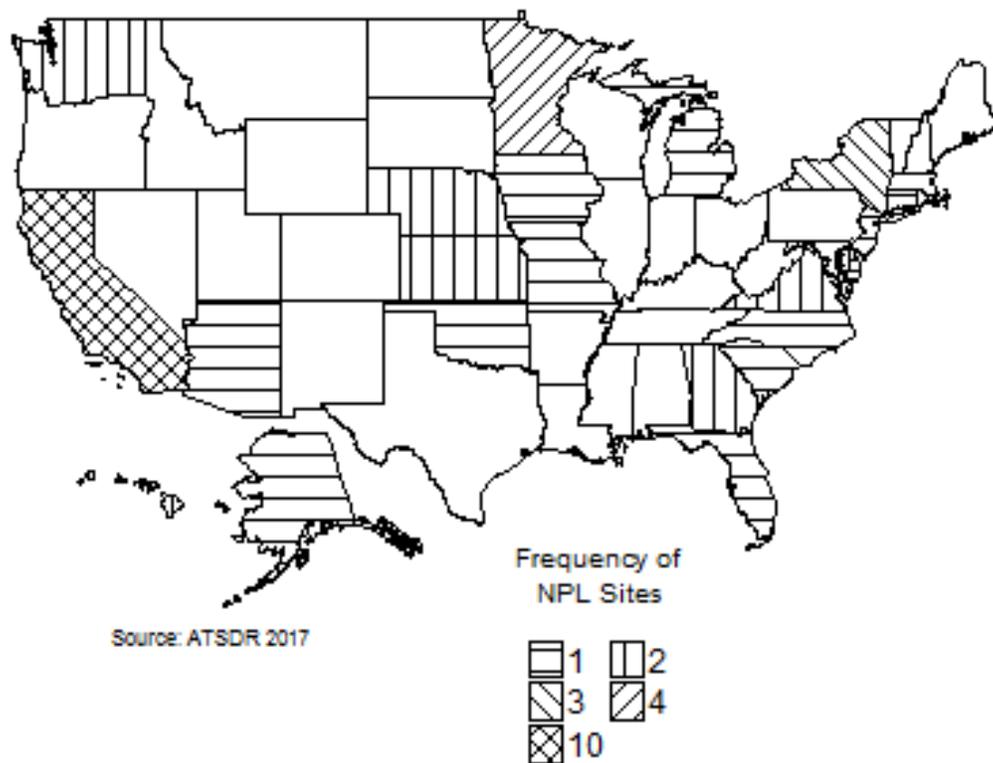


CHAPTER 5. POTENTIAL FOR HUMAN EXPOSURE

5.1 OVERVIEW

1,2-Dibromoethane has been identified in at least 43 of the 1,854 hazardous waste sites that have been proposed for inclusion on the EPA National Priorities List (NPL) (ATSDR 2017). However, the number of sites in which 1,2-dibromoethane has been evaluated is not known. The number of sites in each state is shown in Figure 5-1. Of these sites, 42 are located within the United States and 1 is located in Puerto Rico (not shown).

Figure 5-1. Number of NPL Sites with 1,2-Dibromoethane Contamination



- 1,2-Dibromoethane is used as an intermediate in the production of dyes, resins, gums, and waxes, and as a pesticide treatment of felled logs. Previously, 1,2-dibromoethane was used as an additive to leaded gasoline and as a fumigant; however, these uses are historical only.
- 1,2-Dibromoethane can enter the air and surface waters from industrial releases into air or effluent discharges into water. 1,2-Dibromoethane is highly mobile in soil, yet may persist in it. It is water soluble and may be found in groundwater.

