PBPK	1				1
Renal	3	5			8
Reproductive	8	9			17
Respiratory	16	18			33
Skin and Connective Tissue	1	1			2
No Tag		1			1
Grand Total	63	23			85

Figure 2-10. Peer-reviewed Literature Inventory Heat Map – Human Health and Environmental Hazards Search Results for 1,3-Butadiene

Click here to view the interactive version for additional study details. The numbers indicate the number of studies with TIAB keywords related to a particular health outcome, not the number of studies that observed an association with 1,3-butadiene. Evidence types were manually extracted, and Health Systems were determined via machine learning. Therefore, the studies examining multiple Health Outcomes and Evidence types, connections between health outcome, and evidence type may not be accurately represented. If a study evaluated multiple health outcomes or included multiple populations or study designs, it is shown here multiple times. Data in this figure represent references obtained from the publicly available databases search (see Appendix A.1.2.) that were included during full-text screening as of June 16, 2020. Additional data may be added to the interactive version as they become available.

2.1.3 Search of TSCA Submissions

Table 2-1 presents the results of screening the titles of data sources and reports submitted to EPA under various sections of TSCA. EPA screened a total of 109 submissions using PECO or similar statements that identify inclusion and exclusion criteria specific to individual disciplines (see Table 2-1 for the list of disciplines). The details about the criteria are presented in Appendix A.2.1. EPA identified

92 submissions that met the inclusion criteria and identified 18 submissions with supplemental human health data.[3] EPA excluded 17 submissions because the reports were identified as one of the following:

- Published report that would be identified via other peer or gray literature searches
- Summary of other reports
- Preliminary report of a final available submitted report
- Duplicate of another report
- Submission on a different chemical
- List of references with no original data

Table 2-1. Results of Title Screening of Submissions to EPA Under Various Sections of TSCA[a]

Discipline	Included	Supplemental[b]
Physical and Chemical Properties	1	0
Environmental Fate and Transport	0	0
Environmental and General Population Exposure	14	0
Occupational Exposure/Release Information	34	0
Environmental Hazard	0	0
Human Health Hazard	43	18

[a] Individual submissions may be relevant to multiple disciplines.
[b] Included submissions may contain supplemental data for other disciplines, which will be identified at full-text review.

2.2 Conditions of Use

As described in the *Proposed Designation of 1,3-Butadiene (CASRN 106-99-0) as a High-Priority Substance for Risk Evaluation* (U.S. EPA, 2019d), EPA assembled information from the CDR and TRI programs to determine conditions of use[4] or significant changes in conditions of use of the chemical substance. Once the 2020 CDR submission period ends in November 2020, EPA plans to utilize the most recent CDR information. EPA also consulted a variety of other sources to identify uses of 1,3-butadiene, including: published literature, company websites, and government and commercial trade databases and publications. To identify formulated products containing 1,3-butadiene, EPA searched for safety data sheets (SDS) using internet searches, EPA Chemical and Product Categories (CPCat) (U.S. EPA, 2019c) data, and other resources in which SDSs could be found. SDSs were cross-checked with company websites to make sure that each product SDS was current. In addition, EPA incorporated communications with companies, industry groups, and public comments to supplement the use information.

EPA identified and described the categories and subcategories of conditions of use that EPA plans to consider in the risk evaluation (Section 2.2.1;

Table 2-2). The conditions of use included in the scope of the risk evaluation are those reflected in the life cycle diagrams and conceptual models.

After gathering reasonably available information related to the manufacture, processing, distribution in commerce, use, and disposal of 1,3-butadiene, EPA identified those activities for 1,3-butadiene the

[3] EPA may further consider some supplemental or excluded references depending on the reasons for tagging as supplemental or excluded.
[4] *Conditions of use* means the circumstances, as determined by the Administrator, under which a chemical substance is intended, known, or reasonably foreseen to be manufactured, processed, distributed in commerce, used, or disposed of (TSCA § 3(4)).

Agency determined not to be conditions of use or are otherwise excluded from the scope of the risk evaluation. These excluded activities are described in Section 2.2.2.

2.2.1 Categories and Subcategories of Conditions of Use Included in the Scope of the Risk Evaluation

Table 2-2 lists the conditions of use that are included in the scope of the risk evaluation.

Table 2-2. Categories and Subcategories of Conditions of Use Included in the Scope of the Risk Evaluation

Life Cycle Stage[a]	Category[b]	Subcategory[c]	References
Manufacture	Domestic manufacturing	Domestic manufacturing	U.S. EPA (2019a)
	Importing	Importing	U.S. EPA (2019a)
Processing	Processing as a reactant	Intermediate in: Adhesive manufacturing; All other basic organic chemical manufacturing; Fuel binder for solid rocket fuels; Organic fiber manufacturing; Petrochemical manufacturing; Petroleum refineries; Plastic material and resin manufacturing; Propellant manufacturing; Synthetic rubber manufacturing; Wholesale and retail trade	U.S. EPA (2019a)
		Other: Monomer used in polymerization process in: Plastic material and resin manufacturing; Manufacturing synthetic rubber and plastics	U.S. EPA (2019a);EPA-HQ-OPPT-2018-0451-0004
	Processing – incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: Petrochemical manufacturing	U.S. EPA (2019a)
		Other: Adhesive manufacturing, paints and coatings manufacturing, petroleum lubricating oil and grease manufacturing, and all other chemical product and preparation manufacturing	EPA-HQ-OPPT-2018-0451-0003; EPA-HQ-OPPT-2018-0451-0005; EPA-HQ-OPPT-2018-0451-0009; EPA-HQ-OPPT-2019-0131-0022
	Processing – incorporation into article	Other: Polymer in: Rubber and plastic product manufacturing	U.S. EPA (2019a)
	Repackaging	Intermediate in: Wholesale and retail trade	U.S. EPA (2019a)
	Recycling	Recycling	U.S. EPA (2019a);U.S. EPA (2019e)
Distribution in commerce	Distribution in commerce	Distribution in commerce (*e.g.*, Sold to a trader; Sold to re-sellers	U.S. EPA (2019a)

Life Cycle Stage[a]	Category[b]	Subcategory[c]	References
		for petroleum fuel and petrochemical industry in: Petrochemical manufacturing)	
Industrial Use	Adhesives and sealants	Adhesives and sealants, including epoxy resins	EPA-HQ-OPPT-2018-0451-0003; EPA-HQ-OPPT-2018-0451-0005; EPA-HQ-OPPT-2018-0451-0009; EPA-HQ-OPPT-2019-0131-0022
	Processing aids, specific to petroleum production	Hydraulic fracturing fluids	U.S. EPA (2016)
Commercial Use	Fuels and related products	Fuels and related products	U.S. EPA (2019a)
	Plastic and rubber products not covered elsewhere	Plastic and rubber products not covered elsewhere, including rubber tires	U.S. EPA (2019a);EPA-HQ-OPPT-2018-0451-0003
	Automotive care products	Automotive care products	U.S. EPA (2019a)
	Other use	Monomer used in polymerization process	U.S. EPA (2019a);EPA-HQ-OPPT-2018-0451-0005
		Laboratory chemicals	Sigma-Aldrich (2020)
	Lubricants and lubricant additives	Lubricant additives, including viscosity modifier	EPA-HQ-OPPT-2018-0451-0003; EPA-HQ-OPPT-2019-0131-0022
	Paints and coatings	Paints and coatings, including aerosol spray paint	EPA-HQ-OPPT-2018-0451-0005; EPA-HQ-OPPT-2019-0131-0022
	Adhesives and sealants	Adhesives and sealants, including epoxy resins	EPA-HQ-OPPT-2018-0451-0003; EPA-HQ-OPPT-2018-0451-0009; EPA-HQ-OPPT- 2019-0131-0022
Consumer Use	Plastic and rubber products not covered elsewhere	Plastic and rubber products not covered elsewhere, including rubber tires	U.S. EPA (2019a);EPA-HQ-OPPT-2019-0131-0012
Disposal	Disposal	Disposal	

[a.] Life Cycle Stage Use Definitions (40 CFR § 711.3)
- "Industrial use" means use at a site at which one 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.

Life Cycle Stage[a]	Category[b]	Subcategory[c]	References
– 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 appear in the Life Cycle Diagram, reflect CDR codes, and broadly represent conditions of use of 1,3-butadiene in industrial and/or commercial settings. c. These subcategories reflect more specific conditions of use of 1,3-butadiene. – "Incorporation into article – polymer in rubber product manufacturing," as reported to the 2016 CDR, is a condition of use that EPA plans to consider as manufacturing of articles involving butadiene-derived polymers, including plastics such as acrylonitrile butadiene styrene made using polybutadiene rubber. – "Monomer used in polymerization process," as reported to the 2016 CDR under commercial use, indicates processing of 1,3-butadiene for a polymerization reaction. This reported use will be evaluated under processing as a reactant. In the final scope, EPA made the following changes to the conditions of use: – EPA added "propellant manufacturing" as an "intermediate" condition of use after receiving U.S. Department of Defense feedback on the draft scope document. – EPA moved the "fuel binder for solid rocket rules" use from its own subcategory and into the existing "intermediate" subcategory after reviewing draft scope public comments (EPA-HQ-OPPT-2018-0451-0030) and further analysis. – EPA removed the "plasticizer" and "solvent in rubber manufacturing" uses because after reviewing draft scope public comments (EPA-HQ-OPPT-2018-0451-0030) and further analysis with consideration of 1,3-butadiene physical and chemical properties, these applications are already captured in this COU table as intermediates in plastic and rubber manufacturing. – EPA removed consumer use of 1,3-butadiene in automotive care products. After further communication with the industry reporting the use, EPA concluded that the correct classification of the use of 1,3-butadiene is only commercial use and not also consumer use in automotive care products.			

2.2.2 Activities Excluded from the Scope of the Risk Evaluation

As explained in the final rule for *Procedures for Chemical Risk Evaluation Under the Amended Toxic Substances Control Act* (82 FR 33726, July 20, 2017), TSCA Section 6(b)(4)(D) requires EPA to identify the hazards, exposures, conditions of use, and the PESS the Administrator expects to consider in a risk evaluation, suggesting that EPA may exclude certain activities that it determines to be conditions of use on a case-by-case basis (82 FR 33736, 33729; July 20, 2017). TSCA Section 3(4) also grants EPA discretion to determine the circumstances that are appropriately considered to be conditions of use for a particular chemical substance[5]. As a result, EPA does not plan to include in this scope or in the risk evaluation activities described below that the Agency does not consider to be conditions of use or for which EPA is exercising discretionary authority provided by TSCA Section 6(b)(4)(D).

TSCA Section 3(2) also excludes from the definition of "chemical substance" "any food, food additive, drug, cosmetic, or device (as such terms are defined in Section 201 of the Federal Food, Drug, and Cosmetic Act [21 U.S.C. 321]) when manufactured, processed, or distributed in commerce for use as a food, food additive, drug, cosmetic, or device" as well as "any pesticide (as defined in the Federal

[5] *Chemical substance* means any organic or inorganic substance of a particular molecular identity, including any combination of such substances occurring in whole or in part as a result of a chemical reaction or occurring in nature, and any element or uncombined radical. Chemical substance does not include (1) any mixture; (2) any pesticide (as defined in the Federal Insecticide, Fungicide, and Rodenticide Act) when manufactured, processed, or distributed in commerce for use as a pesticide; (3) tobacco or any tobacco product; (4) any source material, special nuclear material, or byproduct material (as such terms are defined in the Atomic Energy Act of 1954 and regulations issued under such Act); (5) any article the sale of which is subject to the tax imposed by Section 4181 of the Internal Revenue Code of 1954 (determined without regard to any exemptions from such tax provided by Section 4182 or 4221 or any other provision of such Code), and; (6) any food, food additive, drug, cosmetic, or device (as such terms are defined in Section 201 of the Federal Food, Drug, and Cosmetic Act) when manufactured, processed, or distributed in commerce for use as a food, food additive, drug, cosmetic, or device (TSCA § 3(2)).

Insecticide, Fungicide, and Rodenticide Act [7 U.S.C. 136 et seq.]) when manufactured, processed, or distributed in commerce for use as a pesticide." EPA has determined that the following uses of 1,3-butadiene are non-TSCA uses:

Public comments submitted to EPA in the docket indicate the presence of 1,3-butadiene in smoke from tobacco (EPA-HQ-OPPT-2018-0451-0016) and smoke from wildfires (EPA-HQ-OPPT-2018-0451-0014), but these activities and releases are not TSCA conditions of use and will not be evaluated during the risk evaluation. TSCA's definition of "chemical substance" expressly excludes tobacco or tobacco products (TSCA Section 3(2)(B)(iii)); tobacco use is therefore outside the scope of TSCA. Regarding wildfires, after consideration of the public comment, EPA determined that there was no manufacturing, processing, distribution in commerce, use, or disposal associated with wildfire activity.

2.2.3 Production Volume

As reported to EPA during the 2016 CDR submission period and described here as a range to protect production volumes that were claimed as confidential business information (CBI), total production volume of 1,3-butadiene in 2015 was between 1 billion and 5 billion pounds (U.S. EPA, 2020a). EPA also uses pre-2015 CDR production volume information, as detailed in the *Proposed Designation of 1,3-Butadiene (CASRN 106-99-0) as a High-Priority Substance for Risk Evaluation* (EPA-HQ-OPPT-2018-0451-0010) (U.S. EPA, 2019d) and will include more recent production volume information from the 2020 CDR submission period in the risk evaluation to support the exposure assessment.

2.2.4 Overview of Conditions of Use and Lifecycle Diagram

Figure 2-11 provides the lifecycle diagram for 1,3-butadiene. The life cycle diagram is a graphical representation of the various life stages of the industrial, commercial, and consumer use categories included within the scope of the risk evaluation. The information in the life cycle diagram is grouped according to the CDR processing codes and use categories (including functional use codes for industrial uses and product categories for industrial, commercial, and consumer uses). Appendix E contains additional descriptions (*e.g.*, process descriptions, worker activities, process flow diagrams) for each manufacture, processing, distribution in commerce, use and disposal category.

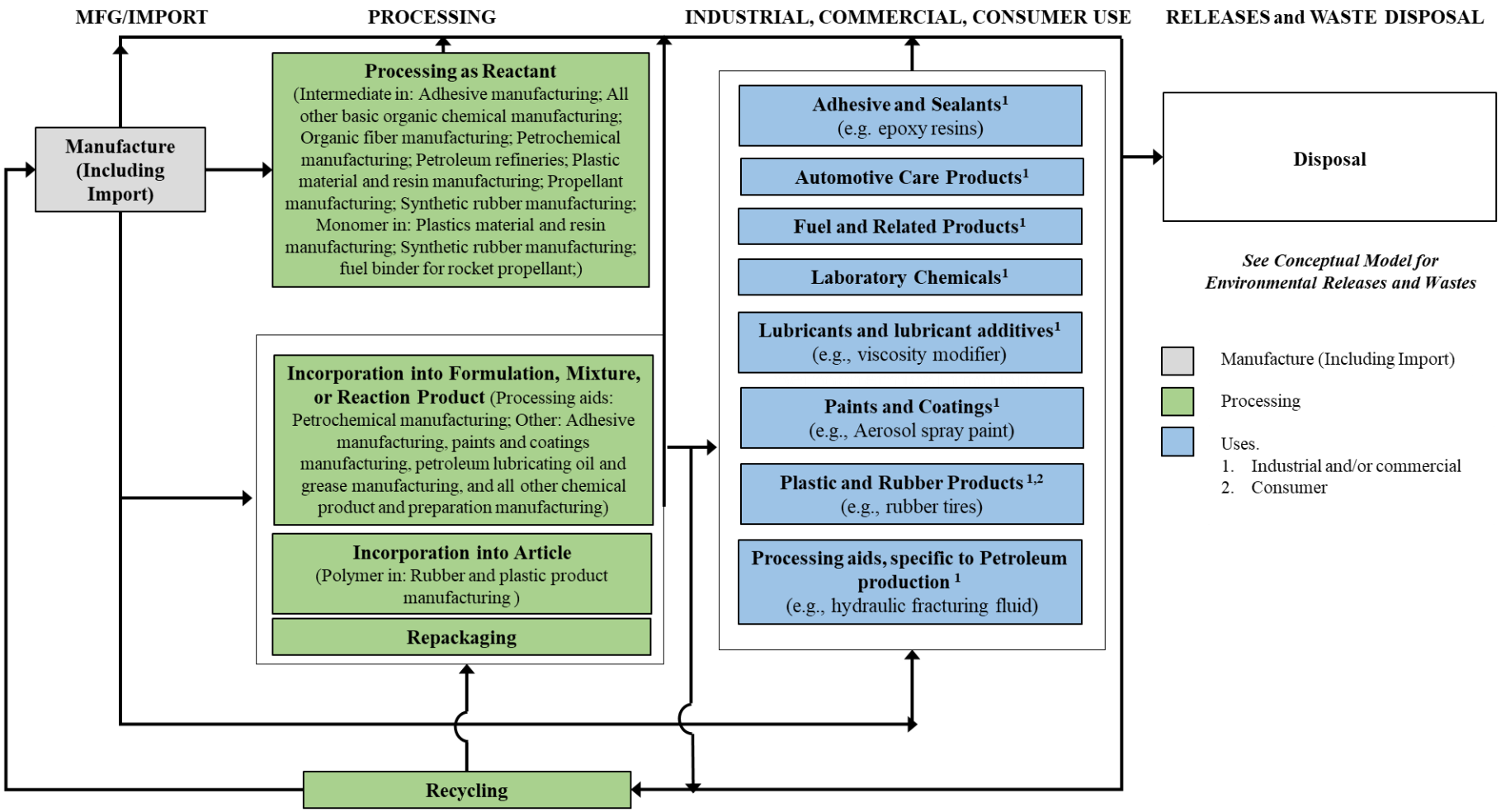


Figure 2-11. 1,3-Butadiene Life Cycle Diagram

2.3 Exposures

For TSCA exposure assessments, EPA plans to analyze human and environmental exposures and releases to the environment resulting from the conditions of use within the scope of the risk evaluation for of 1,3-butadiene. In this section, the physical and chemical properties, environmental fate and transport properties and releases to the environment are described in addition to potential human and environmental exposures from TSCA conditions of use and from other possible or known sources. Release pathways and routes will be described in Section 2.6 to characterize the relationship or connection between the conditions of use of the chemical and the exposure to human receptors, including PESS, and environmental receptors. EPA plans to consider, where relevant, the duration, intensity (concentration), frequency and number of exposures in characterizing exposures to 1,3-butadiene.

2.3.1 Physical and Chemical Properties

Consideration of physical and chemical properties is essential for a thorough understanding or prediction of environmental fate (*i.e.*, transport and transformation) and the eventual environmental concentrations. It can also inform the hazard assessment. Table 2-3 summarizes the physical and chemical property values preliminarily selected for use in the risk evaluation from among the range of reported values collected as of June 2020. This table differs from that presented in the *Proposed Designation of 1,3-Butadiene (CASRN 106-99-0) as a High-Priority Substance for Risk Evaluation* (U.S. EPA, 2019d) and may be updated as EPA continues to evaluate and integrate additional information through systematic review methods. Figure 2-12 summarizes the distribution of reported values for eight physical and chemical properties routinely used in existing chemical risk evaluations. Appendix B presents summary statistics for reported physical and chemical property values. All physical and chemical property values that were extracted and evaluated as of June 2020 are presented in the supplemental file *Data Extraction and Data Evaluation Tables for Physical and Chemical Property Studies* (EPA-HQ-OPPT-2018-0451).

Table 2-3. Physical and Chemical Properties of 1,3-Butadiene

Property or Endpoint	Value[a]	Reference	Data Quality Rating
Molecular formula	C_4H_6	NA	NA
Molecular weight	54.09 g/mol	NA	NA
Physical state	Colorless gas	Rumble (2018a)	High
Physical properties	Colorless, mildly aromatic or gasoline- like odor	NLM (2003)	High
Melting point	-108.966°C	O'Neil (2013)	High
Boiling point	-4.5°C at 760 mm Hg	O'Neil (2013)	High
Density	0.6149 g/cm^3 at 25°C and >1 atm	Rumble (2018a)	High
Vapor pressure	2110 mm Hg	U.S. EPA (2019b)	High
Vapor density	1.87 (air = 1)	NLM (2003)	High
Water solubility	735 mg/L at 20°C	NLM (2003)	High

Property or Endpoint	Value[a]	Reference	Data Quality Rating
Octanol/water partition coefficient (log Kow)	1.99 at 25°C	Rumble (2018c)	High
Henry's Law constant	0.204 atm·m^3/mol at 25°C	Rumble (2018b)	High
Flash point	-76.111°C	RSC (2019)	High
Auto flammability	420°C	Rumble (2018a)	High
Viscosity	0.00754 cP at 20°C	NLM (2003)	High
Refractive index	1.4292	Rumble (2018a)	High
Dielectric constant	2.050	Rumble (2018a)	High

[a] Measured unless otherwise noted.
NA = Not applicable

Figure 2-12 displays a summary of the data collected as of June 2020 for eight physical and chemical values routinely used in TSCA existing chemical risk evaluations. The box and whisker plots for each endpoint illustrate the mean (average, indicated by the blue diamond) and the 10^{th}, 25^{th}, 50^{th} (median), 75^{th}, and 90^{th} percentiles. All individual data points are indicated by black squares, and value preliminarily selected for use in the risk evaluation is overlaid (indicated by the orange circle) to provide context for where it lies within the distribution of the dataset. The number of unique primary data sources is indicated below each box and whisker plot. If multiple sources presented equivalent values and cited the same primary source, only one of those was included in the statistical calculations. As a result, the number of sources listed in Figure 2-12 may differ from the total number of data sources presented in Figure 2-2.

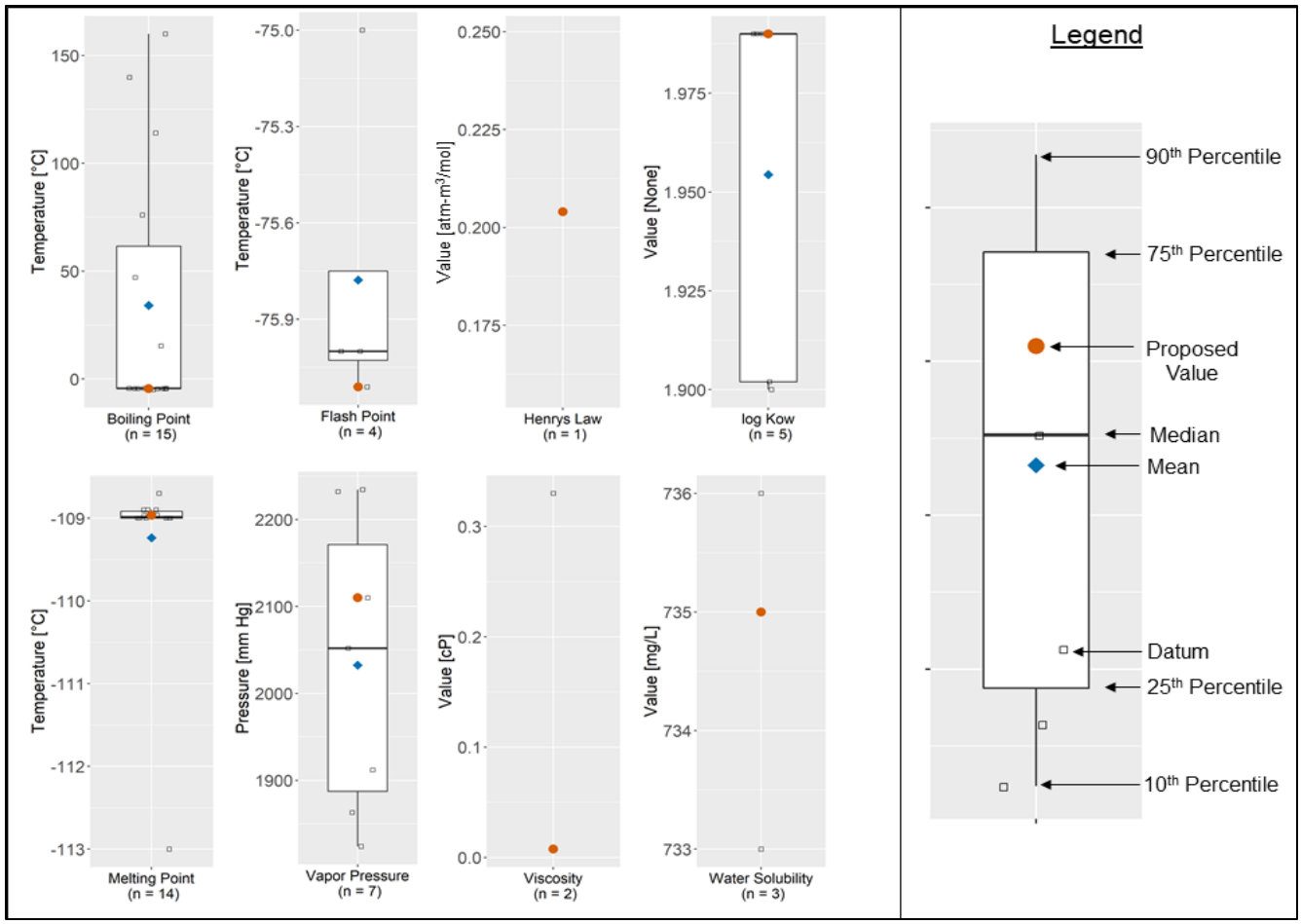


Figure 2-12. Box and Whisker Plots of Reported Physical and Chemical Property Values

2.3.2 Environmental Fate and Transport

Understanding of environmental fate and transport processes assists in the determination of the specific exposure pathways and potential human and environmental receptors that need to be assessed in the risk evaluation for 1,3-butadiene. EPA plans to use the environmental fate characteristics described in Appendix B to support the development of the risk evaluation for 1,3-butadiene. The values for the environmental fate properties may be updated as EPA evaluates and integrates additional information into the risk evaluation through systematic review methods.

2.3.3 Releases to the Environment

Releases to the environment from conditions of use are a component of potential exposure and may be derived from reported data that are obtained through direct measurement, calculations based on empirical data or assumptions and models.

A source of information that EPA plans to consider in evaluating exposure are data reported to the TRI program. EPA's TRI database contains information on chemical waste management activities that are reported to EPA by industrial and federal facilities, including quantities released into the environment (*i.e.*, to air, water, and disposed of to land), treated, burned for energy, recycled, or transferred off-site to other facilities for these purposes.

Under Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA) 1,3-butadiene is a TRI-reportable substance effective January 1, 1987 (40 CFR 372.65). For TRI reporting,[6] facilities in covered sectors in the United States are required to disclose release and other waste management activity quantities of 1,3-butadiene under the CASRN 106-99-0 if they manufacture (including import) or process more than 25,000 pounds or otherwise use more than 10,000 pounds of the chemical in a given year by July 1 of the following year.

Table 2-4 provides production-related waste management data for 1,3-butadiene reported by facilities to the TRI program for reporting year 2018. As shown in the table, 188 facilities reported a total of nearly 114 million pounds of 1,3-butadiene production-related waste managed in 2018. Of this total, roughly equal amounts were recycled or treated (49 million pounds or 43% each). Quantities of 1,3-butadiene burned for energy recovery or released to the environment accounted for 15 million pounds (13%) and 1.2 million pounds (1%) of the total, respectfully. Overall, nearly all production-related waste of 1,3-butadiene was managed on site, with only 2.4% managed off site.

Table 2-4. Summary of 1,3-Butadiene TRI Production-related Waste Managed in 2018

Year	Number of Facilities	Recycled (lbs)	Recovered for Energy (lbs)	Treated (lbs)	Released[a,b,c] (lbs)	Total Production Related Waste (lbs)
2018	188	48,924,121	14,931,906	48,818,860	1,236,393	113,911,280

Data source: 2018 TRI Data U.S. EPA (2019e)
[a] Terminology used in these columns may not match the more detailed data element names used in the TRI public data and analysis access points.
[b] Does not include releases due to one-time event not associated with production such as remedial actions or earthquakes.
[c] Counts all releases including release quantities transferred and release quantities disposed of by a receiving facility reporting to TRI.

Table 2-5 provides a summary of 1,3-butadiene released to the environment during 2018 as reported to TRI.[7] Based on 2018 reporting to the TRI, a total of 248.98 lbs were released to water from 188 facilities. Of the total quantity released to the environment during 2018, 98% was released to air. Roughly three-quarters of these air emissions originated from point sources, with the remainder from fugitive sources. Land disposal accounted for nearly all remaining releases, with 93% disposed of on-site to Class I underground injection wells. Overall, more than 99% of disposal and other releases of 1,3-butadiene to the environment occurred on site.

Table 2-5. Summary of Releases of 1,3-Butadiene to the Environment During 2018

	Number of Facilities	Air Releases		Water Releases (lbs)	Land Disposal			Other Releases [a] (lbs)	Total Releases [b, c] (lbs)
		Stack Air Releases (lbs)	Fugitive Air Releases (lbs)		Class I Under-ground Injection (lbs)	RCRA Subtitle C Landfills (lbs)	All other Land Disposal [a] (lbs)		
Totals 2018	188	918,009	303,486	248.98	22,340	34	1,698	10.715	1,245,827
		1,221,495			24,073				

[6] For TRI reporting criteria see https://www.epa.gov/toxics-release-inventory-tri-program/basics-tri-reporting
[7] Reporting year 2018 is the most recent TRI data available. Data presented in Table 2-4 were queried using TRI Explorer and uses the 2018 National Analysis data set (U.S. EPA, 2019e). This dataset includes revisions for the years 1988 to 2018 processed by EPA.

	Number of Facilities	Air Releases		Water Releases (lbs)	Land Disposal			Other Releases [a] (lbs)	Total Releases [b, c] (lbs)
		Stack Air Releases (lbs)	Fugitive Air Releases (lbs)		Class I Under-ground Injection (lbs)	RCRA Subtitle C Landfills (lbs)	All other Land Disposal [a] (lbs)		

Data source: 2018 TRI Data U.S. EPA (2019e)
[a] Terminology used in these columns may not match the more detailed data element names used in the TRI public data and analysis access points.
[b] These release quantities do include releases due to one-time events not associated with production such as remedial actions or earthquakes.
[c] Counts release quantities once at final disposition, accounting for transfers to other TRI reporting facilities that ultimately dispose of the chemical waste.

While the production-related waste managed shown in Table 2-4 excludes any quantities reported as catastrophic or one-time releases (TRI Section 8 data), release quantities shown in Table 2-5 include both production-related and non-production-related quantities. Approximately 9,660 pounds of 1,3-butadiene waste not related to production were reported for 2018. These waste quantities are included in the total releases stated in Table 2-5.

EPA plans to review these data in conducting the exposure assessment component of the risk evaluation for 1,3-butadiene.

2.3.4 Environmental Exposures

The manufacturing, processing, distribution, use, and disposal of 1,3-butadiene can result in releases to the environment and exposure to aquatic and terrestrial receptors (biota). Environmental exposures to biota are informed by releases into the environment, overall persistence, degradation, and bioaccumulation within the environment, and partitioning across different media. Concentrations of chemical substances in biota provide evidence of exposure. EPA plans to review reasonably available environmental monitoring data for 1,3-butadiene.

2.3.5 Occupational Exposures

EPA plans to evaluate worker activities where there is a potential for exposure under the various conditions of use (manufacturing, processing, industrial/commercial uses and disposal) described in Section 2.2. In addition, EPA plans to evaluate exposure to occupational non-users (ONUs), (*i.e.*, workers who do not directly handle the chemical but perform work in an area where the chemical is present). EPA also expects to consider the effect(s) that engineering controls (EC) and/or personal protective equipment (PPE) have on occupational exposure levels as part of the risk evaluation.

Examples of worker activities associated with the conditions of use within the scope of the risk evaluation for 1,3-butadiene that EPA may analyze include, but are not limited to:

- Unloading and transferring 1,3-butadiene to and from storage containers to process vessels;
- Handling and disposing of waste containing 1,3-butadiene;
- Cleaning and maintaining equipment;
- Sampling chemicals, formulations, or products containing 1,3-butadiene for quality control;
- Repackaging chemicals, formulations, or products containing 1,3-butadiene;
- Performing other work activities in or near areas where 1,3-butadiene is used.

Several commercial uses (adhesives, automotive care products, lubricant additive, and plastic and rubber products) in Section 2.2 are reported to be downstream uses of the polymers produced using 1,3-butadiene as a monomer (ACC, 2019). Residual 1,3-butadiene monomer in plastic and rubber products is expected to be low, so occupational exposures for the commercial use of these products have been

reported to be low (ECB, 2002). Additional key data that EPA expects will inform occupational exposure assessment include: Occupational Safety and Health Administration (OSHA) Chemical Exposure Health Data (CEHD) and National Institute for Occupational Safety and Health (NIOSH) Health Hazard Evaluation (HHE) program data, presented in Appendix E.

1,3-Butadiene is a gas with a vapor pressure of 2,110 mm Hg (at 25 °C) (U.S. EPA, 2019d); hence, inhalation exposure is expected to be a significant route of exposure for workers and ONUs from potential fugitive emissions. Where mist generation is expected (*e.g.* spray application), EPA plans to analyze inhalation exposure to mist for workers and ONU. 1,3-Butadiene has an OSHA standard (29 CFR 1910.1051). The Permissible Exposure Limit (PEL) is 1 part per million (ppm) over an 8-hour work day, time-weighted average (TWA), and there is a Short-Term Exposure Limit (STEL) of 5 ppm (OSHA, 2019). NIOSH considers 1,3-butadiene to be a potential occupational carcinogen with an Immediately Dangerous to Life or Health (IDLH) value of 2,000 ppm (10% of lower explosive limit) (NIOSH, 2020, 2016).

EPA generally does not evaluate occupational exposures through the oral route. Workers and ONUs may inadvertently ingest inhaled particles that deposit in the upper respiratory tract. In addition, workers may transfer chemicals from their hands to their mouths. The frequency and significance of this exposure route are dependent on several factors including the physical and chemical properties of the substance during worker activities, the visibility of the chemicals on the hands while working, workplace training and practices, and personal hygiene that is difficult to predict (Cherrie et al., 2006). EPA plans to consider the relevance of this exposure route on a case-by-case basis, taking into consideration the aforementioned factors and any reasonably available information, and may assess oral exposure for workers for certain COUs and worker activities where warranted.

EPA plans to evaluate dermal exposure to workers for particular conditions of use based on expected handling practices as identified through the Agency's systematic review process. 1,3-Butadiene is transported as a liquid under pressure, contact with rapidly vaporizing liquid can cause frostbite [EPA-2018-0451-0038; (ATSDR, 2012)], EPA does not plan to evaluate routine dermal exposure under these conditions. ONUs do not directly handle 1,3-butadiene; therefore, direct liquid contact with 1,3-butadiene is not expected for any condition of use.

2.3.6 Consumer Exposures

According to reports in the 2016 CDR, plastic and rubber products, including synthetic rubbers, were identified as consumer products for 1,3-butadiene. In addition, consumers using or disposing of plastic and rubber products may be exposed to 1,3-butadiene through vapor emissions which may lead to inhalation exposure, given its volatility at room temperature. Bystanders present during the consumer use or disposal of 1,3-butadiene plastic and rubber products may also be exposed to vapor emissions leading to an inhalation exposure. Of note, 1,3-butadiene, a monomer used in polymer-derived products such as synthetic rubbers, is stable and is not expected to degrade to the 1,3-butadiene monomer. Also, since 1,3-butadiene is a highly volatile vapor at room temperature, oral and dermal exposures to 1,3-butadiene during consumer use of plastic and rubber products are not expected (ECHA, 2019). Based on these potential sources and expected pathways of exposure, EPA plans to analyze 1,3-butadiene inhalation exposure to consumers and bystanders.

2.3.7 General Population Exposures

Monitoring data were identified in EPA's data search for 1,3-butadiene and can be used in the exposure assessment. Relevant and reliable monitoring studies provide information that can be used in an exposure assessment. Monitoring studies that measure environmental concentrations or concentrations

of chemical substances in biota provide evidence of exposure. EPA's Ambient Monitoring Technology Information Center Air Toxics database has identified 1,3-butadiene in air. In addition, EPA's Unregulated Contaminant Monitoring Rule has identified 1,3-butadiene in drinking water. USGS's Monitoring Data – National Water Quality Monitoring Council has identified 1,3-butadiene in ground water. The general population pathways in the scope of this evaluation are described in Sections 2.6.3 and 2.7.2.5.

Releases of 1,3-butadiene from certain conditions of use, such as manufacturing, processing, distribution, use, and disposal activities, may result in general population exposures (OEHHA, 2013). 1,3-Butadiene is likely present at low ambient air concentrations in U.S. cities and large suburban areas (OEHHA, 2013). Elevated ambient air concentrations of 1,3-butadiene have been measured in the vicinity of heavily trafficked areas, refineries, chemical manufacturing plants, and plastic and rubber factories (OEHHA, 2013). Reasonably available assessments note the general population is exposed to low levels of 1,3-butadiene in the air due to its presence in gasoline, motor-vehicle exhausts as a product of incomplete combustion of gasoline and diesel oil, and thermal breakdown of plastics (NTP, 2016). In addition, the general population is also exposed to low levels of 1,3-butadiene in U.S. drinking water supplies (NTP, 2016; ATSDR, 2012). The general population pathways in the scope of this evaluation are described in Sections 2.6.3 and 2.7.2.5.

2.4 Hazards (Effects)

2.4.1 Environmental Hazards

EPA considered reasonably available information (*e.g.,* federal and international government chemical assessments) on 1,3-butadiene as well as public comments received on the *Proposed Designation of 1,3-Butadiene (CASRN 106-99-0) as a High-Priority Substance for Risk Evaluation* (U.S. EPA, 2019d) and draft scope for 1,3-butadiene (U.S. EPA, 2020c) to identify potential environmental hazards. During prioritization, EPA did not identify environmental hazard effects for aquatic and terrestrial organisms.

Since prioritization, EPA applied automated techniques during the data screening phase of systematic review but did not identify potential environmental hazards (Figure 2-10) and related information that may be considered for the risk evaluation (as explained in Appendix A). A summary of references for hazards identified during the screening step of systematic review is included in the interactive literature inventory trees and shows that no references containing environmental hazard information were identified (Figure 2-9). As EPA continues to evaluate reasonably available and relevant hazard information identified through systematic review, EPA may update the list of potential hazard effects to be analyzed in the risk evaluation.

2.4.2 Human Health Hazards

EPA considered reasonably available information (*e.g.,* federal and international government chemical assessments) on 1,3-butadiene as well as public comments on the *Proposed Designation of 1,3-Butadiene (CASRN 106-99-0) as a High-Priority Substance for Risk Evaluation* (U.S. EPA, 2019d) and draft scope for 1,3-butadiene (U.S. EPA, 2020c) to identify potential human health hazards. During prioritization, EPA identified the following potential human health hazards and related information: acute, repeat dose, genetic, reproductive, developmental, irritation/corrosion, cancer, immune and neurological effects.

Since prioritization, EPA applied automated techniques during the data screening phase of systematic review to identify the following additional potential human health hazards and related information that

may be considered for the risk evaluation (as explained in Appendix A): ADME, PBPK, cancer, cardiovascular, developmental, endocrine, gastrointestinal, hematological and immune, hepatic, mortality, musculoskeletal, neurological, nutritional and metabolic, ocular and sensory, renal, reproductive, respiratory, skin and connective tissue (Figure 2-10). A summary of references identified during the screening step of systematic review is included in the interactive literature inventory trees (Figure 2-9). As EPA continues to evaluate reasonably available and relevant hazard information identified through systematic review, EPA may update the list of potential hazard effects to be analyzed in the risk evaluation.

2.5 Potentially Exposed or Susceptible Subpopulations

TSCA§ 6(b)(4) requires EPA to determine whether a chemical substance presents an unreasonable risk to "a potentially exposed or susceptible subpopulation identified as relevant to the risk evaluation." TSCA §3(12) states that "the term 'potentially exposed or susceptible subpopulation' 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." General population is "the total of individuals inhabiting an area or making up a whole group" and refers here to the U.S. general population (U.S. EPA, 2011a).

EPA identified the following PESS based on CDR information and studies reporting developmental and reproductive effects: children, women of reproductive age (e.g., pregnant women), workers, including ONUs and users, and consumers, including users and bystanders (U.S. EPA, 2019a). EPA plans to evaluate these PESS in the risk evaluation. Following further evaluation of the reasonably available information, EPA may evaluate PESS in the general population as they relate to fence line communities.

In developing exposure scenarios, EPA plans to analyze reasonably available data to ascertain whether some human receptor groups may be exposed via exposure pathways that may be distinct to a particular subpopulation or life stage (*e.g.*, children's crawling, mouthing or hand-to-mouth behaviors) and whether some human receptor groups may have higher exposure via identified pathways of exposure due to unique characteristics (*e.g.*, activities, duration or location of exposure) when compared with the general population (U.S. EPA, 2006b). Likewise, EPA plans to evaluate reasonably available human health hazard information to ascertain whether some human receptor groups may have greater susceptibility than the general population to the chemical's hazard(s). Based on these analyses, EPA may update the list of PESS in the risk evaluation.

2.6 Conceptual Models

In this section, EPA presents the conceptual models describing the identified exposures (pathways and routes), receptors and hazards associated with the conditions of use of 1,3-butadiene. Pathways and routes of exposure associated with workers and ONUs are described in Section 2.6.1, and pathways and routes of exposure associated with consumers are described in Section 2.6.2. Pathways and routes of exposure associated with environmental releases and wastes, including those pathways that are under the jurisdiction of other EPA-administered laws, are discussed and depicted in the conceptual model shown in Section 2.6.3.1. Pathways and routes of exposure associated with environmental releases and wastes, excluding those pathways that are under the jurisdiction of other EPA-administered laws, are presented in the conceptual model shown in Section 2.6.3.2.

2.6.1 Conceptual Model for Industrial and Commercial Activities and Uses

Figure 2-13 illustrates the conceptual model for the pathways of exposure from industrial and commercial activities and uses of 1,3-butadiene that EPA plans to include in the risk evaluation. There is potential for exposures to workers and ONUs via inhalation routes and exposures to workers via dermal routes. Due to 1,3-butadiene high vapor pressure, it is expected that inhalation exposure to vapors is the most likely exposure pathway. In addition, workers and ONUs at waste management facilities may be exposed via inhalation routes and workers may be exposed via dermal routes during waste handling, treatment, and disposal. EPA plans to evaluate activities resulting in exposures associated with distribution in commerce (*e.g.*, loading, unloading) throughout the various lifecycle stages and conditions of use (*e.g.*, manufacturing, processing, industrial use, commercial use, and disposal) rather than a single distribution scenario.

One of the commercial uses of 1,3-butadiene is in fuel and fuel products, EPA plans to assess occupational exposures related to the processing and handling of fuel. Preliminary literature suggests 1,3-butadiene presence in fuel is low (ECB, 2002). However, 1,3-butadiene is also generated as a byproduct from the incomplete combustion of fuel, EPA does not plan to assess occupational exposures resulting from 1,3-butadiene formed as a byproduct (*e.g.*, exhaust emissions). EPA believes it is more appropriate to evaluate the potential risks arising from the byproduct within the scope of the risk evaluation for fuel from which the 1,3-butadiene is produced, rather than the 1,3-butadiene risk evaluation.

For each condition of use identified in Table 2-2 a determination was made as to whether or not EPA plans to evaluate each combination of exposure pathway, route, and receptor will be analyzed in the risk evaluation. The results of that analysis along with the supporting rationale are presented in Appendix F.

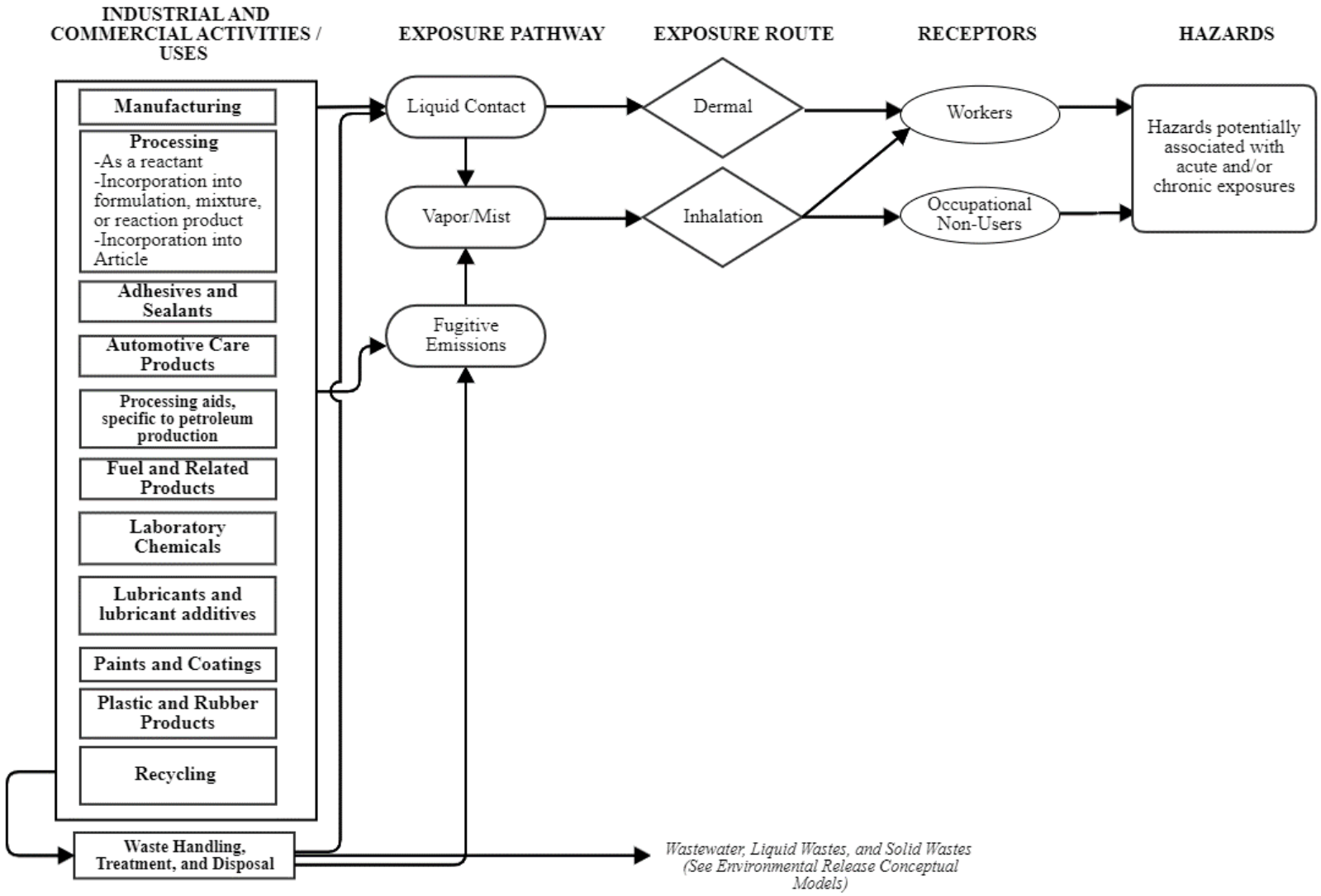


Figure 2-13. 1,3-Butadiene Conceptual Model for Industrial and Commercial Activities and Uses: Worker and ONU Exposures and Hazards

The conceptual model presents the exposure pathways, exposure routes, and hazards to human receptors from industrial and commercial activities and uses of 1,3-butadiene.

2.6.2 Conceptual Model for Consumer Activities and Uses

The conceptual model in Figure 2-14 presents the exposure pathways, exposure routes and hazards to human receptors from consumer activities and uses of 1,3-butadiene. EPA expects inhalation to be the primary route of exposure and plans to evaluate inhalation exposures to 1,3-butadiene vapor for consumers and bystanders during use and disposal of plastics and rubber products. Consumers and bystanders are not expected to have oral or direct dermal contact to 1,3-butadiene. EPA does not plan to evaluate 1,3-butadiene oral or dermal exposures for consumers or bystanders. The supporting rationale for consumer pathways considered for 1,3-butadiene are included in Appendix G.

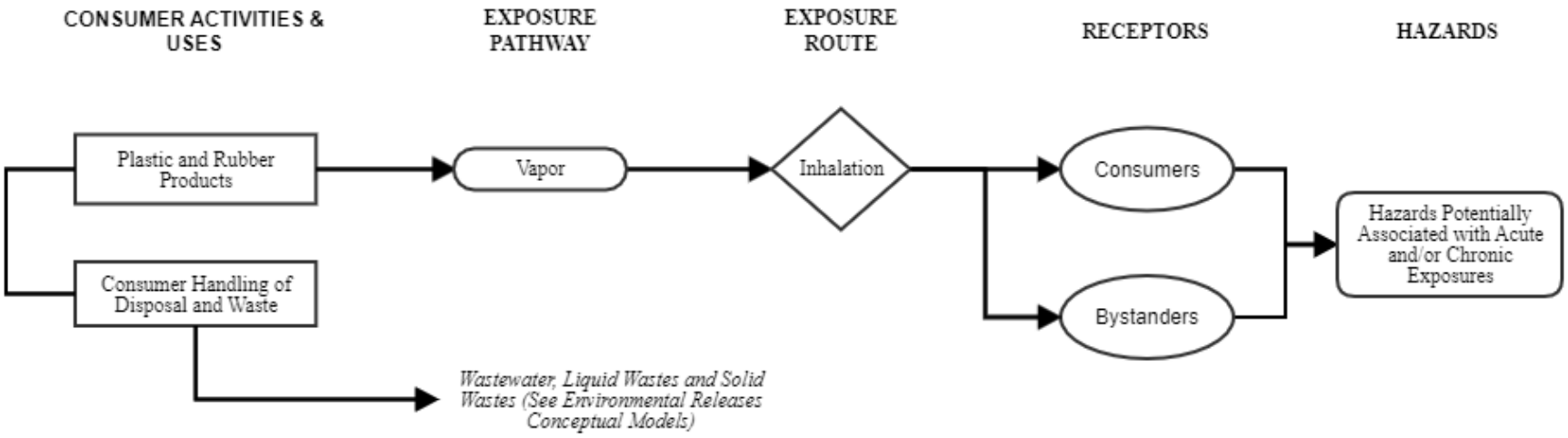


Figure 2-14. 1,3-Butadiene Conceptual Model for Consumer Activities and Uses: Consumer Exposures and Hazards
The conceptual model presents the exposure pathways, exposure routes, and hazards to human receptors from consumer activities and uses of 1,3-butadiene.

2.6.3 Conceptual Models for Environmental Releases and Wastes: Potential Exposures and Hazards (Regulatory Overlay)

In this section, EPA presents the conceptual models describing the identified exposures (pathways and routes from environmental releases and wastes) and hazards to the general population and environmental receptors and hazards associated with the conditions of use of 1,3-butadiene within the scope of the risk evaluation. This section also discusses those pathways that may be addressed pursuant to other EPA-administered laws.

The conceptual model in Figure 2-15 presents the potential exposure pathways, exposure routes and hazards to general population and environmental receptors from releases and waste streams associated with industrial, commercial and consumer uses of 1,3-butadiene. The conceptual model shows the overlays, labeled and shaded to depict the regulatory programs under EPA-administered statutes and associated pathways that EPA considered for the scope of the risk evaluation. The regulatory programs that cover these environmental release and waste pathways are further described in Section 2.6.3.1.

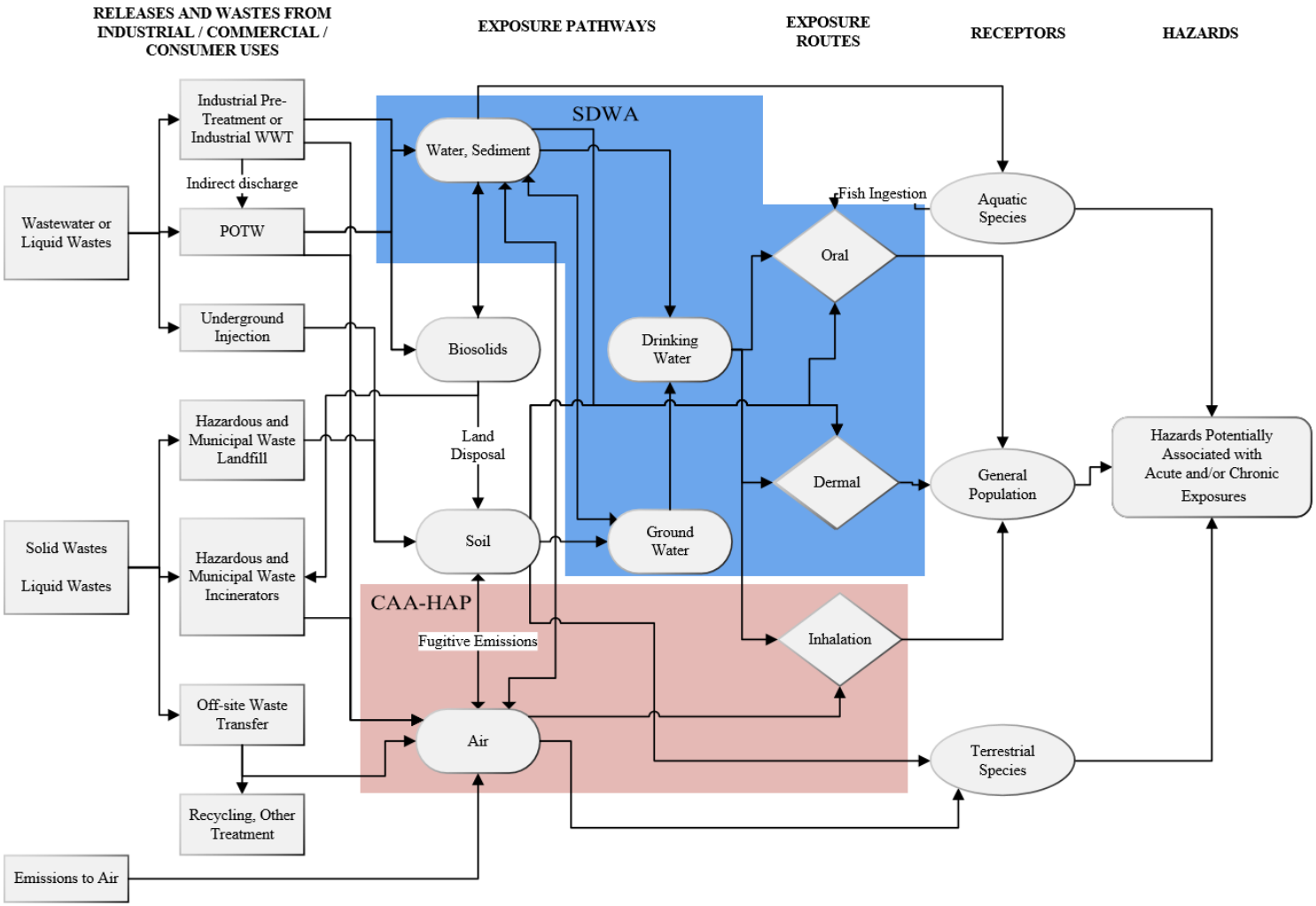


Figure 2-15. 1,3-Butadiene Conceptual Model for Environmental Releases and Wastes: Environmental and General Population Exposures and Hazards (Regulatory Overlay)

The conceptual model presents the exposure pathways, exposure routes and hazards to human receptors from releases and wastes from industrial and commercial uses of 1,3-butadiene showing the environmental statutes covering those pathways.

a) Industrial wastewater or liquid wastes may be treated on-site and then released to surface water (direct discharge), or pre-treated and released to a Publicly Owned Treatment Works (POTW) (indirect discharge). For consumer uses, such wastes may be released directly to POTW. Drinking water will undergo further treatment in drinking water treatment plant. Ground water may also be a source of drinking water.

b) Receptors include PESS (see Section 2.5).

2.6.3.1 Exposure Pathways and Risks Addressed by Other EPA Administered Statutes

In its TSCA Section 6(b) risk evaluations, EPA is coordinating action on certain exposure pathways and risks falling under the jurisdiction of other EPA-administered statutes or regulatory programs. More specifically, EPA is exercising its TSCA authorities to tailor the scope of its risk evaluations, rather than focusing on environmental exposure pathways addressed under other EPA-administered statutes or regulatory programs or risks that could be eliminated or reduced to a sufficient extent by actions taken under other EPA-administered laws. EPA considers this approach to be a reasonable exercise of the Agency's TSCA authorities, which include:

- TSCA Section 6(b)(4)(D): "The Administrator shall, not later than 6 months after the initiation of a risk evaluation, publish the scope of the risk evaluation to be conducted, including the hazards, exposures, conditions of use, and the potentially exposed or susceptible subpopulations the Administrator expects to consider…"
- TSCA Section 9(b)(1): "The Administrator shall coordinate actions taken under this chapter with actions taken under other Federal laws administered in whole or in part by the Administrator. If the Administrator determines that a risk to health or the environment associated with a chemical substance or mixture could be eliminated or reduced to a sufficient extent by actions taken under the authorities contained in such other Federal laws, the Administrator shall use such authorities to protect against such risk unless the Administrator determines, in the Administrator's discretion, that it is in the public interest to protect against such risk by actions taken under this chapter."
- TSCA Section 9(e): "…[I]f the Administrator obtains information related to exposures or releases of a chemical substance or mixture that may be prevented or reduced under another Federal law, including a law not administered by the Administrator, the Administrator shall make such information available to the relevant Federal agency or office of the Environmental Protection Agency."
- TSCA Section 2(c): "It is the intent of Congress that the Administrator shall carry out this chapter in a reasonable and prudent manner, and that the Administrator shall consider the environmental, economic, and social impact of any action the Administrator takes or proposes as provided under this chapter."
- TSCA Section 18(d)(1): "Nothing in this chapter, nor any amendment made by the Frank R. Lautenberg Chemical Safety for the 21st Century Act, nor any rule, standard of performance, risk evaluation, or scientific assessment implemented pursuant to this chapter, shall affect the right of a State or a political subdivision of a State to adopt or enforce any rule, standard of performance, risk evaluation, scientific assessment, or any other protection for public health or the environment that— (i) is adopted or authorized under the authority of any other Federal law or adopted to satisfy or obtain authorization or approval under any other Federal law…"

These TSCA authorities supporting tailored risk evaluations and intra-agency referrals are described in more detail below:

TSCA Section 6(b)(4)(D)

TSCA Section 6(b)(4)(D) requires EPA, in developing the scope of a risk evaluation, to identify the hazards, exposures, conditions of use, and PESS the Agency "expects to consider" in a risk evaluation. This language suggests that EPA is not required to consider all conditions of use, hazards, or exposure pathways in risk evaluations. As EPA explained in the "Procedures for Chemical Risk Evaluation Under the Amended Toxic Substances Control Act" ("Risk Evaluation Rule"), EPA may, on a case-by-case

basis, tailor the scope of the risk evaluation in order to focus its analytical efforts on those exposures that are likely to present the greatest concern, and consequently merit an unreasonable risk determination." 82 FR 33726, 33729 (July 20, 2017).

In the problem formulation documents for many of the first 10 chemicals undergoing risk evaluation, EPA applied the same authority and rationale to certain exposure pathways, explaining that "EPA is planning to exercise its discretion under TSCA 6(b)(4)(D) to focus its analytical efforts on exposures that are likely to present the greatest concern and consequently merit a risk evaluation under TSCA, by excluding, on a case-by-case basis, certain exposure pathways that fall under the jurisdiction of other EPA-administered statutes." This is informed by the legislative history of the amended TSCA, which supports the Agency's exercise of discretion to focus the risk evaluation on areas that raise the greatest potential for risk. See June 7, 2016 Cong. Rec., S3519-S3520. Consistent with the approach articulated in the problem formulation documents, and as described in more detail below, EPA is exercising its authority under TSCA to tailor the scope of exposures evaluated in TSCA risk evaluations, rather than focusing on environmental exposure pathways addressed under other EPA-administered, media-specific statutes and regulatory programs.