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- Residual 1,2-dibromoethane bound to soil micropores is relatively immobile and resistant to degradation. This material is present in ppb concentrations and may be slowly leached from soil micropores over years to contaminate groundwater. If the micropores are disturbed and crushed, there is a greater likelihood of releasing the bound 1,2-dibromoethane. The compound persists in soils and groundwater.
- 1,2-Dibromoethane is transformed in the atmosphere by reaction with hydroxyl radicals and in soils by biodegradation. Volatilization is the most important removal process for 1,2-dibromoethane released to surface waters.
- The most important route of exposure to 1,2-dibromoethane for most members of the general population is ingestion of contaminated drinking water or through inhalation of 1,2-dibromoethane released into air. Individuals living in the vicinity of 1,2-dibromoethane processing facilities or hazardous waste sites contaminated with 1,2-dibromoethane may be exposed to higher concentrations of the compound.

5.2 PRODUCTION, IMPORT/EXPORT, USE, AND DISPOSAL

5.2.1 Production

1,2-Dibromoethane is a halogenated aliphatic hydrocarbon produced when gaseous ethylene comes in contact with bromine. The mixing of ethylene and bromine is accomplished in a variety of ways. One of the more common manufacturing processes involves a liquid-phase bromination of ethylene at 35–85°C. After the bromination of ethylene, the mixture is neutralized to free acid and then purified by distillation. Other methods of 1,2-dibromoethane formation include the hydrobromination of acetylene and a reaction of 1,2-dibromoethane with water (Fishbein 1980; HSDB 1989).

In the 1970s, production of 1,2-dibromoethane in the United States remained stable, averaging 280 million pounds per year; production peaked in 1974 at 332.1 million pounds. In 1979, the production volume averaged 285.9 million pounds (Santodonato et al. 1985). Since then, production has consistently decreased. This decrease was primarily due to increased government regulation and restriction on products using 1,2-dibromoethane. Consequently, by 1982, the U.S. production of 1,2-dibromoethane reached a low of 169.8 million pounds (Santodonato et al. 1985). Data on production of 1,2-dibromoethane are not available after 1984.

1,2-Dibromoethane production constitutes one of the largest single uses of bromine. Table 5-1 summarizes information on U.S. companies that manufactured or used 1,2-dibromoethane in 2016 (TRI16 2017).

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Table 5-1. Facilities that Produce, Process, or Use 1,2-Dibromoethane

State ^a	Number of facilities	Minimum amount on site in pounds ^b	Maximum amount on site in pounds ^b	Activities and uses ^c
CA	2	0	49,999,999	7, 12
LA	2	0	999	1, 5, 7
MN	1	1,000	9,999	7, 9
MS	1	10,000	99,999	7
MT	1	10,000	99,999	2, 3, 4, 7, 9, 10
NY	1	100	999	12
OH	1	1,000	9,999	12
TX	3	10,000	99,999	2, 4, 7, 9

^aPost office state abbreviations used.

^bAmounts on site reported by facilities in each state.

^cActivities/Uses:

- | | | |
|----------------------|-----------------------------|--------------------------|
| 1. Produce | 6. Reactant | 11. Manufacture Aid |
| 2. Import | 7. Formulation Component | 12. Ancillary |
| 3. Used Processing | 8. Article Component | 13. Manufacture Impurity |
| 4. Sale/Distribution | 9. Repackaging | 14. Process Impurity |
| 5. Byproduct | 10. Chemical Processing Aid | |

Source: TRI16 2017 (Data are from 2016)

5.2.2 Import/Export

The U.S. import levels of 1,2-dibromoethane fluctuated between 1977 and 1981, reaching a peak in 1980 of 0.861 million pounds and a low in 1979 of 0.079 million pounds (Santodonato et al. 1985). Previous producers of 1,2-dibromoethane include the United Kingdom, Benelux, France, Spain, Italy, and Switzerland; collectively they produce 10–66 million pounds per year (Fishbein 1980).

The U.S. export level of 1,2-dibromoethane in 1981 was 29.8 million pounds. This was substantially lower than in 1978 when the U.S. export level was 84.8 million pounds (Santodonato et al. 1985).