TSCA Section 9(b)(1)

In addition to TSCA Section 6(b)(4)(D), the Agency also has discretionary authority under the first sentence of TSCA Section 9(b)(1) to "coordinate actions taken under [TSCA] with actions taken under other Federal laws administered in whole or in part by the Administrator." This broad, freestanding authority provides for intra-agency coordination and cooperation on a range of "actions." In EPA's view, the phrase "actions taken under [TSCA]" in the first sentence of Section 9(b)(1) is reasonably read to encompass more than just risk management actions, and to include actions taken during risk evaluation as well. More specifically, the authority to coordinate intra-agency actions exists regardless of whether the Administrator has first made a definitive finding of risk, formally determined that such risk could be eliminated or reduced to a sufficient extent by actions taken under authorities in other EPA-administered Federal laws, and/or made any associated finding as to whether it is in the public interest to protect against such risk by actions taken under TSCA. TSCA Section 9(b)(1) therefore provides EPA authority to coordinate actions with other EPA offices without ever making a risk finding or following an identification of risk. This includes coordination on tailoring the scope of TSCA risk evaluations to focus on areas of greatest concern rather than exposure pathways addressed by other EPA-administered statutes and regulatory programs, which does not involve a risk determination or public interest finding under TSCA Section 9(b)(2).

In a narrower application of the broad authority provided by the first sentence of TSCA Section 9(b)(1), the remaining provisions of Section 9(b)(1) provide EPA authority to identify risks and refer certain of those risks for action by other EPA offices. Under the second sentence of Section 9(b)(1), "[i]f the Administrator determines that a risk to health or the environment associated with a chemical substance or mixture could be eliminated or reduced to a sufficient extent by actions taken under the authorities contained in such other Federal laws, the Administrator shall use such authorities to protect against such risk unless the Administrator determines, in the Administrator's discretion, that it is in the public interest to protect against such risk by actions taken under [TSCA]." Coordination of intra-agency action on risks under TSCA Section 9(b)(1) therefore entails both an identification of risk, and a referral of any risk that could be eliminated or reduced to a sufficient extent under other EPA-administered laws to the EPA office(s) responsible for implementing those laws (absent a finding that it is in the public interest to protect against the risk by actions taken under TSCA).

Risk may be identified by OPPT or another EPA office, and the form of the identification may vary. For instance, OPPT may find that one or more conditions of use for a chemical substance present(s) a risk to human or ecological receptors through specific exposure routes and/or pathways. This could involve a quantitative or qualitative assessment of risk based on reasonably available information (which might include, *e.g.*, findings or statements by other EPA offices or other federal agencies). Alternatively, risk could be identified by another EPA office. For example, another EPA office administering non-TSCA authorities may have sufficient monitoring or modeling data to indicate that a particular condition of use presents risk to certain human or ecological receptors, based on expected hazards and exposures. This risk finding could be informed by information made available to the relevant office under TSCA Section 9(e), which supports cooperative actions through coordinated information-sharing.

Following an identification of risk, EPA would determine if that risk could be eliminated or reduced to a sufficient extent by actions taken under authorities in other EPA-administered laws. If so, TSCA requires EPA to "use such authorities to protect against such risk," unless EPA determines that it is in the public interest to protect against that risk by actions taken under TSCA. In some instances, EPA may find that a risk could be sufficiently reduced or eliminated by future action taken under non-TSCA authority. This might include, *e.g.*, action taken under the authority of the Safe Drinking Water Act (SDWA) to address risk to the general population from a chemical substance in drinking water, particularly if the Office of Water has taken preliminary steps such as listing the subject chemical substance on the Contaminant Candidate List (CCL). This sort of risk finding and referral could occur during the risk evaluation process, thereby enabling EPA to use more a relevant and appropriate authority administered by another EPA office to protect against hazards or exposures to affected receptors.

Legislative history on TSCA Section 9(b)(1) supports both broad coordination on current intra-agency actions, and narrower coordination when risk is identified and referred to another EPA office for action. A Conference Report from the time of TSCA's passage explained that Section 9 is intended "to assure that overlapping or duplicative regulation is avoided while attempting to provide for the greatest possible measure of protection to health and the environment." S. Rep. No. 94-1302 at 84. See also H. Rep. No. 114-176 at 28 (stating that the 2016 TSCA amendments "reinforce TSCA's original purpose of filling gaps in Federal law," and citing new language in Section 9(b)(2) intended "to focus the Administrator's exercise of discretion regarding which statute to apply and to encourage decisions that avoid confusion, complication, and duplication"). Exercising TSCA Section 9(b)(1) authority to coordinate on tailoring TSCA risk evaluations is consistent with this expression of Congressional intent.

Legislative history also supports a reading of Section 9(b)(1) under which EPA coordinates intra-agency action, including information-sharing under TSCA Section 9(e), and the appropriately positioned EPA office is responsible for the identification of risk and actions to protect against such risks. See, *e.g.*, Senate Report 114-67, 2016 Cong. Rec. S3522 (under TSCA Section 9, "if the Administrator finds that disposal of a chemical substance may pose risks that could be prevented or reduced under the Solid Waste Disposal Act, the Administrator should ensure that the relevant office of EPA receives that information"); H. Rep. No. 114-176 at 28, 2016 Cong. Rec. S3522 (under Section 9, "if the Administrator determines that a risk to health or the environment associated with disposal of a chemical substance could be eliminated or reduced to a sufficient extent under the Solid Waste Disposal Act, the Administrator should use those authorities to protect against the risk"). Legislative history on Section 9(b)(1) therefore supports coordination with and referral of action to other EPA offices, especially when statutes and associated regulatory programs administered by those offices could address exposure

pathways or risks associated with conditions of use, hazards, and/or exposure pathways that may otherwise be within the scope of TSCA risk evaluations.

TSCA Sections 2(c) and 18(d)

Finally, TSCA Section 2(c) supports coordinated action on exposure pathways and risks addressed by other EPA-administered statutes and regulatory programs. Section 2(c) directs EPA to carry out TSCA in a "reasonable and prudent manner" and to consider "the environmental, economic, and social impact" of its actions under TSCA. Legislative history from around the time of TSCA's passage indicates that Congress intended EPA to consider the context and take into account the impacts of each action under TSCA. S. Rep. No. 94-698 at 14 ("the intent of Congress as stated in this subsection should guide each action the Administrator takes under other sections of the bill").

Section 18(d)(1) specifies that state actions adopted or authorized under any Federal law are not preempted by an order of no unreasonable risk issued pursuant to TSCA Section 6(i)(1) or a rule to address unreasonable risk issued under TSCA Section 6(a). Thus, even if a risk evaluation were to address exposures or risks that are otherwise addressed by other federal laws and, for example, implemented by states, the state laws implementing those federal requirements would not be preempted. In such a case, both the other federal and state laws, as well as any TSCA Section 6(i)(1) order or TSCA Section 6(a) rule, would apply to the same issue area. See also TSCA Section 18(d)(1)(A)(iii). In legislative history on amended TSCA pertaining to Section 18(d), Congress opined that "[t]his approach is appropriate for the considerable body of law regulating chemical releases to the environment, such as air and water quality, where the states have traditionally had a significant regulatory role and often have a uniquely local concern." Sen. Rep. 114-67 at 26.

EPA's careful consideration of whether other EPA-administered authorities are available, and more appropriate, for addressing certain exposures and risks is consistent with this Congress' intent to maintain existing federal requirements and the state actions adopted to locally and more specifically implement those federal requirements, and to carry out TSCA in a reasonable and prudent manner. EPA believes it is both reasonable and prudent to tailor TSCA risk evaluations, rather than attempt to evaluate and regulate potential exposures and risks from those media under TSCA. This approach furthers Congressional direction and EPA aims to efficiently use Agency resources, avoid duplicating efforts taken pursuant to other Agency programs, and meet the statutory deadline for completing risk evaluations.

EPA-administered statutes and regulatory programs that address specific exposure pathways and/or risks are listed as follows:

<u>Ambient Air Pathway</u>
The Clean Air Act (CAA) contains a list of hazardous air pollutants (HAP) and provides EPA with the authority to add to that list pollutants that present, or may present, a threat of adverse human health effects or adverse environmental effects. For stationary source categories emitting HAPs, the CAA requires issuance of technology-based standards and, if necessary, additions or revisions to address developments in practices, processes, and control technologies, and to ensure the standards adequately protect public health and the environment. The CAA thereby provides EPA with comprehensive authority to regulate emissions to ambient air of any hazardous air pollutant. 1,3-Butadiene is a HAP. See 42 U.S.C. 7412. This regulatory coverage is represented by the red shading in Figure 2-15. EPA has issued a number of technology-based standards for source categories that emit 1,3-butadiene to ambient

air and, as appropriate, has reviewed or is in the process of reviewing remaining risks. See 40 CFR part 63.

Emission pathways to ambient air from commercial and industrial stationary sources and associated inhalation exposure of the general population or terrestrial species in this TSCA evaluation from stationary source releases of 1,3-butadiene to ambient air are covered under the jurisdiction of the CAA. EPA's Office of Air and Radiation and Office of Pollution Prevention and Toxics will continue to work together to exchange information related to toxicity and occurrence data on chemicals undergoing risk evaluation under TSCA. As such, EPA does not plan to evaluate exposures to the general population from ambient air in the risk evaluation under TSCA. This regulatory coverage is represented by the red shading in Figure 2-15.

Drinking Water Pathway

EPA has regular analytical processes to identify and evaluate drinking water contaminants of potential regulatory concern for public water systems under the SDWA. In addition, the SDWA requires EPA to review and revise "as appropriate" existing drinking water regulations every 6 years.

The Contaminant Candidate List (CCL) is a list of unregulated contaminants that are known or anticipated to occur in public water systems and that may require regulation under SDWA. EPA must publish a CCL every 5 years and make Regulatory Determinations to regulate (or not) at least five CCL contaminants every 5 years. To regulate a contaminant, EPA must conclude the contaminant may have adverse health effects, occurs or is substantially likely to occur in public water systems at a level of concern and that regulation, in the sole judgement of the Administrator, presents a meaningful opportunity for health risk reduction.

Once contaminants have been placed on the CCL, EPA identifies if there are any additional data needs, including gaps in occurrence data for evaluation under the Regulatory Determination; if sufficient occurrence data is lacking, the contaminant may be considered for monitoring under the Unregulated Contaminant Monitoring Rule.

Currently, EPA is evaluating 1,3-butadiene through the SDWA statutory processes for developing a National Primary Drinking Water regulation. 1,3-Butadiene is currently one of 109 contaminants listed on EPA's Fourth Contaminant Candidate List (CCL 4), see 81 FR 81099, and was subject to occurrence monitoring in public water systems under the third Unregulated Contaminants Monitoring Rule (UMCR 3), see 77 FR 26072. Under UCMR 3, water systems were monitored for 1,3-butadiene during 2013-2015. Of the 4,916 water systems monitored, 2 systems had detections of 1,3-butadiene in at least one sample.

In February 2020, EPA published a Preliminary Regulatory Determinations for Contaminants on the Fourth Drinking Water Contaminant Candidate List, see 85 FR 14098. The Agency did not make a preliminary determination for 1,3-butadiene because the Agency has not determined whether there is a meaningful opportunity for public health risk reduction. EPA will continue to evaluate 1,3-butadiene prior to making a regulatory determination. The Regulatory Determination 4 Support Document (USEPA, 2019a) and the Occurrence Data from the Third Unregulated Contaminant Monitoring Rule (UCMR 3) (USEPA, 2019b) present additional information and analyses supporting the Agency's evaluation of 1,3-butadiene.

EPA is coordinating actions for the purposes of TSCA Section 9(b). As announced February 20, 2020 in the Preliminary Regulatory Determinations for Contaminants on the Fourth Drinking Water Contaminant Candidate List; 1,3 – butadiene is occurring in finished drinking water but there is no health assessment. EPA continues to evaluate whether there is a meaningful opportunity to reduce health risk for persons served by public water systems from 1,3-butadiene.[8] OCSPP has coordinated with the Office of Water regarding 1,3-butadiene contamination in drinking water. EPA will continue to evaluate 1,3-butadiene through the SDWA on whether there is a meaningful opportunity to reduce health risk for persons served by public water systems. As described above, EPA has regular analytical processes to identify and evaluate drinking water contaminants of potential regulatory concern for public water systems under the SDWA. OW evaluates the regulatory determination criteria under SDWA Section 1412(b)(1)(A) to determine whether or not to initiate the development of a National Primary Drinking Water Regulation. EPA promulgates National Primary Drinking Water Regulations (NPDWRs) under SDWA when the Agency concludes a contaminant may have adverse health effects, occurs or is substantially likely to occur in public water systems at a level of concern and that regulation, in the sole judgement of the Administrator, presents a meaningful opportunity for health risk reduction. For each contaminant with NPDWRs, EPA sets an enforceable Maximum Contaminant Level (MCL) as close as feasible to a health based, non-enforceable Maximum Contaminant Level Goals (MCLG). Feasibility refers to both the ability to treat water to meet the MCL and the ability to monitor water quality at the MCL, SDWA Section 1412(b)(4)(D), and public water systems are required to monitor for the regulated chemical based on a standardized monitoring schedule to ensure compliance with the maximum contaminant level (MCL). Under SDWA, EPA must also review existing drinking water regulations every 6 years, and if appropriate, revise them. SDWA, originally passed by Congress in 1974, thereby is the main federal statute to protect public health by regulating the nation's public drinking water supply and authorizing EPA to set national health-based standards and take other actions to protect against contaminants that may be found in drinking water.

EPA will continue to evaluate 1,3-butadiene under SDWA authorities to determine whether or not to regulate 1,3-butadiene in drinking water from drinking water contaminated by 1,3-butadiene as part of this risk evaluation, the information produced in the risk evaluation process will be considered by the Office of Water as part of the current SDWA actions.

As such, EPA does not plan to evaluate exposures to the general population from drinking water exposure in the risk evaluation. This regulatory coverage is represented by the dark blue shading in Figure 2-15.

Onsite Releases to Land Pathway

The Comprehensive Environmental Response, Compensation, and Liability Act, otherwise known as CERCLA, provides broad authority under the statute (generally referred to as Superfund) to clean up uncontrolled or abandoned hazardous-waste sites as well as accidents, spills, and other releases of hazardous substances, pollutants and contaminants into the environment. Through CERCLA, EPA was given authority to seek out those parties potentially responsible for the release of hazardous substances

[8] EPA does not find that the science standards of TSCA Section 26(h) and (i) apply to this finding of risk, the Agency's determination that the risk could be eliminated or reduced to a sufficient extent by action under the CAA, or the corresponding tailoring of this risk evaluation. TSCA Sections 26(h) and (i) are triggered by EPA "decisions" made under TSCA Sections 4, 5, and 6, and the risk finding and associated determination described herein are both made pursuant to TSCA Section 9. Neither the finding of risk nor the subsequent determination implements TSCA Section 6. EPA will take appropriate action under the SDWA in lieu of TSCA (absent a public interest finding described in TSCA Section 9(b), which EPA did not make). Thus, TSCA itself compels EPA to narrow the scope of the risk evaluation following the Agency's Section 9(b)(1) determination, and there is no separate EPA "decision" subject to TSCA Sections 26(h) and (i).

and either have them clean up the release or compensate the Federal government for undertaking the response action.

CERCLA Section 101(14) defines "hazardous substance" by referencing other environmental statutes, including toxic pollutants listed under CWA Section 307(a); hazardous substances designated pursuant to CWA Section 311(b)(2)(A); hazardous air pollutants listed under CAA Section 112; imminently hazardous substances with respect to which EPA has taken action pursuant to TSCA Section 7; and hazardous wastes having characteristics identified under or listed pursuant to RCRA Section 3001. See 40 CFR 302.4. CERCLA Section 102(a) also authorizes EPA to promulgate regulations designating as hazardous substances those 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.

1,3-Butadiene is a hazardous substance under CERCLA. Releases of 1,3-butadiene in excess of 10 lbs within a 24-hour period must be reported (40 CFR 302.4, 302.6). The scope of this EPA TSCA risk evaluation does not include on-site releases to the environment of 1,3-butadiene at Superfund sites and subsequent exposure of the general population or non-human species.

2.6.3.2 Conceptual Model for Environmental Releases and Wastes: Potential Exposures and Hazards

As described in Section 2.6.3.1, some pathways in the conceptual models are covered under the jurisdiction of other environmental statutes administered by EPA. The conceptual model depicted in Figure 2-16 presents the exposure pathways, exposure routes and hazards to general population and environmental receptors from releases and wastes from industrial and commercial uses of 1,3-butadiene that EPA plans to evaluate.

The diagram shown in Figure 2-16 includes releases from industrial, commercial and/or consumer uses to water/sediment, biosolids and soil via direct and indirect discharges to water, that may lead to exposure to aquatic receptors, and to general population, aquatic species that may occur from industrial and/or commercial and consumer releases to water/sediment; biosolids and soil. Some aquatic species may be exposed to 1,3-butadiene in water bodies in which 1,3-butadiene is found. The general population may be exposed to 1,3-butadiene via fish consumption and may have dermal and oral exposures to 1,3-butadiene through ambient water. The supporting basis for general population and environmental pathways that were considered for 1,3-butadiene are included in Appendix H.

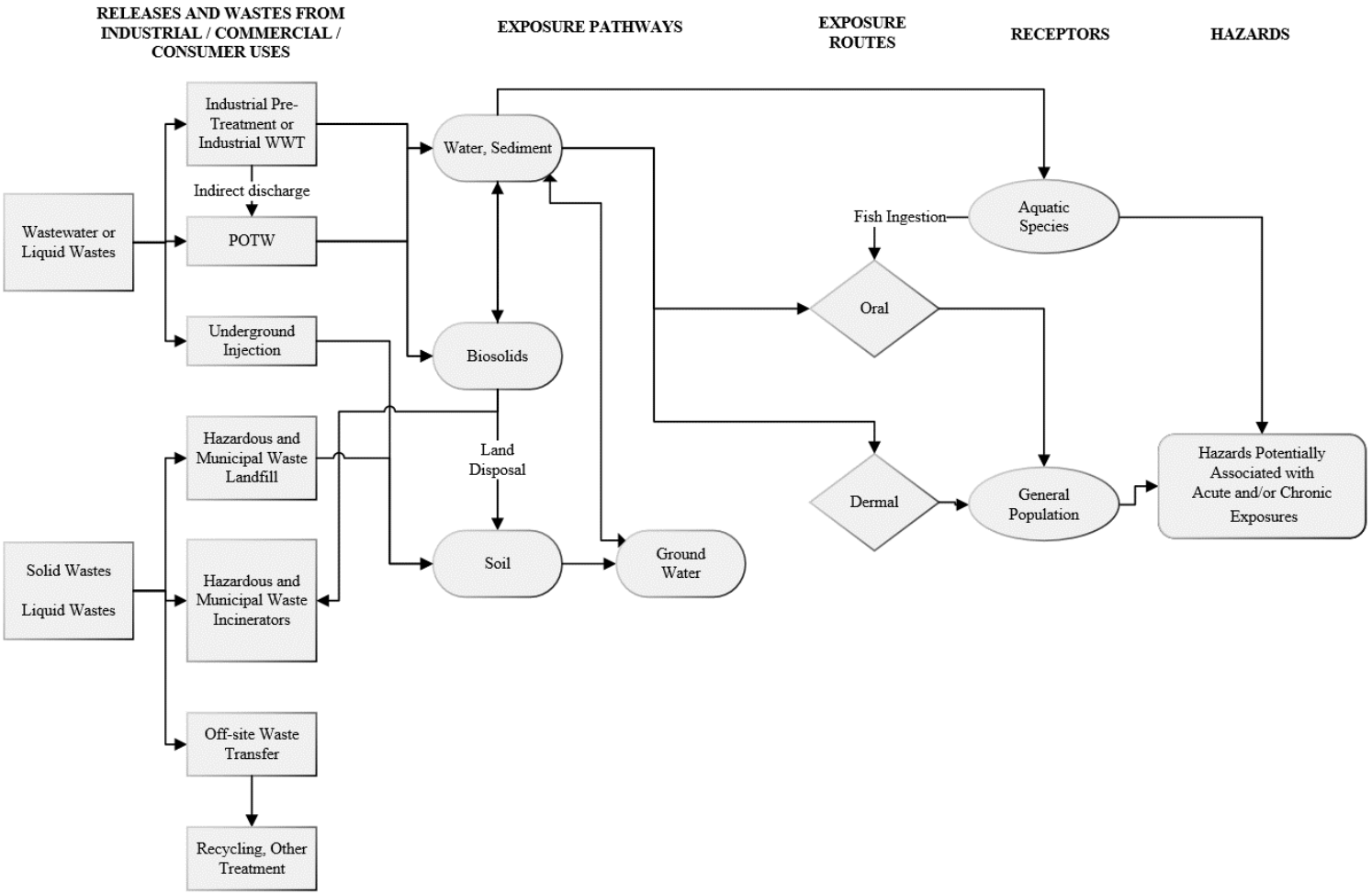


Figure 2-16. 1,3-Butadiene Conceptual Model for Environmental Releases and Wastes: Environmental and General Population Exposures and Hazards

The conceptual model presents the exposure pathways, exposure routes and hazards to human and environmental receptors from releases and wastes from industrial commercial, and consumer uses of 1,3-butadiene that EPA plans to consider in the risk evaluation.

a) Industrial wastewater or liquid wastes may be treated on-site and then released to surface water (direct discharge), or pre-treated and released to POTW (indirect discharge). For consumer uses, such wastes may be released directly to POTW. Drinking water will undergo further treatment in drinking water treatment plant. Ground water may also be a source of drinking water.
b) Receptors include PESS (see Section 2.5).

2.7 Analysis Plan

The analysis plan is based on EPA's knowledge of 1,3-butadiene resulting from the full-text screening of reasonably available information as described in Section 2.1. EPA encourages submission of additional existing data, such as full study reports or workplace monitoring from industry sources that may be relevant to EPA's evaluation of conditions of use, exposures, hazards and PESS during risk evaluation. As discussed in the *Application of Systematic Review in TSCA Risk Evaluations* document (U.S. EPA, 2018), targeted supplemental searches during the analysis phase may be necessary to identify additional information (*e.g.,* commercial mixtures) for the risk evaluation of 1,3-butadiene. For any additional data needs identified during the risk evaluation, EPA may use the Agency's TSCA authorities under Sections 4, 8 or 11, as appropriate.

2.7.1 Physical and Chemical Properties and Environmental Fate

EPA plans to analyze the physical and chemical properties and environmental fate and transport of 1,3-butadiene as follows:

1) **Review reasonably available measured or estimated physical and chemical and environmental fate endpoint data collected using systematic review procedures and, where reasonably available, environmental assessments conducted by other regulatory agencies.** EPA plans to evaluate data and information collected through the systematic review methods and public comments about the physical and chemical properties (Appendix B) and fate endpoints (Appendix B), some of which appeared in the *Proposed Designation of 1,3-Butadiene (CASRN 106-99-0) as a High-Priority Substance for Risk Evaluation* (U.S. EPA, 2019d). All sources cited in EPA's analysis will be evaluated according to the procedures and metrics described in the *Application of Systematic Review in TSCA Risk Evaluations* (U.S. EPA, 2018). Where the systematic review process does not identify experimentally measured chemical property values of sufficiently high quality, testing will be requested under TSCA Section 4 authority, or values will be estimated using chemical parameter estimation models as appropriate. Model-estimated fate properties will be reviewed for applicability and quality.

2) **Using measured data and/or modeling, determine the influence of physical and chemical properties and environmental fate endpoints (*e.g.*, persistence, bioaccumulation, partitioning, transport) on exposure pathways and routes of exposure to human and environmental receptors.**
EPA plans to use measured data and, where necessary, model predictions of physical and chemical properties and environmental fate endpoints to characterize the persistence and movement of 1,3-butadiene within and across environmental media. The physical and chemical and fate properties to be assessed are listed in Appendix B and Appendix B, respectively. Given preliminary findings for physical and chemical property, and fate data, EPA believes it is unlikely that 1,3-butadiene will sorb to biosolids due to its volatility (vapor pressure and Henry's Law Constant), water solubility and unlikely sorption to sludge (Log Koc). However, no assessment pathway will be removed until the full systematic review of available literature is complete. EPA plans to use physical and chemical and fate endpoints in exposure calculations.

3) **Conduct a weight of the scientific evidence evaluation of physical and chemical and environmental fate data, including qualitative and quantitative sources of information.** During risk evaluation, EPA plans to evaluate and integrate the environmental fate evidence identified in the literature inventory using the methods described in the *Application of Systematic Review in TSCA Risk Evaluations* (U.S. EPA, 2018).

2.7.2 Exposure

EPA plans to analyze exposure levels for indoor air, surface water, sediment, soil, and aquatic biota associated with exposure to 1,3-butadiene. Based on its physical and chemical properties, expected sources, and transport and transformation within the outdoor and indoor environment, 1,3-butadiene is more likely to be present in some of these media and less likely to be present in others. EPA has not yet determined the exposure levels in these media. Exposure level(s) can be characterized through a combination of reasonably available monitoring data and estimated exposure levels from modeling approaches. Exposure scenarios include sources (uses), exposure pathways, and exposed receptors. Draft exposure scenarios corresponding to various conditions of use for 1,3-butadiene are presented in Appendix F, Appendix G and Appendix H. EPA plans to analyze scenario-specific exposures.

2.7.2.1 Environmental Releases

EPA plans to analyze releases to environmental media as follows:

1) **Review reasonably available published literature and other reasonably available information on processes and activities associated with the conditions of use to analyze the types of releases and wastes generated.**
   EPA has reviewed some key data sources containing information on processes and activities resulting in releases, and the information found is described in Appendix E. EPA plans to continue to review data sources identified. Potential sources of environmental release data are summarized in Table 2-6 below:

   Table 2-6. Potential Categories and Sources of Environmental Release Data

U.S. EPA TRI Data
U.S. EPA Generic Scenarios
OECD Emission Scenario Documents
EU Risk Assessment Reports
Discharge Monitoring Report (DMR) surface water discharge data for 1,3-butadiene from NPDES-permitted facilities

2) **Review reasonably available chemical-specific release data, including measured or estimated release data (*e.g.*, data from risk assessments by other environmental agencies).**
   EPA has reviewed key release data sources including the Toxics Release Inventory (TRI), and the data from this source is summarized in Section 2.3.3. EPA plans to continue to consider additional reasonably available information and will evaluate it during development of the risk evaluation. EPA plans to continue to review relevant data sources during risk evaluation. EPA plans to continue to consider additional reasonably available information and will evaluate it during development of the risk evaluation. EPA plans to match identified data to applicable conditions of use and identify data gaps where no data are found for particular conditions of use. EPA plans to attempt to address data gaps identified as described in steps 3 and 4 below by considering potential surrogate data and models.

   Additionally, for conditions of use where no measured data on releases are reasonably available, EPA may use a variety of methods including release estimation approaches and assumptions in the Chemical Screening Tool for Exposures and Environmental Releases(ChemSTEER) (U.S. EPA, 2015a).

3) **Review reasonably available measured or estimated release data for surrogate chemicals that have similar uses and physical properties.**
EPA plans to review literature sources identified and if surrogate data are found, these data will be matched to applicable conditions of use for potentially filling data gaps.

4) **Review reasonably available data that may be used in developing, adapting or applying exposure models to the particular risk evaluation.**
This item will be performed after completion of #2 and #3 above. EPA plans to evaluate relevant data to determine whether the data can be used to develop, adapt, or apply models for specific conditions of use (and corresponding release scenarios). EPA has identified information from various EPA statutes and sources (including, for example, regulatory limits, reporting thresholds or disposal requirements) that may be relevant to consider for release estimation and environmental response. EPA plans to further consider relevant regulatory requirements in estimating releases during risk evaluation.

5) **Review and determine applicability of OECD Emission Scenario Documents (ESDs) and EPA Generic Scenarios to estimation of environmental releases.**
EPA has identified potentially relevant OECD Emission Scenario Documents (ESDs) and EPA Generic Scenarios (GS) that correspond to some conditions of use; for example, the 2009 ESD on Plastics Additives (OECD, 2009), the 2004 ESD on Additives in the Rubber Industry (OECD, 2004), the 2011 ESD on the Chemical Industry (OECD, 2011), and the 1991 Petroleum Refining Processing, Crude Separation Process, and Catalytic Cracking GS (U.S. EPA, 1991), may be useful to assess potential releases. EPA plans to critically review these generic scenarios and ESDs to determine their applicability to the conditions of use.

   EPA Generic Scenarios are available at the following: https://www.epa.gov/tsca-screening-tools/chemsteer-chemical-screening-tool-exposures-and-environmental-releases

   OECD Emission Scenario Documents are available at the following: http://www.oecd.org/chemicalsafety/risk-assessment/emissionscenariodocuments.htm

   If ESDs and GSs are not available, other methods may be considered. EPA may perform additional supplemental targeted searches of peer-reviewed or gray literature to understand those conditions of use which may inform identification of release scenarios. EPA may also need to perform supplemental targeted searches for applicable models and associated parameters that EPA may use to estimate releases for certain conditions of use. Additionally, for conditions of use where no measured data on releases are available, EPA may use a variety of methods including the application of default assumptions such as standard loss fractions associated with drum cleaning (3%) or single process vessel cleanout (1%).

6) **Map or group each condition of use to a release assessment scenario(s).**
EPA has completed an initial mapping of release scenarios to relevant conditions of use as shown in Appendix F. EPA plans to refine the mapping of release scenarios based on factors (*e.g.*, process equipment and handling, magnitude of production volume used, and release sources and usage rates of 1,3-butadiene and polymer products and formulations containing 1,3-butadiene) corresponding to conditions of use using reasonably available information. EPA may perform supplemental targeted searches of peer-reviewed or gray literature to better understand certain conditions of use to further develop release scenarios.

7) **Evaluate the weight of the scientific evidence of environmental release data.**
During risk evaluation, EPA plans to evaluate and integrate the exposure evidence identified in the literature inventory using the methods described in the *Application of Systematic Review in TSCA Risk Evaluation* (U.S. EPA, 2018). EPA plans to integrate the data using systematic review methods to assemble the relevant data, evaluate the data for quality and relevance, including strengths and limitations, followed by synthesis and integration of the evidence.

2.7.2.2 Environmental Exposures

EPA plans to analyze the following in developing its environmental exposure assessment of 1,3-butadiene:

1) **Review reasonably available environmental and biological monitoring data for all media relevant to environmental exposure.**
For 1,3-butadiene, environmental media which EPA plans to analyze are biosolids, sediment, soil, and surface water. EPA believes it is unlikely that 1,3-butadiene will sorb to biosolids due to its volatility (vapor pressure and Henry's Law Constant), water solubility and unlikely sorption to sludge (Log Koc). This pathway will not be ruled out until further evaluation.

2) **Review reasonably available information on releases to determine how modeled estimates of concentrations near industrial point sources compare with reasonably available monitoring data.**
EPA plans to analyze and consider reasonably available environmental exposure models that meet the scientific standards under TSCA Section 26(h) and that estimate water, sediment, soil and biosolids concentrations alongside reasonably available water, sediment, and soil monitoring data to characterize environmental exposures. Modeling approaches to estimate surface water concentrations, sediment concentrations, and soil concentrations may include the following inputs: direct release into water, sediment, or soil, indirect release into water, sediment, or soil *(i.e.*, air deposition), fate and transport (partitioning within media) and characteristics of the environment (*e.g.*, river flow, volume of lake, meteorological data).

3) **Determine applicability of existing additional contextualizing information for any monitored data or modeled estimates during risk evaluation.**
There have been changes to use patterns of 1,3-butadiene over the last few years. Review and characterize monitoring data or modeled estimates to determine how representative they are of applicable use patterns.

   Any studies which relate levels of 1,3-butadiene in the environment or biota with specific sources or groups of sources will be evaluated.

4) **Group each condition(s) of use to environmental assessment scenario(s).**
EPA plans to refine and finalize exposure scenarios for environmental receptors by considering sources (use descriptors), exposure pathways including routes, and populations exposed. For 1,3-butadiene, the following are noteworthy considerations in constructing exposure scenarios for environmental receptors:

   - Estimates of surface water concentrations, sediment concentrations, soil concentrations and biosolids concentrations near industrial point sources based on reasonably available monitoring data.

- Review and characterize the following modeling inputs: release into the media of interest, fate and transport and characteristics of the environment.
- Reasonably available biomonitoring data. Monitoring data could be used to compare with species or taxa-specific toxicological benchmarks.
- Applicability of existing contextualizing information for any monitored data or modeled estimates during risk evaluation. Review and characterize the spatial and temporal variability, to the extent that data are reasonably available, and characterize exposed aquatic populations.
- Weight of the scientific evidence of environmental occurrence data and modeled estimates.

5) **Evaluate the weight of the scientific evidence of environmental occurrence data and modeled estimates.**
During risk evaluation, EPA plans to evaluate and integrate the exposure evidence identified in the literature inventory using the methods described in the *Application of Systematic Review in TSCA Risk Evaluation* (U.S. EPA, 2018).

2.7.2.3 Occupational Exposures

EPA plans to analyze both worker and ONU exposures as follows:

1) **Review reasonably available exposure monitoring data for specific condition(s) of use.**
EPA plans to review exposure data including workplace monitoring data collected by government agencies such as the OSHA and the NIOSH, and monitoring data found in published literature. These workplace monitoring data include personal exposure monitoring data (direct exposures) and area monitoring data (indirect exposures).

   OSHA has established a permissible exposure limit (PEL) for 1,3-butadiene of 1 ppm 8-hour time-weighted average (TWA). The OSHA Short-Term Exposure Limit (STEL) for 1,3-butadiene is 5 ppm (OSHA, 2019). EPA plans to consider the influence of these regulatory limits on occupational exposures in the occupational exposure assessment. The following are some data sources identified thus far:

Table 2-7. Potential Sources of Occupational Exposure Data

2012 ATSDR Toxicological Profile for 1,3-Butadiene
U.S. OSHA Chemical Exposure Health Data (CEHD) program data
U.S. NIOSH Health Hazard Evaluation (HHE) Program reports

2) **Review reasonably available exposure data for surrogate chemicals that have uses, volatility and physical and chemical properties similar to 1,3-butadiene.**
EPA plans to review literature sources identified and if surrogate data are found, these data will be matched to applicable conditions of use for potentially filling data gaps.

3) **For conditions of use where data are limited or not reasonably available, review existing exposure models that may be applicable in estimating exposure levels.**
EPA has identified potentially relevant OECD ESDs and EPA GS corresponding to some conditions of use. For example, 2009 ESD on Plastics Additives (OECD, 2009), the 2004 ESD on Additives in the Rubber Industry (OECD, 2004), the 2011 ESD on the Chemical Industry (OECD, 2011), and the 1991 Petroleum Refining Processing, Crude Separation Process, and Catalytic Cracking GS (U.S. EPA, 1991) are some of the ESDs and GS's that EPA may use to

estimate occupational exposures. EPA plans to critically review these generic scenarios and ESDs to determine their applicability to the conditions of use. EPA was not able to identify ESDs or GS's corresponding to some conditions of use, including use of 1,3-butadiene in automotive care products and recycling of 1,3-butadiene. EPA may conduct industry outreach or perform supplemental targeted searches of peer-reviewed or gray literature to understand those conditions of use, which may inform identification of exposure scenarios. EPA may also need to perform targeted supplemental searches to identify applicable models that EPA may use to estimate exposures for certain conditions of use.

4) **Review reasonably available data that may be used in developing, adapting or applying exposure models to a particular risk evaluation scenario.**
This step will be performed after #2 and #3 are completed, and based on information developed during #2 and #3, EPA plans to evaluate relevant data to determine whether the data can be used to develop, adapt, or apply models for specific conditions of use (and corresponding exposure scenarios). EPA may utilize existing, peer-reviewed exposure models developed by EPA or other government agencies, or reasonably available in the scientific literature, or EPA may elect to develop additional models to assess specific condition(s) of use. Inhalation exposure models may be simple box models or two-zone (near-field/far-field) models. In two-zone models, the near-field exposure represents potential inhalation exposures to workers, and the far-field exposure represents potential inhalation exposures to ONUs.

5) **Consider and incorporate applicable EC and/or PPE into exposure scenarios.**
EPA plans to review potentially relevant data sources on EC and PPE to determine their applicability and incorporation into exposure scenarios during risk evaluation. OSHA recommends employers utilize the hierarchy of controls to address hazardous exposures in the workplace. The hierarchy of controls strategy outlines, in descending order of priority, the use of elimination, substitution, engineering controls, administrative controls, and lastly personal protective equipment (PPE). EPA plans to assess worker exposure pre- and post-implementation of EC, using reasonably available information on available control technologies and control effectiveness. For example, EPA may assess worker exposure in industrial use scenarios before and after implementation of local exhaust ventilation.

6) **Map or group each condition of use to occupational exposure assessment scenario(s).**
EPA has identified occupational exposure scenarios and mapped them to relevant conditions of use (see Appendix F). As presented in the fourth column in Table_Apx F-1, EPA has completed an initial mapping of exposure scenarios to conditions of use. EPA plans to refine mapping or grouping of occupational exposure scenarios based on factors (*e.g.*, process equipment and handling, magnitude of production volume used, and exposure/release sources) corresponding to conditions of use as additional information is identified. EPA may perform supplemental targeted searches of peer-reviewed or gray literature to better understand certain conditions of use to further develop exposure scenarios.

7) **Evaluate the weight of the scientific evidence of occupational exposure data, which may include qualitative and quantitative sources of information.**
During risk evaluation, EPA plans to evaluate and integrate the exposure evidence identified in the literature inventory using the methods described in the *Application of Systematic Review in TSCA Risk Evaluation* (U.S. EPA, 2018). EPA plans to rely on the weight of the scientific evidence when evaluating and integrating occupational data. EPA plans to integrate the data

using systematic review methods to assemble the relevant data, evaluate the data for quality and relevance, including strengths and limitations, followed by synthesis and integration of the evidence.

2.7.2.4 Consumer Exposures

EPA plans to analyze both consumers using a consumer product and bystanders associated with the consumer using the product as follows:

1) **Group each condition of use to consumer exposure assessment scenario(s).**
   Refine and finalize exposure scenarios for consumers by considering combinations of sources (ongoing consumer uses), exposure pathways including routes, and exposed populations.

   For 1,3-butadiene, the following are noteworthy considerations in constructing consumer exposure scenarios:

   - Conditions of use
   - Duration, frequency and magnitude of exposure
   - Weight fraction of chemical in products
   - Amount of chemical used

2) **Evaluate the relative potential of indoor exposure pathways based on reasonably available data.**
   Based on the physical and chemical properties of 1,3-butadiene and the consumer uses identified, inhalation of vapors is expected to be an important indoor exposure pathway for consumers. EPA plans to review all reasonably available information in developing the consumer exposure scenarios and evaluating the exposure pathways in indoor environments.

3) **Review existing indoor exposure models that may be applicable in estimating indoor air exposures.**
   Indoor exposure models that estimate emissions from use of consumer products are available. These models generally consider physical and chemical properties (*e.g.*, vapor pressure, molecular weight), product specific properties (*e.g.*, weight fraction of the chemical in the product), use patterns (*e.g.*, duration and frequency of use), user environment (*e.g.*, room of use, ventilation rates), and receptor characteristics (*e.g.*, exposure factors, activity patterns). The OPPT's Consumer Exposure Model (CEM) and other similar models can be used to estimate indoor air exposures from consumer products.

4) **Review reasonably available empirical data that may be used in developing, adapting or applying exposure models to a particular risk evaluation scenario. For example, existing models developed for a chemical assessment may be applicable to another chemical assessment if model parameter data are reasonably available.**
   To the extent other organizations have already modeled a 1,3-butadiene consumer exposure scenario that is relevant to the OPPT's assessment, EPA plans to evaluate those modeled estimates. In addition, if other chemicals similar to 1,3-butadiene have been modeled for similar uses, those modeled estimates will also be evaluated. The underlying parameters and assumptions of the models will also be evaluated.

5) **Review reasonably available consumer product-specific sources to determine how those exposure estimates compare with each other and with indoor monitoring data reporting 1,3-butadiene in specific media (*e.g.*, indoor air).**

The availability of 1,3-butadiene concentration for various conditions of use will be evaluated. This data provides the source term for any subsequent indoor modeling.

6) **Review reasonably available population- or subpopulation-specific exposure factors and activity patterns to determine if PESS need to be further refined.**
For 1,3-butadiene, EPA plans to evaluate exposure scenarios that involve PESS and plans to consider age-specific behaviors, activity patterns and exposure factors unique to those subpopulations. For some exposure scenarios related to consumer uses, EPA plans to consider whether exposures for adults may differ from those of children due to different activities (*e.g.*, children may mouth certain products) or exposure factors (*e.g.*, inhalation rates)."

7) **Evaluate the weight of the scientific evidence of consumer exposure estimates based on different approaches.**
EPA plans to rely on the weight of the scientific evidence when evaluating and integrating data related to consumer exposure. The weight of the scientific evidence may include qualitative and quantitative sources of information. EPA plans to integrate the data using systematic review methods to assemble the relevant data, evaluate the data for quality and relevance, including strengths and limitations, followed by synthesis and integration of the evidence.

2.7.2.5 General Population

EPA plans to analyze general population exposures as follows:

1) **Refine and finalize exposure scenarios for the general population by considering sources, conditions of use, exposure pathways including routes, and exposed populations.**
For 1,3-butadiene, the following are noteworthy considerations in constructing exposure scenarios for the general population:

- Reviewing reasonably available environmental and biological monitoring data for media to which general population exposures are expected.
- For exposure pathways where data are not reasonably available, reviewing existing exposure modeling approaches that may be applicable in estimating exposure levels.
- Considering and incorporating applicable media-specific regulations into exposure scenarios or modeling.
- Reviewing reasonably available data that may be used in developing, adapting or applying exposure models to the particular risk evaluation. For example, existing models developed for a chemical assessment may be applicable to another chemical assessment if model parameter data are reasonably available and relevant.
- Reviewing reasonably available information on releases to determine how modeled estimates of concentrations near industrial point sources compare with reasonably available monitoring data.
- Reviewing reasonably available population- or subpopulation-specific exposure factors and activity patterns to determine if PESS need to be further defined.
- Evaluating the weight of the scientific evidence of general population exposure data.
- Map or group each condition of use to general population exposure assessment scenario(s).

EPA plans to evaluate a variety of data types to determine which types are most appropriate when quantifying exposure scenarios. Environmental monitoring data, biomonitoring data, modeled estimates, experimental data, epidemiological data, and survey-based data can all be

used to inform exposure scenarios. EPA anticipates that there will be a range in the potential exposures associated with the exposure scenarios identified in Section 2.6.

After refining and finalizing exposure scenarios, EPA plans to quantify concentrations and/or doses for these scenarios. The number of scenarios will depend on condition of use, exposure pathways, and receptors. The number of scenarios is also dependent upon the reasonably available data and approaches to quantify scenarios. When quantifying exposure scenarios, EPA plans to use a tiered approach. First-tier analysis is based on data that is reasonably available without a significant number of additional inputs or assumptions, and may be qualitative, semi-quantitative, or quantitative. The results of first tier analyses inform whether scenarios require more refined analysis. Refined analyses will be iterative and require careful consideration of variability and uncertainty.

2) **For exposure pathways where empirical data is not reasonably available, review existing exposure models that may be applicable in estimating exposure levels.**
For 1,3-butadiene, media where exposure models will be considered for general population exposure include models that estimate surface water concentrations, sediment concentrations, soil concentrations, and uptake from aquatic environments into edible aquatic organisms.

3) **Review reasonably available exposure modeled estimates. For example, existing models developed for a previous 1,3-butadiene chemical assessment may be applicable to EPA's assessment. In addition, another chemical's assessment may also be applicable if model parameter data are reasonably available.**
To the extent other organizations have already modeled 1,3-butadiene general population exposure scenario that is relevant to this assessment, EPA plans to evaluate those modeled estimates. In addition, if modeled estimates for other chemicals with similar physical and chemical properties, and similar uses are available, those modeled estimates will also be evaluated. The underlying parameters and assumptions of the models will also be evaluated.

4) **Review reasonably available information on releases to determine how modeled estimates of concentrations near industrial point sources compare with reasonably available monitoring data.**
The expected releases from industrial facilities are changing over time. Any modeled concentrations based on recent release estimates will be carefully compared with reasonably available monitoring data to determine representativeness.

5) **Review reasonably available information about population- or subpopulation-specific exposure factors and activity patterns to determine if PESS need to be further defined (*e.g.*, early life and/or puberty as a potential critical window of exposure).**
For 1,3-butadiene, exposure scenarios that involve PESS will consider age-specific behaviors, activity patterns, and exposure factors unique to those subpopulations. For example, children will have different intake rates for soil than adults.

6) **Evaluate the weight of the scientific evidence of general population exposure estimates based on different approaches.**

During risk evaluation, EPA plans to evaluate and integrate the exposure evidence identified in the literature inventory using the methods described in the *Application of Systematic Review in TSCA Risk Evaluation* (U.S. EPA, 2018).

2.7.3 Hazards (Effects)

2.7.3.1 Environmental Hazards

EPA plans to conduct an environmental hazard assessment of 1,3-butadiene as follows:

1) **Review reasonably available environmental hazard data, including data from alternative test methods (*e.g.*, computational toxicology and bioinformatics; high-throughput screening methods; data on categories and read-across; *in vitro* studies).**
   EPA plans to analyze the hazards of 1,3-butadiene to aquatic organisms, including plants, invertebrates (*e.g.*, insects, arachnids, mollusks, crustaceans), and vertebrates (*e.g.*, mammals, birds, amphibians, fish, reptiles) across exposure durations and conditions if potential environmental hazards are identified through systematic review results and public comments. Additional types of environmental hazard information will also be considered (*e.g.*, analogue and read-across data) when characterizing the potential hazards of 1,3-butadiene to aquatic organisms.

   EPA plans to evaluate environmental hazard data using the evaluation strategies laid out in the *Application of Systematic Review in TSCA Risk Evaluations* (U.S. EPA, 2018). The study evaluation results will be documented in the risk evaluation phase and data from acceptable studies will be extracted and integrated in the risk evaluation process.

   Mechanistic data may include analyses of alternative test data such as novel *in vitro* test methods and high throughput screening. The association between acute and chronic exposure scenarios to the agent and each health outcome will also be integrated. Study results will be extracted and presented in evidence tables or another appropriate format by organ/system.

2) **Derive hazard thresholds for aquatic organisms.**
   Depending on the robustness of the evaluated data for a particular organism or taxa (*e.g.*, aquatic invertebrates), environmental hazard values (*e.g.*, EC_x, LC_x, NOEC, LOEC) may be derived and used to further understand the hazard characteristics of 1,3-butadiene to aquatic species. Identified environmental hazard thresholds may be used to derive concentrations of concern (COC), based on endpoints that may affect populations of organisms or taxa analyzed.

3) **Evaluate the weight of the scientific evidence of environmental hazard data.**
   During risk evaluation, EPA plans to evaluate and integrate the environmental hazard evidence identified in the literature inventory using the methods described in the *Application of Systematic Review in TSCA Risk Evaluation* (U.S. EPA, 2018).

4) **Consider the route(s) of exposure, based on reasonably available monitoring and modeling data and other approaches to integrate exposure and hazard assessments.**
   EPA plans to consider aquatic (*e.g.*, water and sediment exposures) pathways in the 1,3-butadiene conceptual model. These organisms may be exposed to 1,3-butadiene via a number of environmental pathways (*e.g.*, surface water, sediment, diet).

5) **Consider a persistent, bioaccumulative, and toxic (PBT) assessment of 1,3-butadiene.**
EPA plans to consider the persistence, bioaccumulation, and toxic (PBT) potential of 1,3-butadiene after reviewing relevant physical and chemical properties and exposure pathways. EPA plans to assess the reasonably available studies collected from the systematic review process relating to bioaccumulation and bioconcentration (*e.g.,* BAF, BCF) of 1,3-butadiene. In addition, EPA plans to integrate traditional environmental hazard endpoint values (*e.g.,* LC_{50}, LOEC) and exposure concentrations (*e.g.,* surface water concentrations, tissue concentrations) for 1,3-butadiene with the fate parameters (*e.g.,* BAF, BCF, BMF, TMF).

6) **Conduct an environmental risk estimation and characterization of 1,3-butadiene.**
EPA plans to conduct a risk estimation and characterization of 1,3-butadiene to identify if there are risks to the aquatic environments from the measured and/or predicted concentrations of 1,3-butadiene in environmental media (*e.g.,* water, sediment). Risk quotients (RQs) may be derived by the application of hazard and exposure benchmarks to characterize environmental risk (U.S. EPA, 1998; Barnthouse et al., 1982). Analysis of risk for characterization includes a confidence statement in risk estimation which qualitative judgment describing the certainty of the risk estimate considering the strength the evidence scores for hazard and exposure and the limitations, and relevance.

2.7.3.2 Human Health Hazards

EPA plans to analyze human health hazards as follows:

1) **Review reasonably available human health hazard data, including data from alternative test methods (*e.g.*, computational toxicology and bioinformatics; high-throughput screening methods; data on categories and read-across; *in vitro* studies; systems biology).**
EPA plans to evaluate human health studies using the evaluation strategies laid out in the *Application of Systematic Review in TSCA Risk Evaluations* (U.S. EPA, 2018) and updates to the epidemiological data quality criteria released with the first ten risk evaluations. The study evaluation results will be documented in the risk evaluation phase and data from acceptable studies will be extracted and integrated in the risk evaluation process.

   Mechanistic data may include analyses of alternative test data such as novel *in vitro* test methods and high throughput screening. The association between acute and chronic exposure scenarios to the agent and each health outcome will also be integrated. Study results will be extracted and presented in evidence tables or another appropriate format by organ/system.

2) **In evaluating reasonably available data, determine whether particular human receptor groups may have greater susceptibility to the chemical's hazard(s) than the general population.**
Reasonably available human health hazard data will be evaluated to ascertain whether some human receptor groups may have greater susceptibility than the general population to 1,3-butadiene hazard(s). Susceptibility of particular human receptor groups to 1,3-butadiene will be determined by evaluating information on factors that influence susceptibility.

   EPA has reviewed some sources containing hazard information associated with susceptible populations and lifestages such as pregnant women and infants. Pregnancy (*i.e.,* gestation) and childhood are potential susceptible lifestages for 1,3-butadiene exposure. EPA may quantify

these differences in the risk evaluation following further evaluation of the reasonably available data and information.

3) **Conduct hazard identification (the qualitative process of identifying non-cancer and cancer endpoints) and dose-response assessment (the quantitative relationship between hazard and exposure) for identified human health hazard endpoints.**
Human health hazards from acute and chronic exposures will be identified by evaluating the human and animal data that meet the systematic review data quality criteria described in the *Application of Systematic Review in TSCA Risk Evaluation* (U.S. EPA, 2018). Hazards identified by studies meeting data quality criteria will be grouped by routes of exposure relevant to humans (*e.g.*, oral, dermal, inhalation) and by the cancer and noncancer endpoints identified in Section 2.4.2.

   Dose-response assessment will be performed in accordance with EPA guidance (U.S. EPA, 2012a, 2011b, 1994) developing points of departure (POD) for either margins of exposure (MOEs), cancer slope factors (CSFs), oral slope factors (OSFs), and/or inhalation unit risks (IURs). Dose-response analyses may be used if the data meet data quality criteria and if additional information on the identified hazard endpoints are not reasonably available or would not alter the analysis.

   The cancer mode of action (MOA) analyses determine the relevancy of animal data to human risk and how data can be quantitatively evaluated. If cancer hazard is determined to be applicable to 1,3-butadiene, EPA plans to evaluate information on genotoxicity and the MOA for all cancer endpoints to determine the appropriate approach for quantitative cancer assessment in accordance with the U.S. EPA Guidelines for Carcinogen Risk Assessment (U.S. EPA, 2005a). In accordance with EPA's Supplemental Guidance for Assessing Susceptibility from Early-life Exposures to Carcinogens (U.S. EPA, 2005b), EPA plans to determine whether age-dependent adjustment factors (ADAFs) are appropriate for 1,3-butadiene for specific conditions of use based upon potential exposures to children.

4) **Derive points of departure (PODs) where appropriate; conduct benchmark dose modeling depending on the reasonably available data. Adjust the PODs as appropriate to conform *(e.g.,* adjust for duration of exposure) to the specific exposure scenarios evaluated.**
Hazard data will be evaluated to determine the type of dose-response modeling that is applicable. Where modeling is feasible, a set of dose-response models that are consistent with a variety of potentially underlying biological processes will be applied to empirically model the dose-response relationships in the range of the observed data consistent with EPA's *Benchmark Dose Technical Guidance Document* (U.S. EPA, 2012a). Where dose-response modeling is not feasible, NOAELs or LOAELs will be identified. Non-quantitative data will also be evaluated for contribution to weight of the scientific evidence or for evaluation of qualitative endpoints that are not appropriate for dose-response assessment.

   EPA plans to evaluate whether the reasonably available PBPK and empirical kinetic models are adequate for route-to-route and interspecies extrapolation of the POD, or for extrapolation of the POD to standard exposure durations (*e.g.*, lifetime continuous exposure). If application of the PBPK model is not possible, oral PODs may be adjusted by $BW^{3/4}$ scaling in accordance with U.S. EPA (2011b), and inhalation PODs may be adjusted by exposure duration and chemical properties in accordance with U.S. EPA (1994).

5) **Evaluate the weight of the scientific evidence of human health hazard data.**
During risk evaluation, EPA plans to evaluate and integrate the human health hazard evidence identified in the literature inventory under acute and chronic exposure conditions using the methods described in the *Application of Systematic Review in TSCA Risk Evaluation* (U.S. EPA, 2018).

6) **Consider the route(s) of exposure (*e.g.*, oral, inhalation, dermal), reasonably available route-to-route extrapolation approaches; biomonitoring data; and approaches to correlate internal and external exposures to integrate exposure and hazard assessment.**
At this stage of review, EPA believes there will be sufficient reasonably available data to conduct a dose-response analysis and/or benchmark dose modeling for the oral route of exposure. EPA plans to also evaluate any potential human health hazards following dermal and inhalation exposure to 1,3-butadiene, which could be important for worker, consumer and general population risk analysis. Reasonably available data will be assessed to determine whether or not a point of departure can be identified for the dermal and inhalation routes.

   If sufficient reasonably available toxicity studies are not identified through the systematic review process to assess risks from inhalation or dermal exposure, then a route-to-route extrapolation may be needed. The preferred approach is to use a PBPK model (U.S. EPA, 2006a). Without an adequate PBPK model, considerations regarding the adequacy of data for route-to-route extrapolation are described in Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry (U.S. EPA, 1994). EPA may use these considerations when determining whether to extrapolate from the oral to the inhalation route of exposure. Similar approaches for oral-to-dermal route extrapolation are described in EPA guidance document Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) (U.S. EPA, 2004).

   If there are acceptable inhalation data after completion of systematic review, EPA may also consider extrapolating from the inhalation to the dermal route if first-pass metabolism through the liver via the oral route is expected because in that case, use of data from the oral route is not recommended (U.S. EPA, 1994). EPA may also consider inhalation-to-dermal route extrapolation if an inhalation toxicity study with a sensitive hazard endpoint is used to evaluate risks. Based on these considerations, EPA extrapolated from the inhalation to the dermal route for several of the first ten risk evaluations under amended TSCA, including methylene chloride (U.S. EPA, 2020d) and carbon tetrachloride (U.S. EPA, 2020b).

7) **Conduct a human health risk estimation and characterization of 1,3-butadiene.**
Analysis of risk for characterization includes a confidence statement in risk estimation. This confidence statement is based on qualitative judgment describing the certainty of the risk estimate considering the strength of the evidence scores for hazard and exposure along with their limitations and relevance. The lowest confidence evaluation for either hazard or exposure will drive the overall confidence estimate.

2.7.4 Summary of Risk Approaches for Characterization

Risk characterization is an integral component of the risk assessment process for both environmental and human health risks. EPA plans to derive the risk characterization in accordance with EPA's *Risk Characterization Handbook* (U.S. EPA, 2000). As defined in EPA's Risk Characterization Policy, "the risk characterization integrates information from the preceding components of the risk evaluation and

synthesizes an overall conclusion about risk that is complete, informative and useful for decision makers" (U.S. EPA, 2000) Risk characterization is considered to be a conscious and deliberate process to bring all important considerations about risk, not only the likelihood of the risk but also the strengths and limitations of the assessment, and a description of how others have assessed the risk into an integrated picture.

The level of information contained in each risk characterization varies according to the type of assessment for which the characterization is written. Regardless of the level of complexity or information, the risk characterization for TSCA risk evaluations will be prepared in a manner that is transparent, clear, consistent, and reasonable (U.S. EPA, 2000) and consistent with the requirements of the *Procedures for Chemical Risk Evaluation Under the Amended Toxic Substances Control Act* (82 FR 33726, July 12, 2017). As discussed in 40 CFR 702.43, risk characterization has a number of considerations. This is the step where EPA integrates the hazard and exposure assessments into risk estimates for the identified populations (including any PESS) and ecological characteristics and weighs the scientific evidence for the identified hazards and exposures. The risk characterization does not consider costs or other nonrisk factors, and takes into account, "where relevant, the likely duration, intensity, frequency, and number of exposures under the condition(s) of use…." The risk characterization also summarizes the following considerations: (1) uncertainty and variability in each step of the risk evaluation; (2) data quality, and any applicable assumptions used; (3) alternative interpretations of data and analyses, where appropriate; and (4) any considerations for environmental risk evaluations, if necessary (e.g., related to nature and magnitude of effects).

EPA plans to also be guided by EPA's Information Quality Guidelines (U.S. EPA, 2002) as it provides guidance for presenting risk information. Consistent with those guidelines, in the risk characterization, EPA plans to also identify: (1) Each population addressed by an estimate of applicable risk effects; (2) the expected risk or central estimate of risk for the PESS affected; (3) each appropriate upper-bound or lower bound estimate of risk; (4) each significant uncertainty identified in the process of the assessment of risk effects and the studies that would assist in resolving the uncertainty; and (5) peer reviewed studies known to the Agency that support, are directly relevant to, or fail to support any estimate of risk effects and the methodology used to reconcile inconsistencies in the scientific information.

2.8 Peer Review

Peer review will be conducted in accordance with EPA's regulatory procedures for chemical risk evaluations, including using EPA's Peer Review Handbook (U.S. EPA, 2015b) and other methods consistent with Section 26 of TSCA (see 40 CFR 702.45). As explained in the Risk Evaluation Rule, the purpose of peer review is for the independent review of the science underlying the risk assessment. Peer review will therefore address aspects of the underlying science as outlined in the charge to the peer review panel such as hazard assessment, assessment of dose-response, exposure assessment, and risk characterization. The draft risk evaluation for 1,3-butadiene will be peer reviewed.

REFERENCES

ACC (American Chemistry Council). (2019). Butadiene product stewardship guidance manual. https://www.americanchemistry.com/olefinspanel/Butadiene-Product-Stewardship-Guidance-Manual.pdf

Atkinson, R. (1989). Kinetics and mechanisms of the gas-phase reactions of the hydroxyl radical with organic compounds. J Phys Chem Ref Data 1: 1-246.