5.2.3 Use

The main historical use of 1,2-dibromoethane was as an anti-knock additive in leaded gasoline, where 1,2-dibromoethane acted as a "scavenger" that converted lead oxides to lead halides. In the 1970s and early 1980s, the second largest application of 1,2-dibromoethane was as a soil fumigant to protect against insects, pests, and nematodes in citrus, vegetable, and grain crops and as a fumigant for turf, particularly on golf courses (HSDB 1989). However, in 1984, EPA banned the use of 1,2-dibromoethane as a soil

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and grain fumigant, thus eliminating this market for 1,2-dibromoethane manufacturers (Santodonato et al. 1985).

Current uses of 1,2-dibromoethane include treatment of felled logs for bark beetles, termite control, control of wax moths in beehives, spot treatment of milling machinery, Japanese beetle control in ornamental plants, as a chemical intermediate for dyes, resins, waxes, and gums, and precursor in the synthesis of vinyl chloride (EPA 2004; HSDB 1989).

5.2.4 Disposal

Disposal methods of 1,2-dibromoethane fall under the general regulation for organic pesticide disposal developed by EPA. The two main methods of disposal are incineration and burial. Incineration is the preferred method; disposal by burial, in a specially designated landfill, is used only if no appropriate incineration facilities are available. All incinerator emissions must meet the requirements of the Clean Air Act of 1970 relating to gaseous emissions. Similarly, dispose of combustible organic pesticide containers in a pesticide incinerator or bury in a specially designated landfill. Triple rinse noncombustible containers and recycle them.

5.3 RELEASES TO THE ENVIRONMENT

The Toxics Release Inventory (TRI) data should be used with caution because only certain types of facilities are required to report (EPA 2005). This is not an exhaustive list. Manufacturing and processing facilities are required to report information to the TRI only if they employ ≥ 10 full-time employees; if their facility is included in Standard Industrial Classification (SIC) Codes 10 (except 1011, 1081, and 1094), 12 (except 1241), 20–39, 4911 (limited to facilities that combust coal and/or oil for the purpose of generating electricity for distribution in commerce), 4931 (limited to facilities that combust coal and/or oil for the purpose of generating electricity for distribution in commerce), 4939 (limited to facilities that combust coal and/or oil for the purpose of generating electricity for distribution in commerce), 4953 (limited to facilities regulated under RCRA Subtitle C, 42 U.S.C. section 6921 et seq.), 5169, 5171, and 7389 (limited S.C. section 6921 et seq.), 5169, 5171, and 7389 (limited to facilities primarily engaged in solvents recovery services on a contract or fee basis); and if their facility produces, imports, or processes $\geq 25,000$ pounds of any TRI chemical or otherwise uses $>10,000$ pounds of a TRI chemical in a calendar year (EPA 2005).

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1,2-Dibromoethane was widely released to the environment mainly as a result of the historical use of the compound as a gasoline additive and a fumigant (Fishbein 1979). The compound was also released from industrial processing facilities. For example, in 1977, 1,2-dibromoethane was found in air, water, soil, and sediment samples taken near industrial bromine facilities in Arkansas (Pellizzari et al. 1978).

Class and Ballschmitter (1988) suggested that 1,2-dibromoethane may be produced naturally in seawater from a dibromomethane precursor via a halogen exchange reaction. The dibromoethane is produced by brown algae via haloperoxidase enzymes and released to seawater.

5.3.1 Air

Estimated releases of 783 pounds (~0.36 metric tons) of 1,2-dibromoethane to the atmosphere from 12 domestic manufacturing and processing facilities in 2016, accounted for about 92% of the estimated total environmental releases from facilities required to report to the TRI (TRI16 2017). These releases are summarized in Table 5-2.

Historically, 1,2-dibromoethane releases to the atmosphere have been due to fugitive emissions from leaded gasolines, automobile exhaust, and the former use of the compound as a fumigant (Fishbein 1979).

5.3.2 Water

No 1,2-dibromoethane was released to surface water or publicly owned treatment works from 12 domestic manufacturing and processing facilities in 2016 (TRI16 2017). These releases are summarized in Table 5-2.

Historical use of 1,2-dibromoethane as a solvent and chemical intermediate has led to release of the compound to surface waters in industrial process effluents (Fishbein 1979).