Atkinson, R; Aschmann, SM; Winer, AM; Pitts, JN, Jr. (1984). Kinetics of the gas-phase reactions of NO3 radicals with a series of dialkenes, cycloalkenes, and monoterpenes at 295 +/- 1K. Environ Sci Technol 18: 370-375. http://dx.doi.org/10.1021/es00123a016

Atkinson, R; Carter, WPL. (1984). Kinetics and mechanisms of the gas-phase reactions of ozone with organic compounds under atmospheric conditions. Chem Rev 84: 437-470. http://dx.doi.org/10.1021/cr00063a002

ATSDR (Agency for Toxic Substances and Disease Registry). (2012). Toxicological profile for 1,3-butadiene [ATSDR Tox Profile]. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=459&tid=81

Baker, J; Arey, J; Atkinson, R. (2005). Formation and reaction of hydroxycarbonyls from the reaction of OH radicals with 1,3-butadiene and isoprene. 39: 4091-4099. http://dx.doi.org/10.1021/es047930t

Barnthouse, LW; DeAngelis, DL; Gardner, RH; O'Neill, RV; Suter, GW; Vaughan, DS. (1982). Methodology for environmental risk analysis. (ORNL/TM-8167). Oak Ridge, TN: Oak Ridge National Laboratory.

Cherrie, J; Semple, S; Christopher, Y; Saleem, A; Hughson, GW; Phillips, A. (2006). How important is inadvertent ingestion of hazardous substances at work? 50: 693-704.

ECB (European Chemicals Bureau). (2002). European Union risk assessment report: 1,3-butadiene. Luxembourg: European Union, European Chemicals Bureau, Institute for Health and Consumer Protection. https://echa.europa.eu/documents/10162/1f512549-5bf8-49a8-ba51-1cf67dc07b72

ECHA (European Chemicals Agency). (2019). Registration dossier: Buta-1,3-diene. https://echa.europa.eu/registration-dossier/-/registered-dossier/15570

Hansch, C; Leo, A; Hoekman, D. (1995). [1,3-Butadiene] [Type of Work]. Washington, DC: American Chemical Society.

Hou, CT; Patel, R; Laskin, AI. (1979). Microbial oxidation of gaseous hydrocarbons: Epoxidation of C2 to C4 n-alkenes by methylotrophic bacteria. Appl Environ Microbiol 38: 127-134.

Howard, BE; Phillips, J; Miller, K; Tandon, A; Mav, D; Shah, MR; Holmgren, S; Pelch, KE; Walker, V; Rooney, AA; Macleod, M; Shah, RR; Thayer, K. (2016). SWIFT-Review: a text-mining workbench for systematic review. Syst Rev 5: 87. http://dx.doi.org/10.1186/s13643-016-0263-z

IARC (International Agency for Research on Cancer). (1986). 1,3-Butadiene. In Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans (pp. 156). https://monographs.iarc.fr/wp-content/uploads/2018/06/mono39.pdf

Kirman, CR; Albertini, RA; Gargas, ML. (2010). 1,3-Butadiene: III. Assessing carcinogenic modes of action [Review]. Crit Rev Toxicol 40 Suppl 1: 74-92. http://dx.doi.org/10.3109/10408444.2010.507183

Kopczynski, SL; Lonneman, WA; Sutterfield, FD; Darley, PE. (1972). Photochemistry of atmospheric samples in Los Angeles. Environ Sci Technol 6: 342-347.

Lyman, WJ; Reehl, WF; DH, R. (1990). 1,3-Butadiene [Type of Work]. Washington, DC: American Chemical Society.

Miller, LM; Villaume, JE. (1978). Investigation of selected potential environmental contaminants: 1,3 Butadiene-Final report [EPA Report]. (EPA 560/2-78-003). Washington, DC: U.S.

Environmental Protection Agency. https://nepis.epa.gov/Exe/ZyNET.exe/910036J7.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1976+Thru+1980&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C76thru80%5CTxt%5C00000010%5C910036J7.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL

NIOSH. (2016). Updated Immediately Dangerous To Life or Health (IDLH) Values (as of 2016). Atlanta, GA. http://www.cdc.gov/niosh/idlh/intridl4.html

NIOSH. (2020). NIOSH Potential Carcinogen List [Database]. https://www.cdc.gov/niosh/topics/cancer/npotocca.html

NITE (National Institute of Technology and Evaluation). (2019). Japan Chemicals Collaborative Knowledge Database. CAS RN: 106-99-0. https://www.nite.go.jp/chem/jcheck/detail.action?cno=106-99-0&mno=2-0017&request_locale=en

NLM (National Library of Medicine). (2003). PubChem: Hazardous Substance Data Bank: 1,3-Butadiene, 106-99-0 [Website]. https://pubchem.ncbi.nlm.nih.gov/compound/7845#source=HSDB

NLM (National Library of Medicine). (2020). PubChem, data Sources: HSDB: Annotation record: 1,3-Butadiene. https://pubchem.ncbi.nlm.nih.gov/source/hsdb/181

NTP (National Toxicology Program). (1999). NTP report on carcinogens background document for 1,3-butadiene. 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/newhomeroc/other_background/butadiene_508.pdf

NTP (National Toxicology Program). (2016). Report on carcinogens, fourteenth edition: 1,3-butadiene. 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/butadiene.pdf

O'Neil, MJ. (2013). 1,3-Butadiene. 106-99-0 [Type of Work] (15th ed.). Cambridge, UK: The Royal Society of Chemistry.

OECD (Organisation for Economic Co-operation and Development). (2004). Emission scenario document on additives in rubber industry. (JT00166668). Paris, France. http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono(2004)11&doclanguage=en

OECD (Organisation for Economic Co-operation and Development). (2009). Emission scenario document on plastic additives. (JT03267870). Paris, France: OECD Environmental Health and Safety Publications. http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono(2004)8/rev1&doclanguage=en

OECD (Organisation for Economic Co-operation and Development). (2011). Emission scenario document on the chemical industry. (JT03307750). Paris, France. http://www.oecd.org/env/ehs/risk-assessment/48774702.pdf

OEHHA (California Office of Environmental Health Hazard Assessment). (2013). 1,3-Butadiene reference exposure levels (pp. 102). California: California Environmental Protection Agency,

Office of Environmental Health Hazard Assessment. https://oehha.ca.gov/media/downloads/crnr/072613bentcrel.pdf

OSHA (Occupational Safety & Health Administration). (2019). Permissible exposure limits: OSHA annotated table Z-1. United States Department of Labor, Occupational Safety & Health Administration. https://www.osha.gov/dsg/annotated-pels/tablez-1.html

Patel, RN; Hou, CR; Laskin, AI. (1982). Oxidation of gaseous hydrocarbons and related compounds by methanotrophic organisms. Dev Ind Microbiol 23: 187-205.

Peterson, CA; Key, JA; Hobbs, FD; Blackburn JW, B, asdekis, H. S.; Dylewski, SW; Standifer, RL; Helsel, RW. (1980). Organic chemical manufacturing: Selected processes, volume 10. (EPA-450/3-80-028e). U.S. Environmental Protection Agency. https://nepis.epa.gov/Exe/ZyNET.exe/9101OKIA.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1976+Thru+1980&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C76thru80%5CTxt%5C00000033%5C9101OKIA.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL

RSC (Royal Society of Chemistry). (2019). ChemSpider: 1,3-Butadiene [Website]. http://www.chemspider.com/Chemical-Structure.7557.html?rid=1d69cb81-3e1b-49ee-88e7-4dd851d3f977

Rumble, JR. (2018a). 1,3-Butadiene [Type of Work] (99 ed.). Boca Raton, FL: CRC Press. Taylor & Francis Group.

Rumble, JR. (2018b). Aqueous solubility and Henry's law constants of organic compounds [Type of Work] (99 ed.). Boca Raton, FL: CRC Press. Taylor & Francis Group.

Rumble, JR. (2018c). Octanol-water partition coefficients [Type of Work] (99 ed.). Boca Raton, FL: CRC Press. Taylor & Francis Group.

Sigma-Aldrich. (2020). Safety data sheet: 1,3 Butadiene (pp. 11). https://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=US&language=en&productNumber=295035&brand=ALDRICH&PageToGoToURL=https%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fsearch%3Fterm%3D106-99-0%26interface%3DCAS%2520No.%26N%3D0%2B%26mode%3Dpartialmax%26lang%3Den%26region%3DUS%26focus%3Dproduct

Sun, HN; Wristers, JP. (2002). Butadiene. In Kirk-othmer encyclopedia of chemical technology (1999-2013). New York, NY: John Wiley & Sons. http://dx.doi.org/10.1002/0471238961.02212001192114.a01.pub2

U.S. EPA (U.S. Environmental Protection Agency). (1991). Petroleum refining processing crude separation processes and catalytic cracking- generic scenario for estimating occupational exposure and environmental releases: Draft. Washington, DC: U.S. Environmental Protection Agency. https://www.epa.gov/tsca-screening-tools/chemsteer-chemical-screening-tool-exposures-and-environmental-releases#genericscenarios

U.S. EPA (U.S. Environmental Protection Agency). (1994). Methods for derivation of inhalation reference concentrations and application of inhalation dosimetry [EPA Report]. (EPA/600/8-90/066F). Research Triangle Park, NC: U.S. Environmental Protection Agency, Office of Research and Development, Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office.

https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=71993&CFID=51174829&CFTOKEN=25006317
U.S. EPA (U.S. Environmental Protection Agency). (1996). Locating and estimating air emissions from sources of 1,3-butadiene. (EPA 454/R-96-008). https://www3.epa.gov/ttn/chief/le/butadien.pdf
U.S. EPA (U.S. Environmental Protection Agency). (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
U.S. EPA (U.S. Environmental Protection Agency). (2000). Science Policy Council handbook: Risk characterization handbook. (EPA/100/B-00/002). Washington, D.C.: U.S. Environmental Protection Agency, Science Policy Council. https://www.epa.gov/risk/risk-characterization-handbook
U.S. EPA (U.S. Environmental Protection Agency). (2002). Guidelines for ensuring and maximizing the quality, objectivity, utility, and integrity of information disseminated by the Environmental Protection Agency. (EPA/260/R-02/008). Washington, DC: U.S. Environmental Protection Agency, Office of Environmental Information. https://www.epa.gov/sites/production/files/2017-03/documents/epa-info-quality-guidelines.pdf
U.S. EPA (U.S. Environmental Protection Agency). (2004). Risk assessment guidance for superfund (RAGS), Volume I: Human health evaluation manual, (Part E: Supplemental guidance for dermal risk assessment). (EPA/540/R/99/005). Washington, DC: U.S. Environmental Protection Agency, Risk Assessment Forum. http://www.epa.gov/oswer/riskassessment/ragse/index.htm
U.S. EPA (U.S. Environmental Protection Agency). (2005a). Guidelines for carcinogen risk assessment [EPA Report]. (EPA/630/P-03/001B). Washington, DC: U.S. Environmental Protection Agency, Risk Assessment Forum. https://www.epa.gov/sites/production/files/2013-09/documents/cancer_guidelines_final_3-25-05.pdf
U.S. EPA (U.S. Environmental Protection Agency). (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://www3.epa.gov/airtoxics/childrens_supplement_final.pdf
U.S. EPA. (U.S. Environmental Protection Agency). (2006a). Approaches for the application of physiologically based pharmacokinetic (PBPK) models and supporting data in risk assessment (Final Report) [EPA Report] (pp. 1-123). (EPA/600/R-05/043F). Washington, DC: U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=157668
U.S. EPA (U.S. Environmental Protection Agency). (2006b). A framework for assessing health risk of environmental exposures to children (pp. 1-145). (EPA/600/R-05/093F). Washington, DC: U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=158363
U.S. EPA (U.S. Environmental Protection Agency). (2011a). Exposure factors handbook: 2011 edition [EPA Report]. (EPA/600/R-090/052F). Washington, DC. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=236252
U.S. EPA (U.S. Environmental Protection Agency). (2011b). Recommended use of body weight 3/4 as the default method in derivation of the oral reference dose (pp. 1-50). (EPA/100/R-11/0001). Washington, DC: U.S. Environmental Protection Agency, Risk Assessment Forum, Office of the Science Advisor. https://www.epa.gov/sites/production/files/2013-09/documents/recommended-use-of-bw34.pdf
U.S. EPA (U.S. Environmental Protection Agency). (2012a). Benchmark dose technical guidance. (EPA/100/R-12/001). Washington, DC: U.S. Environmental Protection Agency, Risk Assessment Forum. https://www.epa.gov/risk/benchmark-dose-technical-guidance

U.S. EPA (U.S. Environmental Protection Agency). (2012b). Estimation Programs Interface Suite™ for Microsoft® Windows, v 4.11. Washington, DC. Retrieved from https://www.epa.gov/tsca-screening-tools/epi-suitetm-estimation-program-interface

U.S. EPA. (U.S. Environmental Protection Agency). (2014). Generic scenario on the use of additives in the thermoplastics converting industry. Washington, DC.

U.S. EPA (U.S. Environmental Protection Agency). (2015a). ChemSTEER user guide - Chemical screening tool for exposures and environmental releases. Washington, DC. https://www.epa.gov/sites/production/files/2015-05/documents/user_guide.pdf

U.S. EPA (U.S. Environmental Protection Agency). (2015b). Peer review handbook [EPA Report] (4th ed.). (EPA/100/B-15/001). Washington, DC: U.S. Environmental Protection Agency, Science Policy Council. https://www.epa.gov/osa/peer-review-handbook-4th-edition-2015

U.S. EPA (U.S. Environmental Protection Agency). (2015c). Science policy council peer review handbook [EPA Report] (4th ed.). (EPA/100/B-15/001). Washington, DC: U.S. Environmental Protection Agency, Science Policy Council.

U.S. EPA (U.S. Environmental Protection Agency). (2016). Hydraulic fracturing for oil and gas: Impacts from the hydraulic fracturing water cycle on drinking water resources in the United States. EPA-600-R-16-236Fb. December 2016. https://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=332990

U.S. EPA (U.S. Environmental Protection Agency). (2018). Application of systematic review in TSCA risk evaluations. (740-P1-8001). Washington, DC: U.S. Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention. https://www.epa.gov/sites/production/files/2018-06/documents/final_application_of_sr_in_tsca_05-31-18.pdf

U.S. EPA (U.S. Environmental Protection Agency). (2019a). Chemical data reporting (2012 and 2016 CBI CDR database). U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics.

U.S. EPA (U.S. Environmental Protection Agency). (2019b). Chemistry Dashboard information for 1,3-butadiene. 106-99-0 [Website]. https://comptox.epa.gov/dashboard/dsstoxdb/results?search=DTXSID3020203

U.S. EPA (U.S. Environmental Protection Agency). (2019c). CPCat: Chemical and Product Categories. https://actor.epa.gov/cpcat/faces/home.xhtml

U.S. EPA (U.S. Environmental Protection Agency). (2019d). Proposed designation of 1,3-butadiene (CASRN 106-99-0) as a high-priority substance for risk evaluation. U.S. Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention.

U.S. EPA (U.S. Environmental Protection Agency). (2019e). TRI Explorer (2018 dataset released November 2019). Washington, DC: U.S. Environmental Protection Agency. https://enviro.epa.gov/triexplorer/

U.S. EPA (U.S. Environmental Protection Agency). (2020a). Chemical data reporting (2012 and 2016 Public CDR database). Washington, DC: U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics. ChemView: July 2020. https://chemview.epa.gov/chemview

U.S. EPA. (U.S. Environmental Protection Agency). (2020b). Draft risk evaluation for carbon tetrachloride (methane, tetrachloro-); CASRN: 56-23-5 (pp. 1-301). (EPA-740-R1-8014). Office of Chemical Safety and Pollution Prevention, U.S. Environmental Protection Agency. https://nepis.epa.gov/Exe/ZyPDF.cgi/P100YHUW.PDF?Dockey=P100YHUW.PDF

U.S. EPA. (U.S. Environmental Protection Agency). (2020c). Draft Scope of the Risk Evaluation for 1,3-Butadiene CASRN 106-99-0. (EPA-740-D-20-011). https://www.epa.gov/sites/production/files/2020-04/documents/casrn-106-99-6_13-butadiene_draft_scope.pdf

U.S. EPA. (U.S. Environmental Protection Agency). (2020d). Risk evaluation for methylene chloride (dichloromethane, dcm); CASRN: 75-09-2 (pp. 1-753). (EPA-740-R1-8010). Office of Chemical Safety and Pollution Prevention, U.S. Environmental Protection Agency. https://www.epa.gov/sites/production/files/2020-06/documents/1_mecl_risk_evaluation_final.pdf

Watkinson, RJ; Somerville, HJ. (1976). The microbial utilization of butadiene [Type of Work]. London, England: Applied Science Publishers.

APPENDICES

Appendix A ABBREVIATED METHODS FOR SEARCHING AND SCREENING

A.1 Literature Search of Publicly Available Databases

A.1.1 Search Term Genesis and Chemical Verification

To develop the chemical terms for the subsequent literature search for 1,3-butadiene ,several online sources were queried.

- California Department of Pesticide Regulation: https://www.cdpr.ca.gov/docs/chemical/monster2.htm
- USEPA Chemistry Dashboard: https://comptox.epa.gov/dashboard
- University of Hertfordshire PPDB: Pesticide Properties DataBase: https://sitem.herts.ac.uk/aeru/ppdb/en/search.htm
- USEPA Reregistration Eligibility Decision (RED) documents: https://archive.epa.gov/pesticides/reregistration/web/html/status.html
- Office of Pesticide Programs Pesticide Chemical Search: https://ofmpub.epa.gov/apex/pesticides/f?p=CHEMICALSEARCH:1
- Food and Agriculture Organization of the United Nations: http://www.fao.org/home/en/
- PAN Pesticides Database: http://www.pesticideinfo.org/Search_Chemicals.jsp

Prior to inclusion in the search term string, all forms of chemical names were subjected to verification from several potential sources (*e.g.*, US EPA Chemistry Dashboard, STN International-CAS; see complete list of sources for chemical verification in Table_Apx A-1. From these sources, all chemical names, synonyms, CAS number(s), trade names, etc. were documented and used to generate terms for database searches.

Table_Apx A-1. Sources of Verification for Chemical Names and Structures

CHEMICAL SOURCE	CONTENTS	DOCUMENT LOCATION
Chemistry Dashboard (https://comptox.epa.gov/dashboard)	CAS Numbers, Synonyms, Structures, Properties, Environmental Fate and Transport.	Online
Dictionary of Chemical Names and Synonyms	Wide assortment of chemical compounds by chemical name and synonym, has CAS index and some structure data	ECOTOX
Farm Chemicals Handbook-1992	Pesticide information, CAS numbers and synonyms, some structure data ***Sometimes CAS number presented for a compound is for the main constituent only	ECOTOX
OPPT SMILES Verification Source	Structure Data	Electronic verification
RTECS (Registry of Toxic Effects of chemical substance, 1983-84 ed., 2 vols)	Chemical names, synonyms and CAS numbers	ECOTOX

CHEMICAL SOURCE	CONTENTS	DOCUMENT LOCATION
Sigma – Aldrich website58784 http://www.sigma-aldrich.com	Organic and inorganic Compounds by chemical name, has CAS index and some structure and Physical Property data	Online
STN International (CAS) 1994	***Most complete source of chemical name, synonym and structure information, no physical properties	Online
The Pesticide Manual 10th edition, 1994	Pesticide Compounds by chemical name, synonym, product code, has CAS index and some structure and Physical Property data	ECOTOX
TSCA (Toxic Substances Control Act Chemical Substance Inventory, 1985 ed., 5 vols)	Chemical names, synonyms and CAS numbers	ECOTOX
World Wide Web (misc. web sources) A copy of the verification page is saved to the Attachments tab of the chemical entry. This includes company MSDS sheets or Chemical Labels.	Chemical names, synonyms and CAS numbers	Online
California Department of Pesticide Regulation (http://www.cdpr.ca.gov/dprdatabase.htm)	Multiple databases containing chemicals, pesticides, companies, products, etc.	Online
PAN Pesticide Database (http://www.pesticideinfo.org/Search_Chemicals.jsp)	Pesticides searchable by name or CAS #. Includes CAS #, Name, synonyms, targets, toxicity data, related chemicals and regulatory information.	Online
US EPA Office of Pesticide Programs Pesticide Fate Database – No web access available. An electronic copy of the data file is located at the Contractor site: PFATE_37_Tables.mdb.	Multiple databases containing chemicals, pesticides, companies, products, etc.	Online

A.1.2 Publicly Available Database Searches

The databases listed below were searched for literature containing the chemical search terms. Database searching occurred during April and May of 2019 by an information specialist and the results were stored in the Health and Environmental Research Online (HERO) database and assigned a HERO reference identification number.[9] The present literature search focused only on the chemical name (including synonyms and trade names) with no additional limits. Full details of the search strategy for each database are presented in Appendix A.1.2.1.

After initial deduplication in HERO[10], these studies were imported into SWIFT Review software (Howard et al., 2016) to identify those references most likely to be applicable to each discipline area (*i.e.* consumer, environmental, and general population exposure, occupational exposure and environmental releases, environmental hazards, human health hazards, and fate and physical chemistry).

A.1.2.1 Query Strings for the Publicly Available Database Searches on 1,3-Butadiene

Table_Apx A-2 presents a list of the data sources, the search dates and number of peer-reviewed references resulting from the searches for 1,3-butadiene. The sources are found as online databases and

[9]EPA's HERO database provides access to the scientific literature behind EPA science assessments. The database includes more than 600,000 scientific references and data from the peer-reviewed literature used by EPA to develop its regulations.
[10] Deduplication in HERO involves first determining whether a matching unique ID exists (*e.g.*, PMID, WOSid, or DOI). If one matches one that already exists in HERO, HERO will tag the existing reference instead of adding the reference again. Second, HERO checks if the same journal, volume, issue and page number are already in HERO. Third, HERO matches on the title, year, and first author. Title comparisons ignore punctuation and case.

the resulting references were gathered and uploaded into the EPA Health and Environmental Research Online (HERO) database for literature screening.

Table_Apx A-2. Summary of Data Sources, Search Dates and Number of Peer-Reviewed Literature Search Results for 1,3-Butadiene

Source	Date of Search	Number of References
Current Contents	05/23/2019	3405
Web of Science	09/10/2019	29,774
ProQuest CSA	05/23/2019	6542
Dissertation Abstracts	05/30/2019	305
Science Direct	05/23/2019	11792
Agricola	05/24/2019	688
TOXNET	05/24/2019	6302
PubMed	05/28/2019	5330
UNIFY	06/06/2019	22
Totals:		**64,160**

GENERAL:
General search terms were compiled and used in the search strategies for each of the databases/sources listed below. Based upon the online search manuals for the respective databases/sources, it was necessary to construct searches as noted for each of the sources. The search terms are listed below in full for each source and noted if the general search terms or other search terms were used.

"1,2-Butadien" OR "1,2-Butadiene" OR "1,3-BUTADIEN" OR "1,3-Butadiene" OR "1-Methylallene" OR "2-Butene-1,4-diyl" OR "Allene, methyl-" OR "alpha,gamma-Butadiene" OR "Biethylene" OR "Bivinyl" OR "Buta-1,2-dien" OR "Buta-1,2-diene" OR "Buta-1,3-dien" OR "Buta-1,3-diene" OR "Butadien" OR "Butadiene" OR "Butadiene" OR "Butadiene monomer" OR "Butadiene-1,2" OR "Butadiene-1,3" OR "Divinyl" OR "Erythrene" OR "Methylallene" OR "NCI-C50602" OR "UN 1010" OR "UNII-2AZI943A8R" OR "UNII-JSD5FGP5VD" OR "Vinylethylene"

CURRENT CONTENTS CONNECT:
Current Contents Connect may be accessed through EPA Desktop Library *(https://intranet.epa.gov/desktop/databases.htm).*

Date Searched: 05/23/2019
Date Range of Search: 1998 to Present
N = 3405

TS=("1,2-Butadien" OR "1,2-Butadiene" OR "1,3-BUTADIEN" OR "1,3-Butadiene" OR "1-Methylallene" OR "2-Butene-1,4-diyl" OR "Allene, methyl-" OR "alpha,gamma-Butadiene" OR "Biethylene" OR "Bivinyl" OR "Buta-1,2-dien" OR "Buta-1,2-diene" OR "Buta-1,3-dien" OR "Buta-1,3-diene" OR "Butadien" OR "Butadiene" OR "Butadiene" OR "Butadiene monomer" OR "Butadiene-1,2" OR "Butadiene-1,3" OR "Divinyl" OR "Erythrene" OR "Methylallene" OR "NCI-C50602" OR "UN 1010" OR "UNII-2AZI943A8R" OR "UNII-JSD5FGP5VD" OR "Vinylethylene")
N = 3405

WOS Core Collection:
Web of Science Core Collection may be accessed through EPA Desktop Library (https://intranet.epa.gov/desktop/databases.htm) by clicking on the Web of Science Link or copying and pasting (https://apps.webofknowledge.com).

Date Searched: 09/10/2019
Date Range of Search: 1970 to Present
N = 29,774

TS=("1,2-Butadien" OR "1,2-Butadiene" OR "1,3-BUTADIEN" OR "1,3-Butadiene" OR "1-Methylallene" OR "2-Butene-1,4-diyl" OR "Allene, methyl-" OR "alpha,gamma-Butadiene" OR "Biethylene" OR "Bivinyl" OR "Buta-1,2-dien" OR "Buta-1,2-diene" OR "Buta-1,3-dien" OR "Buta-1,3-diene" OR "Butadien" OR "Butadiene" OR "Butadiene" OR "Butadiene monomer" OR "Butadiene-1,2" OR "Butadiene-1,3" OR "Divinyl" OR "Erythrene" OR "Methylallene" OR "NCI-C50602" OR "UN 1010" OR "UNII-2AZI943A8R" OR "UNII-JSD5FGP5VD" OR "Vinylethylene")
N = 29,774

PROQUEST Agricultural and Environmental Science Database:
ProQuest Agricultural and Environmental Science Database may be accessed through EPA Desktop Library (https://intranet.epa.gov/desktop/databases.htm).

Date Searched: 05/23/2019

Date Range of Search: 1900 to Present
N = 6542

ALL("1,2-Butadien" OR "1,2-Butadiene" OR "1,3-BUTADIEN" OR "1,3-Butadiene" OR "1-Methylallene" OR "2-Butene-1,4-diyl" OR "Allene, methyl-" OR "alpha,gamma-Butadiene" OR "Biethylene" OR "Bivinyl" OR "Buta-1,2-dien" OR "Buta-1,2-diene" OR "Buta-1,3-dien" OR "Buta-1,3-diene" OR "Butadien" OR "Butadiene" OR "Butadiene" OR "Butadiene monomer" OR "Butadiene-1,2" OR "Butadiene-1,3" OR "Divinyl" OR "Erythrene" OR "Methylallene" OR "NCI-C50602" OR "UN 1010" OR "UNII-2AZI943A8R" OR "UNII-JSD5FGP5VD" OR "Vinylethylene") AND STYPE("Scholarly Journals" OR Reports OR Thesis OR "Government Documents") AND LA(ENG)
N = 6542

PROQUEST Dissertations and Theses:
ProQuest Dissertations and Theses may be accessed through the Kathryn A. Martin Library at the University of Minnesota at Duluth (https://libguides.d.umn.edu/az.php).

Date Searched: 05/30/2019
Date Range of Search: 1900 to Present
N = 305

ALL("1,2-Butadien" OR "1,2-Butadiene" OR "1,3-BUTADIEN" OR "1,3-Butadiene" OR "1-Methylallene" OR "2-Butene-1,4-diyl" OR "Allene, methyl-" OR "alpha,gamma-Butadiene" OR "Biethylene" OR "Bivinyl" OR "Buta-1,2-dien" OR "Buta-1,2-diene" OR "Buta-1,3-dien" OR "Buta-1,3-diene" OR "Butadien" OR "Butadiene" OR "Butadiene" OR "Butadiene monomer" OR "Butadiene-

1,2" OR "Butadiene-1,3" OR "Divinyl" OR "Erythrene" OR "Methylallene" OR "NCI-C50602" OR "UN 1010" OR "UNII-2AZI943A8R" OR "UNII-JSD5FGP5VD" OR "Vinylethylene") AND LA(ENG)

SCIENCE DIRECT:
Science Direct may be accessed through the EPA Desktop Library (https://intranet.epa.gov/desktop/databases.htm).

Date Searched: 05/23/19
Date Range of Search: 1823 to Present
N = 11,792

Science Direct 01:
"1,2-Butadien" OR "1,2-Butadiene" OR "1,3-BUTADIEN" OR "1,3-Butadiene" OR "1-Methylallene" OR "2-Butene-1,4-diyl" OR "Allene, methyl-" OR "alpha,gamma-Butadiene" OR "Biethylene"
N = 2539

Science Direct 02:
"Bivinyl" OR "Buta-1,2-dien" OR "Buta-1,2-diene" OR "Buta-1,3-dien" OR "Buta-1,3-diene" OR "Butadien" OR "Butadiene" OR "Butadiene" OR "Butadiene monomer"
N = 8149

Science Direct 03:
"Butadiene-1,2" OR "Butadiene-1,3" OR "Divinyl" OR "Erythrene" OR "Methylallene" OR "NCI-C50602" OR "UN 1010" OR "UNII-2AZI943A8R" OR "UNII-JSD5FGP5VD"
N = 1091

Science Direct 04:
"Vinylethylene"
N = 13

AGRICOLA:
Agricola may be accessed through the EPA Desktop Library (https://intranet.epa.gov/desktop/databases.htm) or within the EndNote environment.

Date Searched: 05/24/2019
Date Range of Search: 15th century to the Present
N = 688

Agricola 01:
1,2-Butadien
1,2-Butadiene
1,3-BUTADIEN
1,3-Butadiene
1-Methylallene
2-Butene-1,4-diyl
Allene, methyl-
alpha,gamma-Butadiene

Biethylene
Bivinyl
N = 322

Agricola 02:
Buta-1,2-dien
Buta-1,2-diene
Buta-1,3-dien
Buta-1,3-diene
Butadien
Butadiene
Butadiene
Butadiene monomer
Butadiene-1,2
Butadiene-1,3
N = 50

Agricola 03:
Divinyl
Erythrene
Methylallene
NCI-C50602
UN 1010
UNII-2AZI943A8R
UNII-JSD5FGP5VD
Vinylethylene
N = 316

TOXNET/(Toxline):
TOXNET(Toxline) may be accessed through the EPA Desktop Library (https://intranet.epa.gov/desktop/databases.htm).

Date Searched: 05/24/2019
Date Range of Search: 1900 to Present
N = 6302

TOXNET 01:
106-99-0 OR 590-19-2 OR 1213224-27-1 OR 130983-70-9 OR 183592-61-2
N = 2348

TOXNET 02:
25339-57-5
N = 3954

PubMed:
PubMed may be accessed through the EPA Desktop Library (https://www.ncbi.nlm.nih.gov/pubmed/)

Date Searched: 05/24/2019
Date Range of Search: 1900 to present
N = 5330

"1,2-Butadien" OR "1,2-Butadiene" OR "1,3-BUTADIEN" OR "1,3-Butadiene" OR "1-Methylallene" OR "2-Butene-1,4-diyl" OR "Allene, methyl-" OR "alpha,gamma-Butadiene" OR "Biethylene" OR "Bivinyl" OR "Buta-1,2-dien" OR "Buta-1,2-diene" OR "Buta-1,3-dien" OR "Buta-1,3-diene" OR "Butadien" OR "Butadiene" OR "Butadiene" OR "Butadiene monomer" OR "Butadiene-1,2" OR "Butadiene-1,3" OR "Divinyl" OR "Erythrene" OR "Methylallene" OR "NCI-C50602" OR "UN 1010" OR "UNII-2AZI943A8R" OR "UNII-JSD5FGP5VD" OR "Vinylethylene"
N = 5330

ECOTOX UNIFY:
This is an internal EPA database that is not accessible to the public. Results from the ECOTOX Unify search strategy.

Date Searched: 06/06/2019
Date Range of Search: all years
N = 22

A.1.2.2 Data Prioritization for Environmental Hazard, Human Health Hazard, Fate and Physical Chemistry

In brief, SWIFT Review has pre-set literature search strategies ("filters") developed by information specialists that can be applied to identify studies that are more likely to be useful for identifying human health and ecotoxicity content from those that likely do not (*e.g.*, analytical methods). The filters function like a typical search strategy where studies are tagged as belonging to a certain filter if the terms in the filter literature search strategy appear in title, abstract, keyword or medical subject headings (MeSH*)* fields content. The applied SWIFT Review filters focused on lines of evidence: human, animal models for human health, ecological taxa (which includes ecotoxicological animal models, plants, and other taxa), and *in vitro* studies. The details of the search strategies that underlie the filters are available online. Studies not retrieved using these filters were not considered further. Studies that included one or more of the search terms in the title, abstract, keyword, or MeSH fields were exported as a RIS file for screening in SwiftActiveScreener or DistillerSR[11].

A.1.2.3 Data Prioritization for Occupational Exposures and Environmental Releases and General Population, Consumer and Environmental Exposures

To prioritize references related to occupational exposure, environmental release, general population exposure, consumer exposure, and environmental exposure, EPA used positive and negative seed studies to build a classification model in SWIFT Review. The positive seeds were identified using relevant literature pool for the first ten TSCA risk evaluations, while the negative seeds were identified from a subset of literature for the current high-priority substances. The model was then applied to the unclassified literature to generate a classification score for each reference. Scores above a certain threshold value were then prioritized for further review in SWIFT-ActiveScreener.

[11] DistillerSR is a web-based systematic review software used to screen studies available at https://www.evidencepartners.com/products/distillersr-systematic-review-software.

A.2 Peer-reviewed Screening Process

The studies identified from publicly available database searches and SWIFT-Review filtering/prioritization were housed in HERO system and imported into SWIFT-ActiveScreener or DistillerSR for title/abstract and full-text screening. Both title/abstract and full-text screening were conducted by two independent reviewers. Screening is initiated with a pilot phase of screening (between 10 and 50) studies to identify areas where clarification in screening criteria might be needed or chemical-specific supplemental material tags might be identified. Records that met PECO (or equivalent criteria (Appendix A.1.2) during title and abstract screening were considered for full-text screening. At both the title/abstract and full-text review levels, screening conflicts were resolved by topic-specific experts and/or discussion among the primary screeners. For citations with no abstract, the articles are initially screened based on all or some of the following: title relevance (titles that suggest a record is not relevant can be excluded rather than marked as unclear), and page numbers (articles two pages in length or less were assumed to be conference reports, editorials, or letters). During title/abstract or full-text level screening in DistillerSR, studies that did not meet the PECO criteria, but which could provide supporting information were categorized (or "tagged") as supplemental information.

It is important to emphasize that being tagged as supplemental material does not mean the study would necessarily be excluded from consideration in an assessment. The initial screening level distinctions between a study meeting the PECO criteria and a supplemental study are often made for practical reasons and the tagging structure structures (as seen in the literature inventory trees and heat maps in Section 2.1 of this document) are designed to ensure the supplemental studies are categorized for easy retrieval if needed while conducting the assessment. The impact on the assessment conclusions of individual studies tagged as supporting material is often difficult to assess during the screening phase of the assessment. These studies may emerge as being critically important to the assessment and need to be evaluated and summarized at the individual study level (*e.g.*, cancer MOA mechanistic or non-English-language studies), or be helpful to provide context (*e.g.*, summarize current levels of exposure, provide hazard evidence from routes or durations of exposure not pertinent to the PECO), or not be cited at all in the assessment (*e.g.*, individual studies that contribute to a well-established scientific conclusion). Studies maybe be tagged as supplemental material during either title and abstract or full-text screening. When tagged as supplemental material during title and abstract screening, it may not be completely clear whether the chemical of interest is reported in the study (*i.e.*, abstracts may not describe all chemicals investigated). In these cases, studies are still tagged with the expectation that if full-text retrieval is pursued, then additional screening would be needed to clarify if the study is pertinent.

A.2.1 Inclusion/Exclusion Criteria

A PECO (population, exposure, comparator, and outcome) statement is typically used to focus the research question(s), search terms, and inclusion/exclusion criteria in a systematic review. PECO criteria were developed *a priori* to screening and modified to fit the various discipline areas supporting the TSCA risk evaluations. Variations include the RESO (receptor, exposure, scenario/setting, and outcome) used for the occupational exposure and environmental releases discipline, and PESO (pathways/processes, exposures, setting/scenario, and outcomes) used by the fate and transport discipline. All PECOs and PECO-equivalent criteria can be found in the following sections.

A.2.1.1 PECO for Environmental and Human Health Hazards

The PECO used in this evidence map to identify literature pertinent to 1,3-butadiene effects on human health and environmental hazard is presented in Table_Apx A-3. In addition to the PECO

criteria, studies containing potentially relevant supplemental material were tracked and categorized during the literature screening process as outlined in Table_Apx A-4.

Table_Apx A-3. Hazards Title and Abstract and Full-Text PECO Criteria for 1,3-Butadiene

PECO Element	Evidence
P	**Human:** Any population and life stage (*e.g.*, occupational or general population, including children and other sensitive populations). **Animal:** Aquatic and terrestrial species (live, whole organism) from any life stage (*e.g.*, preconception, in utero, lactation, peripubertal, and adult stages). Animal models will be inventoried according to the categorization below: Human health models: rat, mouse, rabbit, dog, hamster, guinea pig, cat, non-human primate, pig, hen (neurotoxicity only) Ecotoxicological models: invertebrates (*e.g.*, insects, spiders, crustaceans, mollusks, and worms) and vertebrates (*e.g.*, mammals and all amphibians, birds, fish, and reptiles). All hen studies (including neurotoxicity studies) will be included for ecotoxicological models. **Plants:** All aquatic and terrestrial species (live), including algal, moss, lichen and fungi species. **Screener note:** To identify human health and environmental hazards, other organisms not listed above in their respective categories can also be used. Non-mammalian model systems are increasingly used to identify potential human health hazards (*e.g.*, Xenopus, zebrafish), and traditional human health models (*e.g.*, rodents) can be used to identify potential environmental hazard. Neurotoxicity studies performed in hens (*e.g.*, OECD 418 and 419) are considered relevant to both human and eco hazard PECO considerations should be directed toward effects on target species only and not on the indirect effects expressed in taxa as a result of chemical treatment (*e.g.*, substance is lethal to a targeted pest species leading to positive effects on plant growth due to diminished presence of the targeted pest species). Tests of the single toxicants in *in vitro* systems or on gametes, embryos, or plant or fungal sections capable of forming whole, new organisms will be tagged as potentially supplemental (mechanistic studies). Bacteria and yeast studies specific for assessing genotoxicity or mutagenicity (*e.g.*, Ames assay) will also be tagged as potentially supplemental (mechanistic studies) but are otherwise excluded. Studies on viruses are excluded.
E	**Relevant forms and isomers:** 1,3-Butadiene (CASRN 106-99-0) **Related isomer:** 1,1-Dibromoethane - CASRN 557-91-5 For **synonyms** see the EPA Chemistry Dashboard. **Human:** Any exposure to 1,3-butadiene (CASRN 106-99-0). **Animal:** Any exposure to 1,3-butadiene (CASRN 106-99-0) including via water (including environmental aquatic exposures), soil or sediment, diet, gavage, injection, dermal, and inhalation. **Plants:** Any exposure to 1,3-butadiene (CASRN 106-99-0) including via water, soil, sediment. **Screener notes:** Field studies with media concentrations (*e.g.*, surface water, interstitial water, soil, sediment) and/or body/tissue concentrations of animals or plants are to be identified as **Supplemental** if any biological effects are reported.

PECO Element	Evidence
	Studies involving exposures to mixtures will be included only if they also include exposure to 1,3-Butadiene (CASRN 106-99-0) alone. Otherwise, mixture studies will be tagged as **Supplemental.** Controlled outdoor experimental studies (*e.g.*, controlled crop/greenhouse studies, mesocosm studies, artificial stream studies) are considered to be laboratory studies (**not field studies**) because there is a known and prescribed exposure dose(s) and an evaluation of hazardous effect(s). Whereas field studies (*e.g.*, biomonitoring) where there is no prescribed exposure dose(s) will be **excluded** if there is no evaluated hazardous effect, and tagged as **supplemental** field, if there is an evaluated hazardous effect.
C	**Human:** A comparison or referent population exposed to lower levels (or no exposure/exposure below detection limits) of 1,3-butadiene (CASRN 106-99-0), or exposure to 1,3-butadiene (CASRN 106-99-0) for shorter periods of time. **Animal and Plants:** A concurrent control group exposed to vehicle-only treatment and/or untreated control (control could be a baseline measurement). **Screener note:** • If no control group is explicitly stated or implied (*e.g.* by mention of statistical results that could only be obtained if a control group was present), the study will be marked as ***Unclear*** during Title/Abstract Screening. • All case series and case studies describing findings in a sample size of less than 20 people in any setting (*e.g.*, occupation, general population) will be tracked as ***Supplemental.*** Case-control, case-crossover, case-referent, case-only, case-specular, case-cohort, case-parent, nested case-control study designs are all ***Included.***
O	**Human**: All health outcomes (cancer and noncancer). **Animal and Plants**: All biological effects (including bioaccumulation from laboratory studies with concurrently measured water and tissue concentrations). **Screener note:** • **Measurable biological effects relevant for humans, animals and plants may include but are not limited to** mortality, behavioral, population, cellular, physiological, growth, reproduction, systemic, point of contact effects

Table_Apx A-4. Major Categories of Potentially Relevant Supplemental Material for 1,3-Butadiene

Category	Evidence
Mechanistic studies	Studies reporting measurements related to a health outcome that inform the biological or chemical events associated with phenotypic effects, in both mammalian and non-mammalian model systems, including *in vitro*, *in vivo* (by various non-inhalation routes of exposure), *ex vivo*, and *in silico* studies. These studies include assays for genotoxicity or mutagenicity using bacteria or yeast.
ADME, PBPK, and toxicokinetic	Studies designed to capture information regarding absorption, distribution, metabolism, and excretion (ADME), toxicokinetic studies, or physiologically based pharmacokinetic (PBPK) models.
Case reports or case series	Case reports ($n \leq 3$ cases) and case series (non-occupational) will be tracked as potentially relevant supplemental information.
Susceptible populations (no health outcome)	Studies that identify potentially susceptible subgroups; for example, studies that focus on a specific demographic, life stage, or genotype. This tag applies primarily during full-text screening. **Screener note:** if biological susceptibility issues are clearly present or ***strongly*** implied in the title/abstract, this supplemental tag may be applied at the title abstract level. If uncertain at title/abstract, do not apply this tag to the reference during title/abstract screening.
Mixture studies	Mixture studies that are not considered PECO-relevant because they do not contain an exposure or treatment group assessing only the chemical of interest. Human health animal model and eco animal model/plant will be tagged separately for mixture studies.
Non-English records	Non-English records will be tracked as potentially relevant supplemental information.
Records with no original data	Records that do not contain original data, such as other agency assessments, informative scientific literature reviews, editorials or commentaries.
Conference abstracts	Records that do not contain sufficient documentation to support study evaluation and data extraction.
Field Studies	Field studies with media concentrations (*e.g.*, surface water, interstitial water, soil, sediment) and/or body/tissue concentrations of animals or plants if biological effects reported.
Isomer	PECO-relevant studies with an exposure to one of the identified isomers, if any.

A.2.1.2 PECO for Consumer, Environmental, and General Population Exposures.

Table_Apx A-5. Generic Inclusion Criteria for the Data Sources Reporting Exposure Data on General Population, Consumers and Environmental Receptors

PECO Element	Evidence
Population	**Human:** General population; consumers; bystanders in the home; near-facility populations (includes industrial and commercial facilities manufacturing, processing, or using the chemical substance); children; susceptible populations (life stages, preexisting conditions, genetic factors), pregnant women; lactating women, women of child-bearing age. Many human population groups may be exposed. No chemical-specific exclusions are suggested at this time.
	Environmental: aquatic species, terrestrial species, terrestrial plants, aquatic plants (field studies only)
Exposure	**Expected Primary Exposure Sources, Pathways, Routes:** Pathways: indoor air/vapor/mist; indoor dust; particles; outdoor/ambient air; surface water; biosolids; sediment; breastmilk; food items containing 1,3-butadiene including fish; consumer product uses in the home (including consumer product containing chemical); Routes of Exposure: Inhalation, Oral, Dermal
Comparator (Scenario)	**Human:** Consider media-specific background exposure scenarios and use/source specific exposure scenarios as well as which receptors are and are not reasonably exposed across the projected exposure scenarios.
	Environmental Consider media-specific background exposure scenarios and use/source specific exposure scenarios as well as which receptors are and are not reasonably exposed across the projected exposure scenarios.
Outcomes for Exposure Concentration or Dose	**Human:** Acute, subchronic, and/or indoor air and water concentration estimates (mg/m^3 or mg/L). Both external potential dose and internal dose based on biomonitoring and reverse dosimetry mg/kg/day will be considered. Characteristics of consumer products or articles (weight fraction, emission rates, etc) containing 1,3-butadiene
	Environmental: A wide range of ecological receptors will be considered (range depending on available ecotoxicity data) using surface water concentrations, sediment concentrations.

Table_Apx A-6. Pathways Identified as Supplemental for 1,3-Butadiene[a]

Chemical	Drinking Water	Ambient Air	Air Disposal	Land Disposal	Underground Disposal	Ground Water
1,3-Butadiene	X	X	X	--	--	--

[a] "Supplemental pathways" refer to pathways addressed by other EPA administered statutes (see Section 2.6.3.1). Studies tagged under these pathways provide media information that is not prioritized in the screening process.

A.2.1.3 RESO for Occupational Exposure and Environmental Releases

EPA developed a generic RESO statement to guide the screening of engineering and occupational exposure data or information sources for the TSCA risk evaluations. Data or information sources that comply with the inclusion criteria specified in the RESO statement are eligible for inclusion, considered for evaluation, and possibly included in the environmental release and occupational exposure assessments. On the other hand, data or information sources that fail to meet the criteria in the RESO

statement are excluded from further consideration.

Assessors seek information on various chemical-specific engineering and occupational exposure data needs as part of the process of developing the exposure assessment for each risk evaluation. EPA uses the RESO statement (Table_Apx A-7) along with the information in Table_Apx A-8 when screening the engineering and occupational exposure data and information.

Table_Apx A-7. Inclusion Criteria for Data Sources Reporting Engineering and Occupational Exposure Data

RESO Element	Evidence
Receptors	• Humans: Workers, including occupational non-users • Environment: All environmental receptors (relevant release estimates input to Exposure) Please refer to the conceptual models for more information about the environmental and human receptors included in the TSCA risk evaluation.
Exposure	• Worker exposure to and relevant environmental releases of the chemical substance from occupational scenarios: Dermal and inhalation exposure routes (as indicated in the conceptual model) Oral route (as indicated in the conceptual model) Please refer to the conceptual models for more information about the routes and media/pathways included in the TSCA risk evaluation.
Setting or Scenario	• Any occupational setting or scenario resulting in worker exposure and relevant environmental releases (includes all manufacturing, processing, use, disposal.
Outcomes	• Quantitative estimates* of worker exposures and of relevant environmental releases from occupational settings • General information and data related and relevant to the occupational estimates*

* Metrics (*e.g.*, mg/kg/day or mg/m^3 for worker exposures, kg/site/day for releases) are determined by toxicologists for worker exposures and by exposure assessors for releases; also, the Engineering, Release and Occupational Exposure Data Needs (Table_Apx A-8) provides a list of related and relevant general information.

Table_Apx A-8. Engineering, Environmental Release and Occupational Data Necessary to Develop the Environmental Release and Occupational Exposure Assessments

Objective Determined during Scoping	Type of Data [a]
General Engineering Assessment (may apply to Occupational Exposures and / or Environmental Releases)	Description of the life cycle of the chemical(s) of interest, from manufacture to end-of-life (*e.g.*, each manufacturing, processing, or use step), and material flow between the industrial and commercial life cycle stages. The total annual U.S. volume (lb/yr or kg/yr) of the chemical(s) of interest manufactured, imported, processed, and used; and the share of total annual manufacturing and import volume that is processed or used in each life cycle step. Description of processes, equipment, and unit operations during each industrial/ commercial life cycle step. Material flows, use rates, and frequencies (lb/site-day or kg/site-day and days/yr; lb/site-batch and batches/yr) of the chemical(s) of interest during each industrial/ commercial life cycle step. Note: if available, include weight fractions of the chemicals (s) of interest and material flows of all associated primary chemicals (especially water). Number of sites that manufacture, process, or use the chemical(s) of interest for each industrial/ commercial life cycle step and site locations. Concentration of the chemical of interest
Occupational Exposures	Description of worker activities with exposure potential during the manufacture, processing, or use of the chemical(s) of interest in each industrial/commercial life cycle stage. Potential routes of exposure (*e.g.*, inhalation, dermal). Physical form of the chemical(s) of interest for each exposure route (*e.g.*, liquid, vapor, mist) and activity. Breathing zone (personal sample) measurements of occupational exposures to the chemical(s) of interest, measured as time-weighted averages (TWAs), short-term exposures, or peak exposures in each occupational life cycle stage (or in a workplace scenario similar to an occupational life cycle stage). Area or stationary measurements of airborne concentrations of the chemical(s) of interest in each occupational setting and life cycle stage (or in a workplace scenario similar to the life cycle stage of interest). For solids, bulk and dust particle size characterization data. Dermal exposure data. Exposure duration (hr/day). Exposure frequency (days/yr). Number of workers who potentially handle or have exposure to the chemical(s) of interest in each occupational life cycle stage. PPE types employed by the industries within scope. ECs employed to reduce occupational exposures in each occupational life cycle stage (or in a workplace scenario similar to the life cycle stage of interest), and associated data or estimates of exposure reductions.
Environmental Releases (to relevant environmental media)	Description of sources of potential environmental releases, including cleaning of residues from process equipment and transport containers, involved during the manufacture, processing, or use of the chemical(s) of interest in each life cycle stage. Estimated mass (lb or kg) of the chemical(s) of interest released from industrial and commercial sites to each environmental medium (water) and treatment and disposal methods (POTW), including releases per site and aggregated over all sites (annual release rates, daily release rates) Release or emission factors. Number of release days per year.

Objective Determined during Scoping	Type of Data [a]
	Waste treatment methods and pollution control devices employed by the industries within scope and associated data on release/emission reductions.

[a] These are the tags included in the full-text screening form. The screener makes a selection from these specific tags, which describe more specific types of data or information.
In addition to the data types listed above, EPA may identify additional data needs for mathematical modeling. These data needs will be determined on a case-by-case basis.
Abbreviations:
hr=Hour
kg=Kilogram(s)
lb=Pound(s)
yr=Year
PV=Particle volume
POTW=Publicly owned treatment works
PPE=Personal protection equipment
PSD=Particle size distribution
TWA=Time-weighted average

A.2.1.4 PESO for Fate and Transport

EPA developed a generic PESO statement to guide the screening of environmental fate data or information sources for the TSCA risk evaluations. Data or information sources that comply with the inclusion criteria in the PESO statement are eligible for inclusion, considered for evaluation, and possibly included in the environmental fate assessment. On the other hand, data or information sources that fail to meet the criteria in the PESO statement are excluded from further consideration.

Assessors seek information on various chemical-specific fate endpoints and associated fate processes, environmental media and exposure pathways as part of the process of developing the environmental fate assessment for each risk evaluation. EPA uses the PESO statement (Table_Apx A-9) along with the information in Table_Apx A-10 when screening the fate data or information sources to ensure complete coverage of the processes, pathways and data or information relevant to the environmental fate and transport of the chemical substance undergoing risk evaluation.

Table_Apx A-9. Inclusion Criteria for Data or Information Sources Reporting Environmental Fate and Transport Data

PESO Element	Evidence
Pathways and **P**rocesses	Environmental fate, transport, partitioning and degradation behavior across environmental media to inform exposure pathways of the chemical substance of interest Exposure pathways included in the conceptual models: air, surface water, groundwater, wastewater, soil, sediment and biosolids. Processes associated with the target exposure pathways Bioconcentration and bioaccumulation Destruction and removal by incineration Please refer to the conceptual models for more information about the exposure pathways included in each TSCA risk evaluation.
Exposure	Environmental exposure of environmental receptors (*i.e.*, aquatic and terrestrial organisms) to the chemical substance of interest, mixtures including the chemical substance, and/or its degradation products and metabolites Environmental exposure of human receptors, including any potentially exposed or susceptible subpopulations, to the chemical substance of interest, mixtures including the chemical substance, and/or its degradation products and metabolites Please refer to the conceptual models for more information about the environmental and human receptors included in each TSCA risk evaluation.
Setting or **S**cenario	Any setting or scenario resulting in releases of the chemical substance of interest into the natural or built environment (*e.g.*, buildings including homes or workplaces, or wastewater treatment facilities) that would expose environmental (*i.e.*, aquatic and terrestrial organisms) or human receptors (*i.e.*, general population, and potentially exposed or susceptible subpopulation)
Outcomes	Fate properties which allow assessments of exposure pathways: Abiotic and biotic degradation rates, mechanisms, pathways, and products Bioaccumulation magnitude and metabolism rates Partitioning within and between environmental media (see Pathways and Processes)

Table_Apx A-10. Fate Endpoints and Associated Processes, Media and Exposure Pathways Considered in the Development of the Environmental Fate Assessment

Fate Data Endpoint	Associated Process(es)	Associated Media/Exposure Pathways			
		Surface Water, Wastewater, Sediment	Soil, Biosolids	Groundwater	Air
Required Environmental Fate Data					
Abiotic reduction rates or half-lives	Abiotic reduction, Abiotic dehalogenation	X			
Aerobic biodegradation rates or half-lives	Aerobic biodegradation	X	X		
Anaerobic biodegradation rates or half-lives	Anaerobic biodegradation	X	X	X	
Aqueous photolysis (direct and indirect) rates or half-lives	Aqueous photolysis (direct and indirect)	X			
Atmospheric photolysis (direct and indirect) rates or half-lives	Atmospheric photolysis (direct and indirect)				X
Bioconcentration factor (BCF), Bioaccumulation factor (BAF)	Bioconcentration, Bioaccumulation	X	X		X
Biomagnification and related information	Trophic magnification	X			
Desorption information	Sorption, Mobility	X	X	X	
Destruction and removal by incineration	Incineration				X
Hydrolysis rates or half-lives	Hydrolysis	X	X	X	
K_{OC} and other sorption information	Sorption, Mobility	X	X	X	
Wastewater treatment removal information	Wastewater treatment	X	X		
Supplemental (or Optional) Environmental Fate Data					
Abiotic transformation products	Hydrolysis, Photolysis, Incineration	X			X
Aerobic biotransformation products	Aerobic biodegradation	X	X		
Anaerobic biotransformation products	Anaerobic biodegradation	X	X	X	
Atmospheric deposition information	Atmospheric deposition				X
Coagulation information	Coagulation, Mobility	X		X	
Incineration removal information	Incineration				X

A.2.1.5 Generation of Hazard Heat Maps

As stated in Appendix A.1.2.2, SWIFT Review has pre-set literature search strategies ("filters") developed by information specialists that can be applied to identify studies that are more likely to be useful for identifying human health and ecotoxicity content. The filters function like a typical search strategy where studies are tagged as belonging to a certain filter if the terms in the filter literature search strategy appear in title, abstract, keyword or MeSH fields content.

After the completion of full-text screening for hazard data, all references tagged as included (or "PECO-relevant) were uploaded to the SWIFT Review tool for further filtering. The SWIFT Review filters applied at this phase focused on types of health outcomes included: "ADME", "PBPK", "cancer", "cardiovascular", "developmental", "endocrine", "gastrointestinal", "hematological and immune", "hepatic", "mortality", "musculoskeletal", "neurological", "nutritional and metabolic", "ocular and sensory", "renal", "reproductive", "respiratory", and "skin and connective tissue". The details of these health outcome search strategies that underlie the filters are available online. Studies that included one or more of the search terms in the title, abstract, keyword, or MeSH fields were exported and used to populate the Hazard Heat Map (Figure 2-10). Studies that were not retrieved using these filters were tagged as "No Tag". The evidence type listed in the heat map (*e.g.*, human, animal-human health model, animal- environmental model, and plant) was manually assigned to each reference by screeners during the full-text screening.

The health outcome tags were originally designed for vertebrate systems, and as such, did not conform well to plant evidence. Therefore, any plant studies tagged for: "cancer", "cardiovascular", "gastrointestinal", "hematological and immune", "hepatic", "musculoskeletal", "neurological", "ocular and sensory" and "renal and respiratory" were manually reviewed and re-tagged to more appropriate health outcomes.

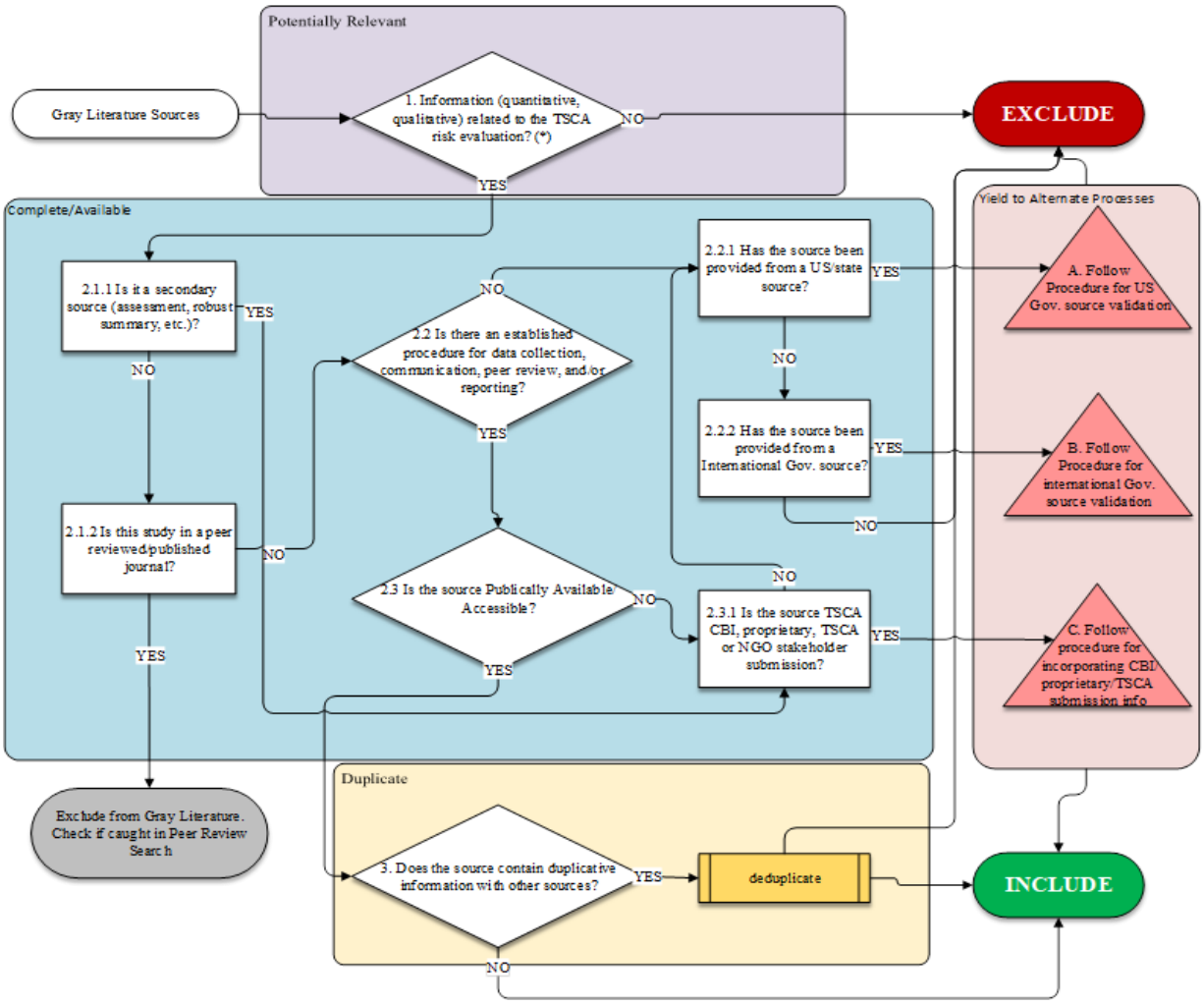
A.3 Gray Literature Search and Screening Strategies

EPA conducted a gray literature search for available information to support the TSCA risk evaluations for the next twenty TSCA risk evaluations. Gray literature is defined as the broad category of data/information sources not found in standard, peer-reviewed literature databases (*e.g.*, PubMed and Web of Science). Gray literature includes data/information sources such as white papers, conference proceedings, technical reports, reference books, dissertations, information on various stakeholder websites, and other databases. Given the nature of how gray literature is searched and collected, results may not come with a bibliographic citation or abstract and were therefore processed using a decision tree logic described in Appendix A.3.1 for potential relevance prior to entering full text screening where a discipline-specific PECO is applied.