5.3.3 Soil

Estimated releases of 69 pounds (~0.03 metric tons) of 1,2-dibromoethane to soil from 12 domestic manufacturing and processing facilities in 2016, accounted for about 8% of the estimated total environmental releases from facilities required to report to the TRI (TRI16 2017). No 1,2-dibromoethane was released via underground injection (TRI16 2017). These releases are summarized in Table 5-2.

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Table 5-2. Releases to the Environment from Facilities that Produce, Process, or Use 1,2-Dibromoethane^a

State ^c	RF ^d	Air ^e	Water ^f	UI ^g	Land ^h	Other ⁱ	Reported amounts released in pounds per year ^b		
							On-site ^j	Off-site ^k	On- and off-site
CA	2	2	0	0	10	0	2	10	12
LA	2	740	0	0	0	0	740	0	740
MN	1	6	0	0	1	0	6	1	7
MS	1	18	0	0	58	0	18	58	76
MT	1	ND	ND	ND	ND	ND	ND	ND	ND
NY	1	1	0	0	0	0	1	0	1
OH	1	1	0	0	0	0	1	0	1
TX	3	15	0	0	0	0	15	0	15
Total	12	783	0	0	69	0	783	69	852

^aThe TRI data should be used with caution since only certain types of facilities are required to report. This is not an exhaustive list. Data are rounded to nearest whole number.

^bData in TRI are maximum amounts released by each facility.

^cPost office state abbreviations are used.

^dNumber of reporting facilities.

^eThe sum of fugitive and point source releases are included in releases to air by a given facility.

^fSurface water discharges, waste water treatment-(metals only), and publicly owned treatment works (POTWs) (metal and metal compounds).

^gClass I wells, Class II-V wells, and underground injection.

^hResource Conservation and Recovery Act (RCRA) subtitle C landfills; other onsite landfills, land treatment, surface impoundments, other land disposal, other landfills.

ⁱStorage only, solidification/stabilization (metals only), other off-site management, transfers to waste broker for disposal, unknown.

^jThe sum of all releases of the chemical to air, land, water, and underground injection wells.

^kTotal amount of chemical transferred off-site, including to POTWs.

ND = no data; RF = reporting facilities; UI = underground injection

Source: TRI16 2017 (Data are from 2016)

The main sources of 1,2-dibromoethane release to soils appear to be the historical use of the compound as a soil fumigant and land disposal of wastes containing the compound.

5.4 ENVIRONMENTAL FATE

5.4.1 Transport and Partitioning

Air. The vapor pressure (11 mmHg at 25°C) of 1,2-dibromoethane suggests that the compound readily partitions to the atmosphere following release to surface water and soils. 1,2-Dibromoethane can be transported for long distances in the atmosphere before removal in wet and dry deposition or degradation.

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Water. Volatilization is the most important removal process for 1,2-dibromoethane released to surface waters. Volatilization half-lives of 1–16 days have been estimated for flowing and standing surface waters. Sorption to sediment or suspended particulate material is not expected to be an important process (EPA 1987a, 1987b; HSDB 1989).

Sediment and Soil. As a result of its low sorption potential, high vapor pressure, and high water solubility, 1,2-dibromoethane is rapidly lost from soils by volatilization to the atmosphere or leaching to surface water and groundwater (EPA 1987a). In studies with two silty clay loam soils and cation saturated montmorillonite clays, a maximum of only 4% of applied 1,2-dibromoethane was found to be sorbed to soil particulates; an experimental soil sorption coefficient (K_{oc}) value of 66 was reported (Rogers and McFarlane 1981). However, Steinberg et al. (1987) have reported that a small fraction of 1,2-dibromoethane released to soils (that is not rapidly volatilized, leached, or degraded) is sorbed strongly to soil micropores where it persists for long periods of time, resistant to mobilization and degradation. This residual 1,2-dibromoethane may slowly leach from micropore sites to contaminate groundwater, with a leaching half-life of years.

Other Media. As a result of its high water solubility, 1,2-dibromoethane is not expected to bioconcentrate or biomagnify in terrestrial and aquatic food chains. Low-exposure bioconcentration factors suggest that 1,2-dibromoethane has limited bioaccumulation potential in organisms (EHC 2013).