Search terms were variable dependent on source and based on knowledge of a given source to provide discipline-specific information. A summary of sources and search terms are provided in Appendix A.3.3. The criteria for determining the potential relevance of documents identified from gray literature sources is described in the following sections for each discipline.

A.3.1 Screening of Gray Literature

To reduce the overall burden of processing gray literature results, EPA developed a screening process to determine the potential relevance of gray literature. This step was introduced prior to collecting the resulting documents. Figure_Apx A-1 describes the decision logic used to screen gray literature results.



Figure_Apx A-1. Decision Logic Tree Used to Screen Gray Literature Results

A.3.2 Initial Screening of Sources using Decision Logic Tree

The purpose of the inclusion/exclusion decision logic tree in Figure_Apx A-1 is to provide a broad, general screening technique to determine whether each gray literature source should be included and further screened or excluded with no additional screening necessary. The diamonds in the decision tree require analysis by the screener, whereas the rectangular boxes are used to classify the type of source. All the questions used in the decision process are provided in Table_Apx A-11.

Table_Apx A-11. Decision Logic Tree Overview

Step	Metric	Questions to Consider
1	Potential Relevance	Does the result have information (qualitative or quantitative) related to TSCA risk evaluations? *Apply Discipline relevancy metric
2.1.1	Complete / Available	Is it a secondary data source (assessment, robust summary, TSCA submission databases, etc.)?
2.1.2		Is the document from a peer reviewed/published journal?
2.2		Is there an established procedure for data collection, communication, peer review, and/or reporting?
2.2.1		Has the data been provided by a US governmental/state source?
2.2.2		Has the data been provided by an international governmental source?
2.3		Are these data publicly available/accessible?
2.3.1		Is the source TSCA CBI, proprietary, TSCA or NGO stakeholder submission?
3	Duplicate	Does the result contain any duplicative information found in other sources?

Results of the gray literature search and decision tree process are included in Appendix A.3.4.

A.3.3 TSCA Submission Searching and Title Screening

EPA screens information submitted under TSCA Sections 4, 5, 8(e), and 8(d), as well as for your information (FYI) submissions. In the gray literature process defined in Appendix A.3.2, EPA considers the databases that contain TSCA submissions to be secondary sources (Step 1.1) because the metadata in the databases are secondary. These databases then advance to Step 2.3.1 and then to Process C. The Process C steps are described here.

EPA first screens the titles using two screeners per title. EPA conducts this step primarily to reduce the number of full studies to be obtained because some studies are available only on microfiche or in long-term storage. Screening is done using the inclusion and exclusion criteria within the relevant PECOs, PESOs or RESOs for each topic area (Appendix A.2.1). EPA excludes interim reports (*e.g.*, interim sacrifices for toxicity studies) and only final reports are further considered. If the title is not clear regarding the document's contents, EPA obtains the full text and advances to the next steps.

After full texts are obtained, EPA reviewed some sources (prior to full-text screening) based on whether they have several factors; primary data, an established procedure for peer review, data collection, communication and/or reporting and are publicly available. Sources that have these factors will move on to full text screening. Other sources will go straight to full text screening using PECO-type criteria without going through this extra step.

EPA may decide to initiate a backwards search on sources that are deemed to have secondary data. In situations where parameters such as procedures for peer review and data collection are unclear, EPA may reach out to the authors to retrieve information to gauge whether the source should be included or

excluded. Studies that are not publicly available (such as proprietary or CBI sources) may undergo additional screening steps.

During the full-text screening step, two individuals screen each source according to the PECOs, PESOs and RESOs (Appendix A.2.1).

Results of the TSCA submission search and decision tree process are included in Appendix A.3.4.

A.3.4 Gray Literature Search Results for 1,3-Butadiene

Table_Apx A-12 provides a list of gray literature sources that yielded results for 1,3-butadiene.

Table_Apx A-12 Gray Literature Sources that Yielded Results for 1,3-butadiene

Source Agency	Source Name	Source Type	Source Category	Source Website
ATSDR	ATSDR Tox Profile Updates and Addendums	Other US Agency Resources	Assessment or Related Document	https://www.atsdr.cdc.gov/toxprofiles/profilesaddenda.asp
ATSDR	ATSDR Toxicological Profiles (original publication)	Other US Agency Resources	Assessment or Related Document	https://www.atsdr.cdc.gov/toxprofiles/index.asp
Australian Government, Department of Health	NICNAS Assessments (human health, Tier I, II or III)	International Resources	Assessment or Related Document	https://www.industrialchemicals.gov.au/chemical-information/search-assessments
CAL EPA	Technical Support Documents for regulations: Cancer Potency Information	Other US Agency Resources	Assessment or Related Document	https://oehha.ca.gov/chemicals
CAL EPA	Technical Support Documents for regulations: Reference Exposure Levels (RELs)	Other US Agency Resources	Assessment or Related Document	https://oehha.ca.gov/chemicals
ECHA	European Union Risk Assessment Report	International Resources	Assessment or Related Document	https://echa.europa.eu/information-on-chemicals/information-from-existing-substances-regulation
ECHA	ECHA Documents	International Resources	Assessment or Related Document	https://echa.europa.eu/information-on-chemicals

Source Agency	Source Name	Source Type	Source Category	Source Website
Env Canada	Priority Substances List Assessment Report; State of Science Report, Environment Canada Assessment	International Resources	Assessment or Related Document	https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/substances-list/priority-list.html
EPA	OPPT: TSCATS database maintained at SRC (TSCA submissions)	US EPA Resources	Database	https://www.nlm.nih.gov/pubs/techbull/so08/so08_sis_reprint_epa_tsca_inventory_reports.html
EPA	OPPT: Chemview (TSCA submissions - chemical test rule data and substantial risk reports)	US EPA Resources	Database	https://chemview.epa.gov/chemview
EPA	OPPT: 8e database (CBI) (TSCA submissions)	US EPA Resources	Database	
EPA	OPPT: CIS (CBI LAN) (TSCA submissions)	US EPA Resources	Database	
EPA	Office of Air: AQS, Annual	US EPA Resources	Database	https://www.epa.gov/aqs/obtaining-aqs-data
EPA	Office of Air: National Emissions Inventory (NEI) - National Emissions Inventory (NEI) Data (2014, 2011, 2008)	US EPA Resources	Database	https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data
EPA	Office of Water: STORET and WQX	US EPA Resources	Database	https://www.waterqualitydata.us/portal/
EPA	Support document for AEGLS	US EPA Resources	Assessment or Related Document	https://www.epa.gov/aegl/access-acute-exposure-guideline-levels-aegls-values
EPA	IRIS Summary	US EPA Resources	Assessment or Related Document	https://cfpub.epa.gov/ncea/iris_drafts/atoz.cfm?list_type=alpha
EPA	Office of Air: TRI	US EPA Resources	Database	https://www.epa.gov/toxics-release-inventory-tri-program/tri-data-and-tools
EPA	IRIS Tox Review	US EPA Resources	Assessment or Related Document	https://cfpub.epa.gov/ncea/iris2/atoz.cfm

Source Agency	Source Name	Source Type	Source Category	Source Website
EPA	Other EPA: Misc sources	US EPA Resources	General Search	https://www.epa.gov/
EPA	EPA: AP-42	US EPA Resources	Regulatory Document or List	https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors
EPA	EPA Ambient Monitoring Technology Information Center – Air Toxics Data	US EPA Resources	Database	https://www3.epa.gov/ttnamti1/toxdat.html
EPA	Office of Water: CFRs	US EPA Resources	Regulatory Document or List	https://www.epa.gov/eg
EPA	Office of Air: CFRs and Dockets	US EPA Resources	Regulatory Document or List	https://www.epa.gov/stationary-sources-air-pollution
EPA	EPA: Generic Scenario	US EPA Resources	Assessment or Related Document	https://www.epa.gov/tsca-screening-tools/chemsteer-chemical-screening-tool-exposures-and-environmental-releases#genericscenarios
IARC	IARC Monograph	International Resources	Assessment or Related Document	http://monographs.iarc.fr/ENG/Monographs/PDFs/index.php
ILO	International Chemical Safety Cards (ICSCs)	International Resources	Database	https://www.ilo.org/safework/info/publications/WCMS_113134/lang--en/index.htm
Japan	Japanese Ministry of the Environment Assessments - Environmental Risk Assessments (Class I Designated Chemical Substances Summary Table)	International Resources	Regulatory Document or List	https://www.env.go.jp/en/chemi/prtr/substances/
KOECT	Kirk-Othmer Encyclopedia of Chemical Technology Journal Article	Other Resource	Encyclopedia	https://onlinelibrary.wiley.com/doi/book/10.1002/0471238961

Source Agency	Source Name	Source Type	Source Category	Source Website
NIOSH	CDC NIOSH - Occupational Health Guideline Documents	Other US Agency Resources	Assessment or Related Document	https://www.cdc.gov/niosh/docs/81-123/default.html
NIOSH	CDC NIOSH - Pocket Guide	Other US Agency Resources	Database	https://www.cdc.gov/niosh/npg/default.html
NIOSH	CDC NIOSH - Health Hazard Evaluations (HHEs)	Other US Agency Resources	Assessment or Related Document	https://www2a.cdc.gov/hhe/search.asp
NIOSH	CDC NIOSH - Publications and Products	Other US Agency Resources	Assessment or Related Document	https://www2a.cdc.gov/hhe/search.asp
NIOSH	CDC NIOSH - Workplace Survey Reports	Other US Agency Resources	Assessment or Related Document	https://www.cdc.gov/niosh/surveyreports/allreports.html
NTP	Technical Reports	Other US Agency Resources	Assessment or Related Document	https://ntp.niehs.nih.gov/publications/reports/index.html?type=Technical+Report
NTP	OHAT Monographs	Other US Agency Resources	Assessment or Related Document	https://ntp.niehs.nih.gov/pubhealth/hat/noms/evals.html
NTP	RoC Monographs	Other US Agency Resources	Assessment or Related Document	https://ntp.niehs.nih.gov/pubhealth/roc/listings/index.html
OECD	OECD Emission Scenario Documents	International Resources	Assessment or Related Document	http://www.oecd.org/document/46/0,2340,en_2649_201185_2412462_1_1_1_1,00.html
OECD	OECD: General Site	International Resources	General Search	https://www.oecd.org/
TERA	Toxicology Excellence for Risk Assessment	Other Resources	Assessment or Related Document	https://tera.org/

Appendix B PHYSICAL AND CHEMICAL PROPERTIES OF 1,3-BUTADIENE

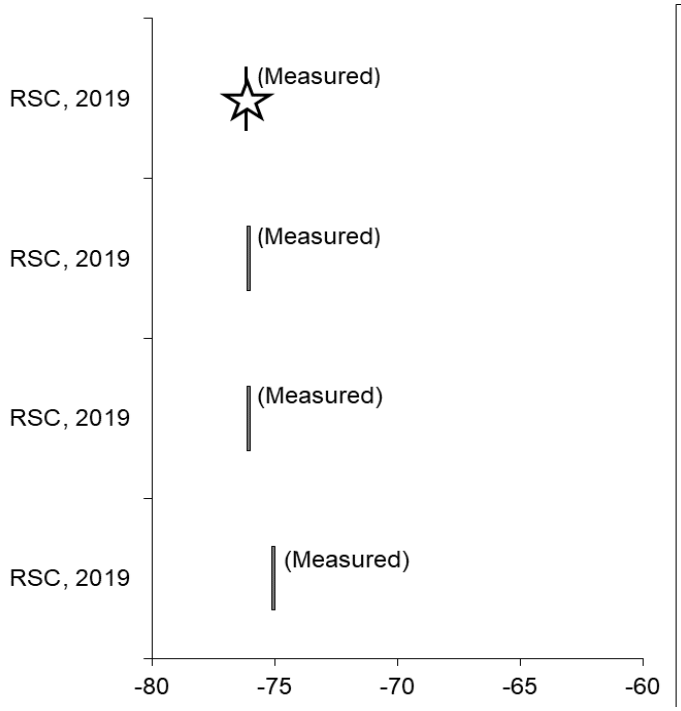
Table_Apx B-1 summarizes statistics for the physical and chemical property values identified through systematic review as of June 2020. The "N" column indicates the number of unique primary sources of data for that endpoint. That is, if multiple sources presented equivalent values and cited the same primary source, only one of those was included in these statistics and included in the statistical calculations. All physical and chemical property values that were extracted and evaluated as of June 2020 are presented in the supplemental file *Data Extraction and Data Evaluation Tables for Physical and Chemical Property Studies* (EPA-HQ-OPPT-2018-0451).

Table_Apx B-1. Summary Statistics for Reviewed Physical Properties

Property or Endpoint	N	Unit	Mean	Standard Deviation	Min	Max
Molecular formula	-	-	NA	NA	NA	NA
Molecular weight	-	g/mol	NA	NA	NA	NA
Physical state	4	-	NA	NA	NA	NA
Physical properties	2	-	NA	NA	NA	NA
Melting point	13	ºC	-109.3	1.1	-113	-108.7
Boiling point	14	ºC	37	60	-5	160
Density	6	g/cm^3	0.62	0.014	0.6149	0.65
Vapor pressure	5	mm Hg	2034	150	1863	2234
Vapor density	1	-	1.87	-	1.87	1.87
Water solubility	4	mg/L	735	1.26	733	736
Octanol/water partition coefficient (log Kow)	5	-	1.95	0.05	1.90	1.99
Henry's Law constant	1	$atm \cdot m^3/mol$	0.204	-	0.204	0.204
Flash point	3	ºC	-75.70	0.61	-76.11	-75.00
Auto flammability	1	ºC	420	-	420	420
Viscosity	2	cP	0.169	0.228	0.00754	0.33
Refractive index	4	-	1.4276	0.00350	1.4223	1.4295
Dielectric constant	1	-	2.05	-	2.05	2.05

NA = Not applicable

The preliminarily selected value for the 1,3-butadiene flash point lies outside the 95% confidence interval, defined as ±2 standard deviations from the mean under the assumption that the data are normally distributed (see Figure 2-8). The preliminarily selected value was selected because it is the only high-quality data collected for this endpoint. Information about all reported flash point values are summarized in Figure_Apx B-1 and presented in the supplemental file *Data Extraction and Data Evaluation Tables for Physical and Chemical Property Studies* (EPA-HQ-OPPT-2018-0451).



Reference	Value	Quality	Type
RSC, 2019	**-76.1111 °C**	High	Measured
RSC, 2019	-76 °C	Medium	Measured
RSC, 2019	-76 °C	Medium	Measured
RSC, 2019	-75 °C	Medium	Measured

Bolded value represent proposed value for use in risk evaluation

Graph Legend

High Data Quality

Medium Data Quality

Low Data Quality

Proposed Value

Value reported as greater than (>)

Value reported as lesser than (<)

Figure_Apx B-1. Tornado Diagram for Flash Point Data Identified in Systematic Review

Appendix C ENVIRONMENTAL FATE AND TRANSPORT PROPERTRIES

Table_Apx C-1 provides the environmental fate characteristics that EPA identified and considered in developing the scope for 1,3-butadiene. This information was presented in *Proposed Designation of 1,3-Butadiene (CASRN 106-99-0)) as a High-Priority Substance for Risk Evaluation* (U.S. EPA, 2019d) and may be updated as EPA collects additional information through systematic review methods.

Table_Apx C-1. Environmental Fate Characteristics of 1,3-Butadiene

Property or Endpoint	Value	Reference
Direct Photodegradation	Absorbs at wavelengths >290 nm, and therefore, may be susceptible to direct photolysis by sunlight	NLM (2020)
	The primary pathway of destruction of 1,3-butadiene is likely to occur by photo-initiated bimolecular processes rather than direct photochemical degradation	ATSDR (2012), Kopczynski et al. (1972)
Indirect Photodegradation	$t_{1/2}$ = 3.7 hours (based on a 12-hour day with 1.5×10^6 OH/cm^3 and hydroxyl radical reaction rate constant of 6.93×10^{-11} cm^3/molecule-sec at 25 °C)	NLM (2020)
	$t_{1/2}$ = 5.6 hours (based on a 12-hour day with 5×10^5 molecules OH /cm^3 and hydroxyl radical reaction rate constant of 6.93×10^{-11} cm^3/molecule-sec at 25 °C) Major products formed from the reaction include acrolein and formaldehyde	ATSDR (2012) citing Atkinson (1989) and Baker et al. (2005)
	$t_{1/2}$ = 1.4–1.7 days (based on a 12-hour day with 7×10^{11} molecules ozone/cm^3 and an ozone reaction rate constant of 6.7×10^{-18} cm^3/molecule-sec at 25 °C) Major products formed from the reaction of 1,3-butadiene with ozone are acrolein, formaldehyde, acetylene, ethylene, and formic anhydride	NLM (2020); ATSDR (2012) citing Atkinson and Carter (1984)
	$t_{1/2}$ = 14.9 hours (based on a 12-hour day with 2.4×10^8 nitrate molecules/cm^3 and a nitrate radical reaction rate constant of 5.4×10^{-14} cm^3/molecule-sec at 22 °C)	NLM (2020); ATSDR (2012) citing Atkinson et al. (1984)

Property or Endpoint	Value	Reference
	Acrolein was identified as the major product of this reaction	
Hydrolysis	Not expected to hydrolyze due to lack of hydrolysable functional groups	ECB (2002)
	Metabolic byproducts of 1,3-butadiene can be hydrolyzed rapidly	ATSDR (2012) citing Kirman et al. (2010)
Biodegradation	0–4%/28 days (based on OECD 301C study with 1-drop of sludge/L)[b]	NITE (2019)
	Biodegradation of 1,3-butadiene in water and soil proceeds through oxidation to form 3,4-epoxy-1-butene, a potent electrophile (with pure cultures)	ATSDR (2012) citing Hou et al. (1979); Patel et al. (1982); Watkinson and Somerville (1976)
Wastewater Treatment	97% total removal (0.02% by biodegradation, 0.53% by sludge, 96% by volatilization to air; estimated)[b]	U.S. EPA (2012b)
Bioconcentration Factor	10 (estimated)[c]	U.S. EPA (2012b)
Bioaccumulation Factor	10 (estimated)[c]	U.S. EPA (2012b)
Soil Organic Carbon: Water Partition Coefficient (Log K_{OC})	2.46	ATSDR (2012) citing Hansch et al. (1995) and Lyman et al. (1990)

[a]Measured unless otherwise noted
[b]OECD 301C may be an inappropriate test method for volatile substances if precautions are not taken to prevent sample loss
[c]EPI Suite™ physical property inputs: Log K_{OW} = 1.99, BP = -4.40 °C, MP = -108.90 °C, VP = 2110 mm Hg, WS = 735 mg/L SMILES C(C=C)=C

Appendix D REGULATORY HISTORY

The chemical substance, 1,3-butadiene, is subject to federal and state laws and regulations in the United States (Table_Apx D-1and Table_Apx D-2). Regulatory actions by other governments, tribes and international agreements applicable to 1,3-butadiene are listed in Table_Apx D-3.

D.1 Federal Laws and Regulations

Table_Apx D-1. Federal Laws and Regulations

Statutes/Regulations	Description of Authority/Regulation	Description of Regulation
EPA Statutes/Regulations		
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.	1,3-Butadiene is one of the 20 chemicals EPA designated as a High-Priority Substance for risk evaluation under TSCA (84 FR 71924, December 30, 2019). Designation of 1,3-butadiene as a high-priority substance constitutes the initiation of the risk evaluation on the chemical.
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.	1,3-Butadiene manufacturing (including importing), processing, and use information is reported under the CDR rule (85 FR 20122, April 2, 2020).
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) or processed in the United States.	1,3-Butadiene was on the initial TSCA Inventory and therefore was not subject to EPA's new chemicals review process under TSCA Section 5 (60 FR 16309, March 29, 1995).
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.	20 risk reports received for 1,3-butadiene (2017, 2011, 2008-2007, 2005, 2002-1997, 1995-1994, 1992, 1990) (U.S. EPA, ChemView, Accessed April 8, 2019).

Statutes/Regulations	Description of Authority/Regulation	Description of Regulation
Emergency Planning and Community Right-to-Know Act (EPCRA) – Section 313	Requires annual reporting from facilities in specific industry sectors that employ 10 or more full-time equivalent employees and that manufacture, process or otherwise use a TRI-listed chemical in quantities above threshold levels. A facility that meets reporting requirements must submit a reporting form for each chemical for which it triggered reporting, providing data across a variety of categories, including activities and uses of the chemical, releases and other waste management (*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).	1,3-Butadiene is a listed substance subject to reporting requirements under 40 CFR 372.65, effective as of January 01, 1987.
Clean Air Act (CAA) – Section 112(b)	Defines the original list of 189 hazardous air pollutants (HAPs). Under 112(c) of the CAA, EPA must identify and list source categories that emit HAPs and then set emission standards for those listed 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 HAPs by adding or deleting a substance. Since 1990, EPA has removed two pollutants from the original list leaving 187 at present.	1,3-Butadiene is listed as a HAP (42 U.S. Code Section 7412).
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 area sources, the standards must	EPA has established NESHAPs for a number of source categories that emit 1,3-butadiene to air.

Statutes/Regulations	Description of Authority/Regulation	Description of Regulation
	require generally achievable control technology (GACT) though may require MACT.	
Clean Air Act (CAA) - Sections 112(d) and 112(f)	Risk and technology review (RTR) of Section 112(d) national emission standards for hazardous air pollutants (NESHAP). 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. Section 112(d)(6) requires EPA to review and revise the emission standards, as necessary, taking into account developments in practices, processes and control technologies.	EPA has promulgated a number of RTR NESHAP and will do so, as required, for the remaining source categories with NESHAP.
Clean Air Act (CAA) - Section 183(e)	Section 183(e) requires EPA to list the categories of consumer and commercial products that account for at least 80 percent of all VOC emissions in areas that violate the National Ambient Air Quality Standards (NAAQS) for ozone and to issue standards for these categories that require "best available controls." In lieu of regulations, EPA may issue control techniques guidelines if the guidelines are determined to be substantially as effective as regulations.	1,3-Butadiene is listed under the National Volatile Organic Compound Emission Standards for Aerosol Coatings (40 CFR part 59, subpart E). 1,3-Butadiene has a reactivity factor of 13.58 g O3/g VOC.
Safe Drinking Water Act (SDWA) – Section 1412(b)	Every 5 years, EPA must publish a list of contaminants that: (1) are currently unregulated, (2) are known or anticipated to occur in public water systems (PWSs) and (3) may require regulations under SDWA. EPA must also determine whether to regulate at	1,3-Butadiene was identified on both the Third (2009) and Fourth (2016) Contaminant

Statutes/Regulations	Description of Authority/Regulation	Description of Regulation
	least five contaminants from the list every 5 years.	Candidate Lists (CCL) (74 FR 51850, October 8, 2009) (81 FR 81099, November 17, 2016).
Safe Drinking Water Act (SDWA) – Section 1445(a)	Every 5 years, EPA must issue a new list of no more than 30 unregulated contaminants to be monitored by PWSs. The data obtained must be entered into the National Drinking Water Contaminant Occurrence Database.	1,3-Butadiene was identified in the Third Unregulated Contaminant Monitoring Rule (UCMR3), issued in 2012 (77 FR 26071, May 2, 2012).
Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) – Sections 102(a) and 103	Authorizes EPA to promulgate regulations designating as hazardous substances those 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.	1,3-Butadiene is a hazardous substance under CERCLA. Releases of 1,3-butadiene in excess of 10 pounds must be reported (40 CFR 302.4).
Superfund Amendments and Reauthorization Act (SARA)	Requires the Agency to revise the hazardous ranking system and update the National	1,3-Butadiene is listed on SARA, an amendment

Statutes/Regulations	Description of Authority/Regulation	Description of Regulation
	Priorities List of hazardous waste sites, increases state and citizen involvement in the superfund program and provides new enforcement authorities and settlement tools.	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) that have been deemed to pose the greatest threat to public health.
Other Federal Statutes/Regulations		
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 (PELs), exposure monitoring, engineering and administrative control measures, and respiratory protection.	OSHA established a PEL for 1,3-butadiene of 1 ppm / 5 ppm short-term exposure limit (STEL) as an 8-hour, TWA (29 CFR 1910.1051).

D.2 State Laws and Regulations

Table_Apx D-2. State Laws and Regulations

State Actions	Description of Action
State Air Regulations	Allowable Ambient Levels: New Hampshire (Env-A 1400: Regulated Toxic Air Pollutants). Rhode Island (Air Pollution Regulation No. 22).
State PELs	California (PEL of 1 ppm and a STEL of 5) (Cal Code Regs. Title 8, § 5155) Hawaii PEL: 1 ppm (Hawaii Administrative Rules Section 12-60-50).
State Right-to-Know Acts	**Massachusetts (105 Code Mass. Regs. § 670.000 Appendix A), New Jersey (N.J.A.C. 7:1G) and Pennsylvania (P.L. 734, No. 159 and 34 Pa. Code § 323).**
Chemicals of High Concern to Children	**Two states have adopted reporting laws for chemicals in children's products containing 1,3-butadiene, including Maine (38 MRSA Chapter 16-D) and Minnesota (Toxic Free Kids Act Minn. Stat. 116.9401 to 116.9407).**
Other	California listed 1,3-butadiene on Proposition 65 in 1998 due to cancer, and in 2004 due to developmental toxicity and female/male reproductive toxicity (Cal Code Regs. Title 27, § 27001). 1,3-Butadiene is listed as a Candidate Chemical under California's Safer Consumer Products Program established under Health and Safety Code § 25252 and 25253 (California, Candidate Chemicals List, Accessed April 15, 2019). California lists 1,3-butadiene as a designated priority chemical for biomonitoring under criteria established by California SB 1379 (Biomonitoring California, Priority Chemicals, February 2019). 1,3-Butadiene is on the MA Toxic Use Reduction Act (TURA) list of 2019 (301 CMR 41.00).

D.3 International Laws and Regulations

Table_Apx D-3. Regulatory Actions by other Governments, Tribes, and International Agreements

Country/Tribe/ Organization	Requirements and Restrictions
Canada	1,3-Butadiene is on the Canadian List of Toxic Substances (CEPA 1999 Schedule 1). Other regulations include: Canada's National Pollutant Release Inventory (NPRI) Part 1A as a VOC.

Country/Tribe/ Organization	Requirements and Restrictions
European Union	1,3-Butadiene is registered for use in the EU with no restrictions CoRAP (Final). 1,3-Butadiene was evaluated under the 2014 Community rolling action plan (CoRAP) under regulation European Commission (EC) No1907/2006. - REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals). European Chemical Agency (ECHA) database, Accessed April 10, 2019.
Australia	1,3-Butadiene was assessed under Human Health Tier II of the Inventory Multi-Tiered Assessment and Prioritisation (IMAP). Uses reported include: • Producing synthetic rubber (used to manufacture automotive tires and tire products); • Producing plastics such as acrylics, high impact polystyrene and acrylonitrile butadiene styrene (ABS) resin plastics, nylon and neoprene; • Producing resins; • Processing petroleum; • As a chemical intermediate in producing some fungicides; and • In manufacturing latex adhesives and paints (NICNAS, 2013, Human Health Tier II assessment for 1,3-butadiene, Accessed April 16, 2019).
Japan	1,3-Butadiene 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 (Accessed April 10, 2019.)
Basel Convention	Solid Plastic Waste is listed as a category of waste under the Basel Convention. Although the United States is not currently a party to the Basel Convention, this treaty still affects U.S. importers and exporters.
Australia, Austria, Belgium, Canada, Denmark, European Union, Finland, France, Germany, Hungary, Ireland, Latvia, New Zealand, People's Republic of China,	Occupational exposure limits for 1,3-butadiene (GESTIS International limit values for chemical agents (Occupational exposure limits, OELs database, Accessed April 16, 2019).

Country/Tribe/ Organization	Requirements and Restrictions
Poland, Romania, Singapore, South Korea, Spain, Sweden, Switzerland, The Netherlands, United Kingdom	

Appendix E PROCESS, RELEASE AND OCCUPATIONAL EXPOSURE INFORMATION

This appendix provides information and data found in preliminary data gathering for 1,3-butadiene.