5.4.2 Transformation and Degradation

Air. Direct photolysis of 1,2-dibromoethane in the troposphere is not expected to occur (Jaber et al. 1984). 1,2-Dibromoethane reacts with hydroxyl radicals in the atmosphere; the half-life for the reaction has been estimated to be about 40 days (EPA 1987a).

Water. Biotic and abiotic degradation of 1,2-dibromoethane in surface waters is slow relative to volatilization of the compound to the atmosphere (EPA 1987b). 1,2-Dibromoethane is resistant to hydrolysis (Jaber et al. 1984); the hydrolytic half-life of the compound has been reported to range from 2.5 years (Vogel and Reinhard 1982) to 13.2 years (HSDB 1989). As a result of its hydrolytic stability and the limited biological activity in subsurface soils, 1,2-dibromoethane in groundwater is expected to persist for years.

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Sediment and Soil. 1,2-Dibromoethane undergoes biodegradation in aerobic surface soils; the rate has been reported to decrease with increasing concentrations of the compound (Pignatello 1986). Biodegradation appears to be limited under anaerobic conditions (Bouwer and McCarty 1983). Residual 1,2-dibromoethane sorbed to soil micropores is resistant to biodegradation, chemical transformation, and mobilization; Steinberg et al. (1987) detected the compound in a surface soil 19 years after 1,2-dibromoethane had been applied for the last time as a fumigant.

5.5 LEVELS IN THE ENVIRONMENT

Reliable evaluation of the potential for human exposure to 1,2-dibromoethane depends, in part, on the reliability of supporting analytical data from environmental samples and biological specimens. Concentrations of 1,2-dibromoethane in unpolluted atmospheres and in pristine surface waters are often so low as to be near the limits of current analytical methods. In reviewing data on 1,2-dibromoethane levels monitored or estimated in the environment, it should also be noted that the amount of chemical identified analytically is not necessarily equivalent to the amount that is bioavailable.

As a result of its persistence in soil and groundwater, and past widespread use as a gasoline additive and fumigant, 1,2-dibromoethane has been detected in ambient air, soils, groundwater, and food. However, most of the monitoring data reported in this section are not current. Volatilization is the most important removal process for 1,2-dibromoethane released to surface waters. Since only a small fraction of the compound is sorbed to soil, sorption to sediment and subsequent persistence in sediment is not expected to be an important process in the removal of 1,2-dibromoethane from the environment. Because of the phaseout of the use of leaded gasoline and the ban on fumigant uses of 1,2-dibromoethane, current ambient media concentrations, with the potential exception of groundwater concentrations, are expected to be much lower than the levels reported here.

Table 5-3 shows the lowest limit of detections that are achieved by analytical analysis in environmental media.

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Table 5-3. Lowest Limit of Detection Based on Standards^a

Media	Detection limit	Reference
Air	0.0003–1 ppm	NIOSH 1987
Water	0.01 µg/L	EPA 1987b
Soil	≤0.018 µg/g	Sawhney et al. 1988
Biological tissues	0.5 µg/g	Letz et al. 1984

^aDetection limits based on using appropriate preparation and analytics. These limits may not be possible in all situations.

Detections of 1,2-dibromoethane in air, water, and soil at NPL sites are summarized in Table 5-4.

Table 5-4. 1,2-Dibromoethane Levels in Water, Soil, and Air of National Priorities List (NPL) Sites

Medium	Median ^a	Geometric mean ^a	Geometric standard deviation ^a	Number of quantitative measurements	NPL sites
Water (ppb)	2.4	2.53	15,800	30	16
Soil (ppb)	118,000	65,600	47,400	5	3
Air (ppbv)	0.01	0.029	4,503.15	5	4

^aConcentrations found in ATSDR site documents from 1981 to 2017 for 1,832 NPL sites (ATSDR 2017). Maximum concentrations were abstracted for types of environmental media for which exposure is likely. Pathways do not necessarily involve exposure or levels of concern.