E.1 Process Information

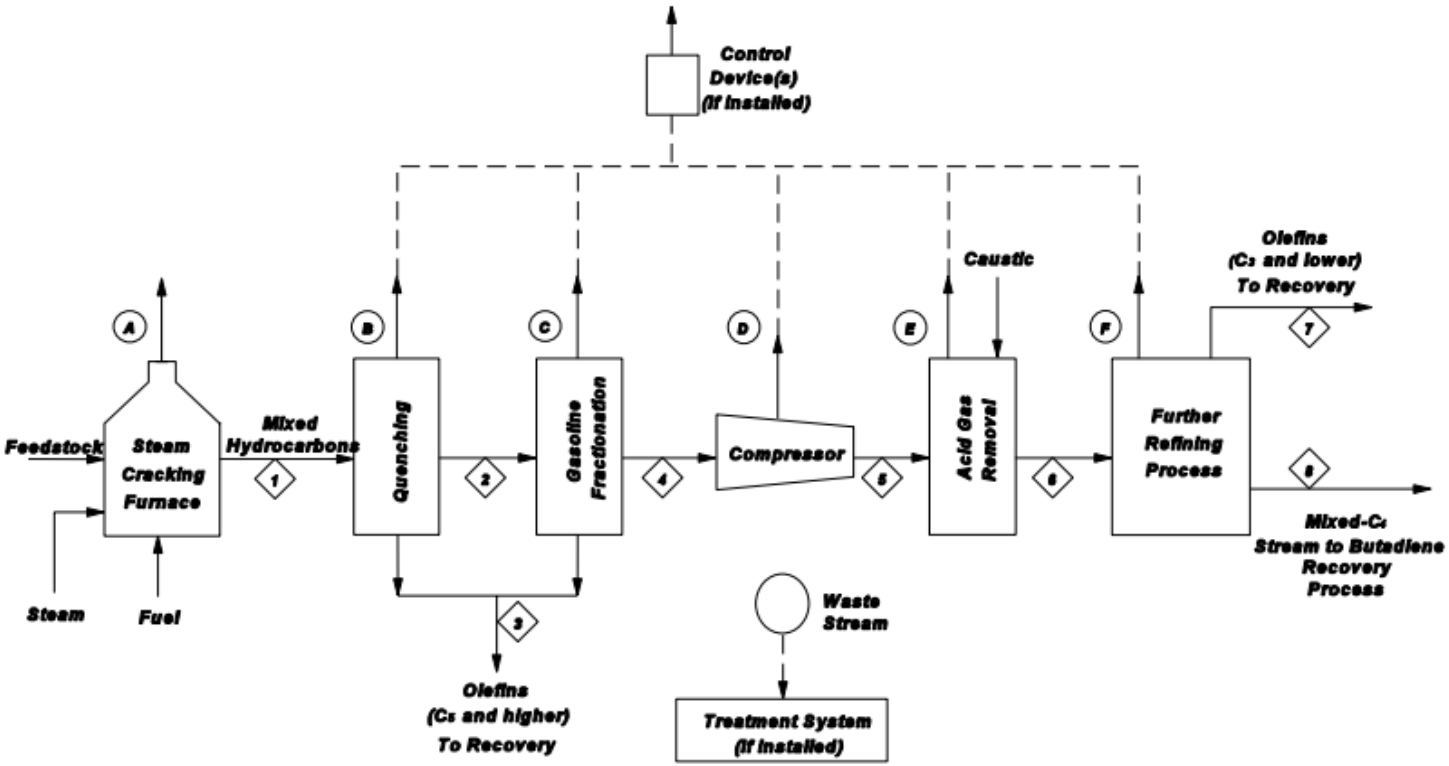
Process-related information potentially relevant to the risk evaluation may include process diagrams, descriptions and equipment. Such information may inform potential release sources and worker exposure activities.

E.1.1 Manufacture (Including Import)

E.1.1.1 Domestic Manufacture

1,3-Butadiene can be produced by three processes: dehydrogenation of n-butane, oxydehydrogenation of n-butenes, and in the process of the steam cracking of hydrocarbon streams for ethylene production. The most common method is as a co-product during ethylene production (Sun and Wristers, 2002). The process can use a variety of hydrocarbon feedstocks, the heavier fractions generally giving a higher 1,3-butadiene yield/amount of ethylene produced (Miller and Villaume, 1978).

In the production process, the hydrocarbon feedstock is pre-heated and cracked in the presence of steam. The product then passes to a pyrolysis/quench system and additional refinery steps and a mixed C_4-hydrocarbon stream is obtained. Figure_Apx E-1 is provided as an example process flow diagram of the 1,3-butadiene manufacturing process. The 1,3-butadiene content in the 'crude butadiene' can be as high as 75% (EPA-HQ-OPPT-2018-0451-0004). 1,3-Butadiene cannot normally be obtained from the mixed C_4-stream by simple distillation and so an extractive distillation process is often used. In this process, a polar solvent (*e.g.*, furfural, acetonitrile, cuprous ammonium acetate, dimethylformamide, a furfural-methoxypropionitrile system, dimethylacetamide or *n*-methylpyrrolidone) is added in order to change the relative volatilities of the components of the mixture (IARC, 1986; Peterson et al., 1980; Miller and Villaume, 1978).



Figure_Apx E-1. Process Flow Diagram of Manufacture of 1,3-Butadiene via Steam Cracking of Hydrocarbons (U.S. EPA, 1996)

E.1.1.2 Import

According to (Sun and Wristers, 2002), 1,3-butadiene is primarily shipped in pressurized containers via railroads or tankers. Other forms of transport include pipeline and barge (NTP, 1999). Uses of 1,3-butadiene are covered by other conditions of use including, but not limited to: processing as a reactant, and to form polymers for rubber and plastics manufacturing, formulated into processing aids and coatings, incorporated into plastic and rubber articles, and used as a laboratory chemical.

E.1.2 Processing and Distribution

Based on the reported industrial processing operations in the 2016 CDR, 1,3-butadiene may be incorporated into a variety of formulations, products and articles, or used industrially as a chemical intermediate (U.S. EPA, 2019a). The main use being as a monomer to produce plastic and rubber products. Some industrial or commercial products may also be repackaged into appropriately-sized containers to meet specific customer demands (U.S. EPA, 2019a).

E.1.2.1 Reactant

Polymerization of 1,3-Butadiene

Processing as a reactant includes the polymerization of 1,3-butadiene with itself or with other monomers (Sun and Wristers, 2002). Some of the common polymers derived from the use of 1,3-butadiene as a monomer feedstock are:

- Polybutadiene
- Hydroxyl-terminated polybutadiene
- Styrene-butadiene rubber
- Styrene-butadiene latex
- Acrylonitrile-butadiene-styrene polymer

The general process at polymerization sites is unloading of 1,3-butadiene, a washing or purification step to remove polymerization inhibitors, then the different monomers are added to the reactor. After completion of reaction, the content of unreacted monomer may vary depending on the reactions and additives used. Typically, this may be followed with a butadiene monomer recovery system to recycle 1,3-butadiene back to feed into the reactor. Polymer production can be done either via emulsion polymerization or solution polymerization depending on the end product use. The final polymer products may be packaged to sale to downstream users (U.S. EPA, 1996). This polymerization product is incorporated into various rubber and plastic articles as discussed below. Hydroxyl-terminated polybutadiene (HTPB) is used in propellants including as a binder for rocket fuel.

Chemical Intermediate

1,3-Butadiene has also been noted as a chemical intermediate for

- Ethylidene norbornene (U.S. EPA, 1996)
- Trans-1,4-hexadiene (U.S. EPA, 1996)
- Chloroprene (U.S. EPA, 1996)
- Sulfolane (U.S. EPA, 1996)
- Adiponitrile (U.S. EPA, 1996)
- in petrochemical manufacturing operations, including fuels (U.S. EPA, 2019a).

E.1.2.2 Incorporated into a Formulation, Mixture or Reaction Product

Incorporation into a formulation, mixture or reaction product refers to the process of mixing or blending of several raw materials to obtain a single product or preparation. 1,3-Butadiene is used as processing

aids and butadiene polymers are used in several petrochemical manufacturing operations, adhesives, lubricants and in formulated paints and coatings (U.S. EPA, 2019a).

E.1.2.3 Incorporated into an Article

Incorporation into an article typically refers to a process in which a chemical becomes an integral component of an article (as defined at 40 CFR 704.3) for distribution in commerce. Exact process operations involved in the incorporation of 1,3-butadiene-containing formulations or reaction products are dependent on the article. EPA identified the following processing activities that incorporate 1,3-butadiene and 1,3-butadiene formulations or reaction products into articles.

Plastics and Rubber Product Manufacturing

1,3-Butadiene is used as a monomer or co-monomer in the manufacture of synthetic rubbers as described earlier. These synthetic rubbers and latex are used to manufacture tires, other rubber components and plastic materials (U.S. EPA, 2019a).

In plastic manufacturing, the final plastic article is produced in a conversion process that forms the compounded plastic into the finished products (U.S. EPA, 2014); (OECD, 2009). The converting process is different depending on whether the plastic is a thermoplastic or a thermosetting material (OECD, 2009). Thermoplastics converting involves the melting of the plastic material, forming it into a new shape and then cooling it (U.S. EPA, 2014); (OECD, 2009). The converting of thermoplastics may involve extrusion, injection molding, blow molding, rotational molding or thermoforming (U.S. EPA, 2014); (OECD, 2009).

Conversion of thermosetting materials involves using heat and pressure to promote curing, typically through cross-linking (OECD, 2009). The primary conversion process for thermosetting materials is compression molding; however, fiber reinforced thermosetting plastics are converted using hand layup, spray molding and filament winding (OECD, 2009). After the forming process, finishing operations such as filing, grinding, sanding, polishing, painting, bonding, coating and engraving are performed to complete the process (U.S. EPA, 2014).

E.1.2.4 Repackaging

Typical repackaging sites receive the chemical in bulk containers and transfer the chemical from the bulk container into another smaller container in preparation for distribution in commerce

E.1.2.5 Recycling

Recovery and recycling of unreacted 1,3-butadiene from the various synthetic rubber manufacturing operations is common. 1,3-Butadiene and other monomers (such as styrene) are recovered and reused in rubber manufacturing to the extent possible (ECB, 2002).

E.1.3 Uses

E.1.3.1 Laboratory Chemicals

A commenter (EPA-HQ-OPPT-2018-0451-0039) provided descriptions of their use of 1,3-butadiene in analytical standard, research, equipment calibration, and sample preparation applications, including reference sample for analysis of terrestrial and extraterrestrial material samples, which the commenter also indicated was a critical use, further informing EPA's understanding of this condition of use. In addition, this commenter provided descriptions of their use of 1,3-butadiene as a component of resin

products that are used in research, which also further informs EPA's understanding of this condition of use.

E.1.3.2 Other Industrial, Commercial and Consumer Uses

EPA has identified industrial, commercial and consumer uses through CDR and public comments for 1,3-butadiene in adhesives and sealants, hydraulic fracking fluids, paints and coatings, plastic and rubber products, lubricants, fuel and related products, laboratory chemicals, and automotive care products. EPA plans to further investigate these use activities of 1,3-butadiene during the risk evaluation.

E.1.4 Disposal

1,3-Butadiene is not listed as a hazardous waste under the Resource Conservation and Recovery Act (RCRA). TRI data indicate 1,3-butadiene may be land disposed, deep well injected, or discharged to water following pretreatment (U.S. EPA, 2019e).

E.2 Preliminary Occupational Exposure Data

EPA presents below an example of occupational exposure-related information obtained from preliminary data gathering. EPA plans to consider this information and data in combination with other data and methods for use in the risk evaluation.

Table_Apx E-1 summarizes NIOSH Health Hazard Evaluations identified during EPA's preliminary data gathering. HHEs can be found at https://www.cdc.gov/niosh/hhe/

Table_Apx E-1. Summary of NIOSH HHEs with Monitoring for 1,3-Butadiene[a]

Year of Publication	Report Number	Facility Description
1990	HETA-90-198-L2060	Polymer manufacturing
1980	HE-80-188-797	Plastic products manufacturing
1980	HE-79-36-656	Plastic helmet manufacturing
1979	HE-78-110-585	Plastic aircraft parts manufacturing
1977	HE-77-1-426	Rubber manufacturing
1976	HE-74-120-260	Rubber tire manufacturing
1973	HE-72-86-38	Rubber hose manufacturing

[a] Table includes HHEs identified to date

Table_Apx E-2 summarizes OSHA CEHD identified during EPA's preliminary data gathering. Number of data points in Table_Apx E-2 was populated from data found at https://www.osha.gov/opengov/healthsamples.html.

Table_Apx E-2. Summary of Industry Sectors with 1,3-Butadiene Monitoring Samples Available from OSHA Inspections Conducted Between 2010 and 2019

NAICS	NAICS Description	Number of Data Points
No NAICS code reported		16
236220	Commercial and Institutional Building Construction	2
324110	Petroleum Refineries	4
325212	Synthetic Rubber Manufacturing	1
326121	Unlaminated Plastics Profile Shape Manufacturing	3
326122	Plastics Pipe and Pipe Fitting Manufacturing	1
326199	All Other Plastics Product Manufacturing	13
326212	Tire Retreading	14
326220	Rubber and Plastics Hoses and Belting Manufacturing	15
326291	Rubber Product Manufacturing for Mechanical Use	8
332323	Ornamental and Architectural Metal Work Manufacturing	8
333220	Plastics and Rubber Industry Machinery Manufacturing	4
337215	Showcase, Partition, Shelving, and Locker Manufacturing	9
453998	All Other Miscellaneous Store Retailers (except Tobacco Stores)	2
611310	Colleges, Universities, and Professional Schools	17
926150	Regulation, Licensing, and Inspection of Miscellaneous Commercial Sectors	3

Appendix F SUPPORTING INFORMATION – CONCEPTUAL MODEL FOR INDUSTRIAL AND COMMERCIAL ACTIVITIES AND USES

Table_Apx F-1. Worker and Occupational Non-User Exposure Conceptual Model Supporting Table

Life-Cycle Stage	Category	Subcategory	Release/Exposure Scenario	Exposure Pathway	Exposure Route	Receptor	Plans to Evaluate	Rationale
Manufacturing	Domestic manufacturing	Domestic manufacturing	Manufacturing of 1,3-butadiene	Liquid Contact	Dermal	Worker	Yes	1,3-Butadiene is expected to be handled as liquid under pressure[12]. Although EPA does not plan to evaluate routine dermal exposure to 1,3-butadiene as a liquid under pressure, EPA may evaluate if 1,3-butadiene is handled at low concentrations.
				Vapor	Inhalation	Worker	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation exposure.
				Liquid Contact	Dermal	ONU	No	Dermal exposure by ONU is not expected for this condition of use as they are not expected to directly handle the chemical.
				Vapor	Inhalation	ONU	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation exposure.
				Mist	Dermal/ Inhalation	Workers, ONU	No	Mist generation not expected during manufacturing.

[12] EPA expects the process to be enclosed to avoid exposure to air that can cause formation of polymeric peroxides as well as based on its volatility (Sun and Wristers, 2002) (Sun, 2002; EPA, 1996), potential exposure to workers from loading and sampling activities could occur. However, skin contact with the liquefied compressed gas can cause frostbite, therefore, EPA does not plan to evaluate routine dermal exposure to 1,3-butadiene under such conditions.

Life-Cycle Stage	Category	Subcategory	Release/Exposure Scenario	Exposure Pathway	Exposure Route	Receptor	Plans to Evaluate	Rationale
Manufacturing	Importing	Importing	Repackaging of import containers	Liquid Contact	Dermal	Worker	Yes	1,3-Butadiene is expected to be handle as liquid under pressure[13]. Although EPA does not plan to evaluate routine dermal exposure to 1,3-butadiene as a liquid under pressure, 1,3-butadiene may be imported in dilute concentrations.
				Vapor	Inhalation	Worker	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation exposure.
				Liquid Contact	Dermal	ONU	No	Dermal exposure by ONU is not expected for this condition of use as they are not expected to directly handle the chemical.
				Vapor	Inhalation	ONU	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation route.
				Mist	Dermal/ Inhalation	Workers, ONU	No	Mist generation not expected during import.

[13] EPA expects the process to be enclosed to avoid exposure to air that can cause formation of polymeric peroxides as well as based on its volatility (Sun and Wristers, 2002) (Sun, 2002; EPA, 1996), potential exposure to workers from loading and sampling activities could occur. However, skin contact with the liquefied compressed gas can cause frostbite, therefore, EPA does not plan to evaluate routine dermal exposure to 1,3-butadiene under such conditions.

Life-Cycle Stage	Category	Subcategory	Release/Exposure Scenario	Exposure Pathway	Exposure Route	Receptor	Plans to Evaluate	Rationale
Processing	Processing as a reactant	Intermediate in: Adhesive manufacturing; All other basic organic chemical manufacturing; Organic fiber manufacturing; Petrochemical manufacturing; Petroleum refineries; Plastic material and resin manufacturing; Propellent Manufacturing; Synthetic rubber manufacturing; Wholesale and retail trade; Fuel binder for solid rocket fuels in: Aerospace Other: Monomer used in polymerization process in: Plastic material and resin manufacturing; Manufacturing synthetic rubber and plastics	Processing of 1,3-butadiene as a reactant or monomer (polymerization)	Liquid Contact	Dermal	Worker	Yes	1,3-Butadiene is expected to be handle as liquid under pressure[14]. Although EPA does not plan to evaluate routine dermal exposure to 1,3-butadiene as a liquid under pressure, 1,3-butadiene may be used in formulations at low concentrations.
				Vapor	Inhalation	Worker	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.
				Liquid Contact	Dermal	ONU	No	Dermal exposure by ONU is not expected for this condition of use as they are not expected to directly handle the chemical.
				Vapor	Inhalation	ONU	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.
				Mist	Dermal/ Inhalation	Workers, ONU	No	Mist generation not expected during processing as a reactant.

[14] EPA expects the process to be enclosed to avoid exposure to air that can cause formation of polymeric peroxides as well as based on its volatility (Sun and Wristers, 2002) (Sun, 2002; EPA, 1996), potential exposure to workers from loading and sampling activities could occur. However, skin contact with the liquefied compressed gas can cause frostbite, therefore, EPA does not plan to evaluate routine dermal exposure to 1,3-butadiene under such conditions.

Life-Cycle Stage	Category	Subcategory	Release/Exposure Scenario	Exposure Pathway	Exposure Route	Receptor	Plans to Evaluate	Rationale
Processing	Processing – incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: Petrochemical manufacturing; Processing aids, not otherwise listed in: Adhesive manufacturing, paints and coatings manufacturing, petroleum lubricating oil and grease manufacturing, and all other chemical product and preparation manufacturing	Processing into formulations, mixtures, or reaction product	Liquid Contact	Dermal	Worker	Yes	Dermal exposure to liquids containing 1,3-butadiene may occur for this exposure scenario. EPA plans to evaluate dermal pathway
				Vapor	Inhalation	Worker	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation route.
				Liquid Contact	Dermal	ONU	No	Dermal exposure by ONU is not expected for this condition of use as they are not expected to directly handle the chemical.
				Vapor	Inhalation	ONU	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation route.
				Mist	Dermal/ Inhalation	Workers, ONU	No	Mist generation not expected during processing/formulation operations.
Processing	Processing – incorporation into article	Other: Polymer in: Rubber and Plastic product manufacturing	Plastics and Rubber product manufacturing	Liquid Contact	Dermal	Worker	Yes	Dermal exposure to liquids containing 1,3-butadiene may occur for this exposure scenario. EPA plans to evaluate dermal pathway
				Vapor	Inhalation	Worker	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation route.
				Liquid Contact	Dermal	ONU	No	Dermal exposure by ONU is not expected for this condition of use as they are not expected to directly handle the chemical.

Life-Cycle Stage	Category	Subcategory	Release/Exposure Scenario	Exposure Pathway	Exposure Route	Receptor	Plans to Evaluate	Rationale
				Vapor	Inhalation	ONU	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation route.
				Mist	Dermal/ Inhalation	Workers, ONU	No	Mist generation not expected during processing operations.
Processing	Repackaging	Intermediate in: Wholesale and retail trade	Repackaging (same exposure scenario as Import)	Liquid Contact	Dermal	Worker	No	1,3-Butadiene is expected to be handle as liquid under pressure[15]. EPA does not plan to evaluate routine dermal exposure.
				Vapor	Inhalation	Worker	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation route.
				Liquid Contact	Dermal	ONU	No	Dermal exposure by ONU is not expected for this condition of use as they are not expected to directly handle the chemical.
				Vapor	Inhalation	ONU	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.
				Mist	Dermal/ Inhalation	Workers, ONU	No	Mist generation not expected during repackaging.
Distribution in commerce	Distribution in commerce	Distribution in commerce	Distribution	Liquid Contact, Vapor	Dermal/ Inhalation	Worker, ONU	Yes	EPA plans to analyze activities resulting in exposures associated with distribution in commerce (*e.g.* loading, unloading) throughout the various lifecycle stages and conditions of use (*e.g.* manufacturing, processing, industrial use) rather than as a single distribution scenario.

[15] EPA expects the process to be enclosed to avoid exposure to air that can cause formation of polymeric peroxides as well as based on its volatility (Sun and Wristers, 2002) (Sun, 2002; EPA, 1996), potential exposure to workers from loading and sampling activities could occur. However, skin contact with the liquefied compressed gas can cause frostbite, therefore, EPA does not plan to evaluate routine dermal exposure to 1,3-butadiene under such conditions..

Life-Cycle Stage	Category	Subcategory	Release/Exposure Scenario	Exposure Pathway	Exposure Route	Receptor	Plans to Evaluate	Rationale
Processing	Recycling	Recycling	Recycling	Liquid Contact	Dermal	Worker	Yes	Dermal exposure may occur for this condition of use, EPA plans to evaluate dermal exposure
				Vapor	Inhalation	Worker	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.
				Liquid Contact	Dermal	ONU	No	Dermal exposure by ONU is not expected for this condition of use as they are not expected to directly handle the chemical.
				Vapor	Inhalation	ONU	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.
				Mist	Dermal/ Inhalation	Workers, ONU	No	Mist generation not expected during processing recycling.
Industrial Uses	Processing aids, specific to petroleum production	Hydraulic fracturing fluids	Use of 1,3-butadiene in hydraulic fracturing fluids	Liquid Contact	Dermal	Worker	Yes	Dermal exposure to liquids containing 1,3-butadiene may occur for this exposure scenario. EPA plans to evaluate dermal exposure
				Vapor	Inhalation	Worker	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation exposure.
				Liquid Contact	Dermal	ONU	No	Dermal exposure by ONU is not expected for this condition of use as they are not expected to directly handle the chemical.
				Vapor	Inhalation	ONU	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.
				Mist	Dermal/ Inhalation	Workers, ONU	No	Mist generation not expected during processing recycling.
Industrial /Commercial Uses	Adhesives and sealants	Adhesives and sealants, including epoxy resins	Use of adhesives and sealants	Liquid Contact	Dermal	Worker	Yes	Dermal exposure may occur for this condition of use. EPA plans to evaluate dermal exposure.

Life-Cycle Stage	Category	Subcategory	Release/Exposure Scenario	Exposure Pathway	Exposure Route	Receptor	Plans to Evaluate	Rationale
				Vapor	Inhalation	Worker	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.
				Liquid Contact	Dermal	ONU	No	Dermal exposure by ONU is not expected for this condition of use as they are not expected to directly handle the chemical.
				Vapor	Inhalation	ONU	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.
				Mist	Dermal/ Inhalation	Workers	Yes	EPA plans to evaluate mist generation for this scenario.
				Mist	Inhalation	ONU	Yes	EPA plans to evaluate mist generation for this scenario.
				Mist	Dermal	ONU	No	Dermal exposure by ONU is not expected for this condition of use as they are not expected to directly handle the chemical
Commercial Uses	Fuel and Related Products	Fuel and Related Products	Use of fuel and fuel related products	Liquid Contact	Dermal	Workers	Yes	Dermal exposure may occur for this condition of use, EPA plans to evaluate dermal exposure
				Vapor	Inhalation	Worker	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.
				Liquid Contact	Dermal	ONU	No	Dermal exposure by ONU is not expected for this condition of use as they are not expected to directly handle the chemical
				Vapor	Inhalation	ONU	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.
Commercial Uses	Plastic and rubber products not	Plastic and rubber products not covered elsewhere,	Use of finished plastic and rubber products not	Liquid Contact	Dermal	Worker, ONUs	No	Products covered under this exposure scenario are expected to be solid articles where dermal

Life-Cycle Stage	Category	Subcategory	Release/Exposure Scenario	Exposure Pathway	Exposure Route	Receptor	Plans to Evaluate	Rationale
	covered elsewhere	including rubber tires	covered elsewhere (*e.g.* tires)					exposure to 1,3-butadiene is not expected.
				Vapor	Inhalation	Worker	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.
				Mist	Dermal/ Inhalation	Workers, ONU	No	Mist generation not expected during plastic and rubber products manufacturing.
Commercial Uses	Automotive care products; Lubricant and lubricant additives	Automotive care products; Lubricant additives, including viscosity modifier	Use of other products developed from butadiene-based polymers	Liquid	Dermal	Worker	Yes	Dermal exposure may occur for this condition of use, EPA plans to evaluate dermal exposure
				Vapor	Inhalation	Worker	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.
				Liquid Contact	Dermal	ONU	No	Dermal exposure by ONU is not expected for this condition of use as they are not expected to directly handle the chemical.
				Vapor	Inhalation	ONU	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.
				Mist	Dermal/ Inhalation	Workers, ONU	No	Mist generation not expected during plastic and rubber products manufacturing.
Commercial Uses	Paints and Coatings	Paints and Coatings, including aerosol spray paint	Spray coating application; and Other paint and coating applications (*e.g.*, roll, dip)	Liquid Contact	Dermal	Worker	Yes	Dermal exposure may occur for this condition of use, EPA plans to evaluate dermal exposure
				Vapor	Inhalation	Worker	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.

Life-Cycle Stage	Category	Subcategory	Release/Exposure Scenario	Exposure Pathway	Exposure Route	Receptor	Plans to Evaluate	Rationale
				Liquid Contact	Dermal	ONU	No	Dermal exposure by ONU is not expected for this condition of use as they are not expected to directly handle the chemical.
				Vapor	Inhalation	ONU	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.
				Mist	Dermal/ Inhalation	Workers	Yes	EPA plans to evaluate mist generation for this scenario.
				Mist	Dermal	ONU	No	Dermal exposure by ONU is not expected for this condition of use as they are not expected to directly handle the chemical
				Mist	Inhalation	ONU	Yes	EPA plans to evaluate mist generation for this scenario.
Commercial Uses	Other Use	Laboratory chemicals	Laboratory Use	Liquid Contact	Dermal	Workers	Yes	Dermal exposure may occur for this condition of use, EPA plans to evaluate dermal exposure
				Vapor	Inhalation	Workers	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway
				Liquid Contact	Dermal	ONU	No	Dermal exposure by ONU is not expected for this condition of use as they are not expected to directly handle the chemical.
				Vapor	Inhalation	ONU	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway

Life-Cycle Stage	Category	Subcategory	Release/Exposure Scenario	Exposure Pathway	Exposure Route	Receptor	Plans to Evaluate	Rationale
				Mist	Dermal/ Inhalation	Workers, ONU	No	Mist generation not expected from waste handling.
Disposal	Waste Handling, Treatment and Disposal	Disposal of 1,3-butadiene wastes	Worker handling of wastes	Liquid Contact	Dermal	Worker	Yes	Dermal exposure is expected for this condition of use
				Vapor	Inhalation	Worker	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.
				Liquid Contact	Dermal	ONU	No	Dermal exposure by ONU is not expected for this condition of use as they are not expected to directly handle the chemical.
				Vapor	Inhalation	ONU	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.
				Mist	Dermal/ Inhalation	Workers, ONU	No	Mist generation not expected from waste handling.

Appendix G SUPPORTING INFORMATION – CONCEPTUAL MODEL FOR CONSUMER ACTIVITIES AND USES

Table_Apx G-1. Consumer Exposure Conceptual Model Supporting Table

Life Cycle Stage	Category	Subcategory	Release from source	Exposure Pathway	Route	Receptor	Plans to Evaluate	Rationale
Consumer Use	Plastic and Rubber Products	Plastic and rubber products not covered elsewhere, including rubber tires	Long-term emission/mass-transfer through application or use of products using butadiene-based polymers	Vapor	Inhalation	Consumers and Bystanders	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.
Consumer Handling of Disposal and Waste	Wastewater, Liquid wastes and solid wastes	Wastewater, Liquid wastes and solid wastes	Long-term emission/mass-transfer through application or use of products using butadiene-based polymers	Vapor	Inhalation	Consumers and Bystanders	Yes	1,3-Butadiene is volatile at room temperature, EPA plans to evaluate the inhalation pathway.

Appendix H SUPPORTING INFORMATION – CONCEPTUAL MODEL FOR ENVIRONMENTAL RELEASES AND WASTES

Table_Apx H-1. General Population and Environmental Exposure Conceptual Model Supporting Table

Life Cycle Stage	Categories	Release	Exposure Pathway / Media	Exposure Routes	Receptor / Population	Plans to Evaluate	Rationale
All	Emissions to Air	Emissions to Air	Near facility ambient air concentrations	Inhalation	General Population	No	1,3-Butadiene is a HAP. Because stationary source releases of 1,3-butadiene to ambient air are under the jurisdiction of the CAA.
			Indirect deposition to nearby bodies of water and soil catchments	Oral; Dermal	General Population	No	
				TBD	Aquatic and Terrestrial Receptors	No	
	Wastewater or Liquid Wastes	Industrial pre-treatment and wastewater treatment, or POTW	Direct release into surface water and indirect partitioning to sediment	TBD	Aquatic Receptors	Yes	This chemical may be released to surface water
			Direct release into surface water and partitioning to sediment and bioaccumulation into edible aquatic species	Oral Inhalation	General Population	Yes	

Life Cycle Stage	Categories	Release	Exposure Pathway / Media	Exposure Routes	Receptor / Population	Plans to Evaluate	Rationale
			Drinking Water via Surface or Ground Water	Oral Dermal and Inhalation (*e.g.* showering)	General Population	No	The drinking water exposure pathway for 1,3-butadiene is currently on the CCL.
			Biosolids: application to soil and/or migration to groundwater and/or surface water	Oral (*e.g.* ingestion of soil) Inhalation	General Population	Yes	Although 1,3-butadiene is a volatile chemical and not expected to sorb onto biosolids, EPA plans to analyze this pathway. However, it is expected to be a minor pathway of exposure to the general population and terrestrial species.
				TBD	Aquatic Receptors	Yes	
		Underground injection	Migration to groundwater, potential surface/drinking water	Oral Dermal Inhalation	General Population	No	1,3-Butadiene is released to Class I Underground Injection Wells
				TBD	Aquatic and Terrestrial Receptors	No	
	Solid and Liquid Wastes	Municipal landfill and other land disposal	Leachate to soil, ground water and/or mitigation to surface water	Oral (*e.g.*, ingestion) Dermal Inhalation	General Population	Yes	Based, on TRI data, this chemical is expected to be released to municipal landfills.
				TBD	Aquatic Receptors	Yes	