5.5.1 Air

1,2-Dibromoethane has been detected in ambient air samples collected at a number of sites in the United States. In a review of available monitoring data for volatile organic compounds, Brodzinsky and Singh (1983) reported the following median concentrations of 1,2-dibromoethane in ambient air samples in the United States: less than detection limit in rural and remote areas; 2.6 parts per trillion (ppt) in urban and suburban areas; and 1.9 ppt in source-dominated areas. Typical daily concentrations at four sites in the metropolitan Los Angeles area in 1983 were reported to range from <5 to 17 ppt (Kowalski et al. 1985b). Ambient air concentrations of 1,2-dibromoethane for other metropolitan areas in the United States in 1980 were reported by Singh et al. (1981) as follows (mean [range]): 15 ppt [10–368 ppt] in Houston, Texas; 16 ppt [8–26 ppt] in St. Louis, Missouri; 31 ppt [10–78 ppt] in Denver, Colorado; and 22 ppt [10–47 ppt] in Riverside, California.

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1,2-Dibromoethane has also been detected in ambient air samples collected at two hazardous waste sites in New Jersey at geometric mean concentrations of 20–50 ppt; the maximum value reported was 6,710 ppt (La Regina et al. 1986).

Long-range transport of 1,2-dibromoethane from industrialized areas may have been the source of the compound found in ambient air samples collected in the Arctic by Rasmussen and Khalil (1984).

1,2-Dibromoethane concentrations in the 1983 study were reported to range from 1.0 to 1.9 ppt.

Natural production was speculated to be the source of 1,2-dibromoethane found in ambient air samples collected from open areas of the North and South Atlantic Ocean by Class and Ballschmitter (1988); concentration levels were reported to be <0.001–0.003 ppt.

5.5.2 Water

As a result of its volatility, 1,2-dibromoethane has been detected at only low levels in surface water samples collected in the United States. Ewing et al. (1977) reported that 1,2-dibromoethane was detected (i.e., concentrations >1,000 ppt) in only 2 of 204 surface water samples collected near heavily industrialized sites throughout the country. 1,2-Dibromoethane was detected at a maximum concentration of 200 ppt in 11 of 175 surface water samples collected in New Jersey from 1977 to 1979 (Page 1981). However, the compound has been widely detected in groundwater samples collected in the United States. In the late 1980s, the states with reported 1,2-dibromoethane groundwater contamination problems included Wisconsin (Krill et al. 1986), Hawaii (Oki and Giambelluca 1987), New Jersey (Page 1981), and Georgia (1,000–94,000 ppt) (Marti et al. 1984). California, Connecticut, Georgia, Massachusetts, New York, and Washington have historically been identified with 1,2-dibromoethane in groundwater. The median and maximum concentrations reported were 900 and 14,000 ppt, respectively (Williams et al. 1988).

Class and Ballschmitter (1988) suggested that brown algae may be the source of the <0.01–0.03 ppt of 1,2-dibromoethane found in the marine water samples collected from the North and South Atlantic Oceans.

5.5.3 Sediment and Soil

This section has not been updated with new information. No information was found in the literature regarding historical ambient concentrations of 1,2-dibromoethane in surface soils in the United States.

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5.5.4 Other Media

1,2-Dibromoethane residues in foods have decreased since the use of the compound as a fumigant was banned by EPA. For example, Daft (1989) reported finding 1,2-dibromoethane in only 2 of 549 samples of fatty and nonfatty foods analyzed for fumigant residues. 1,2-Dibromoethane was detected in samples of peanut butter and whiskey at a mean concentration of 7 µg/g (range 2–11 ng/g). Historical foodstuff residue levels have been reviewed by EPA (1983).

5.6 GENERAL POPULATION EXPOSURE

Current human exposure to 1,2-dibromoethane for most members of the general population appears to be limited to ingestion of low levels of the compound in contaminated drinking water. Data from the early 1980s indicate that daily intake from drinking water has been estimated to range from 0 to 16 µg/kg/day (EPA 1985). Ingestion of contaminated foodstuffs does not appear to be an important source of exposure; EPA (1983) estimated that the maximum intake of 1,2-dibromoethane from contaminated foods was 0.09 µg/kg/day. Average inhalation of ambient air also appears to be of less importance than ingestion of groundwater, although the available data are not current and variable. Daily respiratory intake was estimated by EPA (1985) to range from 0 to 79 µg/kg/day. Average inhalation exposures in four metropolitan areas of the United States in 1980 were estimated by Singh et al. (1981) to range from 2.8 to 9.9 µg/day (or 0.04–0.14 µg/kg/day for a 70-kg human). However, inhalation of 1,2-dibromoethane released to indoor air from contaminated groundwater (e.g., during showering) may be an important source of human exposure. For example, McKone (1987) modeled the mass transfer of several volatile organic compounds, including 1,2-dibromoethane, from water to air and calculated a maximum concentration of 1,2-dibromoethane in household air of 2.4×10^{-4} mg/L, assuming a tap water concentration of 1 mg/L.

Exposure of the general population to higher concentrations of 1,2-dibromoethane may result from contact with contaminated hazardous waste site media, principally soils and groundwater. The human population potentially exposed to 1,2-dibromoethane through contact with contaminated waste site media is unknown.

In occupational settings, current exposures are expected to be substantially reduced from historical levels (Santodonato et al. 1985). The large numbers of people exposed to 1,2-dibromoethane in the workplace through its manufacture and use as a gasoline additive and fumigant have decreased as these uses of the

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compound have been limited. NIOSH (1977) estimated that as many as 108,000 workers were potentially exposed to 1,2-dibromoethane during production and fumigant related uses, and an additional 875,000 workers were exposed to lower levels of the compound through its use in leaded gasoline. Exposure levels are expected to be substantially reduced from the historical inhalation and dermal exposures reported in manufacturing and processing facilities by Rumsey and Tanita (1978) and in fumigation operations reviewed by EPA (1983).

Data from the Fourth National Report on Human Exposure to Environmental Chemical are summarized in Table 5-5. Blood 1,2-dibromoethane measurements were below of limit of detection (CDC 2017).

Table 5-5. Blood 1,2-Dibromoethane Levels (ng/mL) in the NHANES U.S. Population

	Survey years	Geometric mean (95% CI)	Selected percentiles (95% CI)				Sample size
			50 th	75 th	90 th	95 th	
Total	2007–2008	ND	<LOD	<LOD	<LOD	<LOD	2,577
Age group							
12–19 years	2007–2008	ND	<LOD	<LOD	<LOD	<LOD	409
20–59 years	2007–2008	ND	<LOD	<LOD	<LOD	<LOD	1,389
≥60 years	2007–2008	ND	<LOD	<LOD	<LOD	<LOD	779
Sex							
Males	2007–2008	ND	<LOD	<LOD	<LOD	<LOD	1,270
Females	2007–2008	ND	<LOD	<LOD	<LOD	<LOD	1,307
Race/ethnicity							
Mexican Americans	2007–2008	ND	<LOD	<LOD	<LOD	<LOD	471
Non-Hispanic blacks	2007–2008	ND	<LOD	<LOD	<LOD	<LOD	532
Non-Hispanic whites	2007–2008	ND	<LOD	<LOD	<LOD	<LOD	1,165

CI = confidence interval; LOD = level of detection = 0.015 ng/mL; ND = not detected; NHANES = National Health and Nutrition Examination Survey

Source: CDC 2017

5.7 POPULATIONS WITH POTENTIALLY HIGH EXPOSURES

Members of the general population with potentially high exposure to 1,2-dibromoethane include individuals living near the NPL sites currently known to be contaminated with the compound. The size of the population and the concentrations of 1,2-dibromoethane in all of the contaminated media to which these people are potentially exposed have not been completely characterized. Other populations with potentially high exposures to 1,2-dibromoethane include individuals in the six states with confirmed

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groundwater contamination, and workers involved in the manufacture and continued use of 1,2-dibromoethane.