5. POTENTIAL FOR HUMAN EXPOSURE

5.1 OVERVIEW

Relatively little information is available on human exposure to BCEE. In the workplace, the most likely exposure routes are inhalation or dermal contact. For the general public, the most likely route is ingestion of BCEE in drinking water. Low levels of BCEE have been detected in some drinking water systems, and BCEE has been detected in groundwater at about 2% of the waste sites being investigated under Superfund. The most likely means of exposure near these sites is consumption of contaminated water, but dermal contact and inhalation exposure might also occur.

5.2 RELEASES TO THE ENVIRONMENT

No studies were located regarding the amount of BCEE being released from industrial processes or waste sites into air, water or soil.

5.3 ENVIRONMENTAL FATE

5.3.1 Transport and Partitioning

Little information was located on the transport or partitioning of BCEE in the environment. The vapor pressure of BCEE at 20°C is 0.7 mm Hg (Verschueren 1977), suggesting that volatilization from soil or water, while probably very slow, could be significant (Callahan et al. 1979). EPA (1987a) calculated a half-time for volatilization of BCEE from a river to be 3.4 days. Because BCEE is quite soluble in water (10,200 mg/L) (Verschueren 1977), it is expected that BCEE in air would tend to be removed by wet deposition, resulting in a cycle between water, soil and air (Callahan et al. 1979). The relative distribution between these phases, however, is not known.

Because BCEE has good solubility in water and a relatively low log octanol-water partition coefficient (measured to be 1.1 by Veith et al. 1980), BCEE in aqueous media is not expected to adsorb strongly to sediments, nor is it likely to be bioaccumulated by aquatic organisms (Callahan et al. 1979). Consistent with this, a bioconcentration factor of 11 has been measured in sunfish by Veith et al. (1980).

For the same reasons, BGEE is not expected to adsorb strongly to soils, and would be expected to migrate in soil water. Consistent with this, Wilson et al. (1981) reported a soil retardation factor of <1.5 for sandy soil with low organic content, while other contaminants (e.g., di- and trichlorobenzene) had retardation factors of 3.4 to 9.4.

5.3.2 Transformation and Degradation

5.3.2.1 Air

Callahan et al. (1979) reviewed the potential fate of BCEE in the environment and suggested that BCEE in a smog-like atmosphere would probably undergo photooxidative destruction with a half-life of approximately four hours. The rate of atmospheric photooxidation under other conditions was not estimated. Direct photolysis was judged to be an unimportant process, since BCEE does not absorb visible or near ultraviolet light (Callahan et al. 1979).

5.3.2.2 Water

Most ethers are very resistant to hydrolysis, and the rate of cleavage of the carbon-oxygen bond by abiotic processes is expected to be insignificant (Callahan et al. 1979). The carbon-chlorine bond is also quite stable to abiotic cleavage. Based on a measured hydrolysis rate constant of $1.5 \times 10^{-5} min^{-1}$ at 100°C, Mabey et al. (1982) estimated the half-life of the carbon-chlorine bond to be about 22 years at 20°C. This rate is somewhat slower than observed for simple alkyl halides (Callahan et al. 1979; Mabey et al. 1982), an effect which Mabey et al. (1982) attributed to the effect of the chloro-ethoxy group on the adjacent carbon.

Biodegradation may be an important fate process for BCEE in water. In laboratory studies, Tabak et al. (1981) found that in aqueous media inoculated with sewage, BCEE underwent 100% transformation within seven days, and there was a rapid adaptation of the degradative microorganisms. Similar results were reported by Ludzack and Ettinger (1963), although in this case there was a 25 day lag before adaption occurred, and 30 more days were required to convert 80% of the BCEE to CO_2. A second dose of BCEE added to the adapted medium was 80% oxidized in 15 days. Monsen (1986) reported that BCEE also underwent significant biodegradation (68%) in an anaerobic laboratory test pond designed to simulate an industrial primary lagoon. Losses via evaporation and sorption were minimal. In contrast to these findings, Dojlido (1979) did not observe significant biodegradation of BCEE in several laboratory

test systems. The reason for this discrepancy is not certain, but may be due to insufficient incubation time (two weeks) for the adaptation to occur. Biodegradation in surface waters would likely be slower than observed in the laboratory, but could lead to significant destruction of BCEE.

5.3.2.3 Soil

Wilson et al. (1981) observed no significant transformation of BCEE percolated through soil for 45 days, but Kincannon and Lin (1986) found that BCEE was significantly degraded in a 97-day laboratory soil column study. The initial rate constant for degradation was reported to be 0.042 day^{-1} (half-time of 16.7 days). After 48 days, the rate increased to 0.086 day^{-1} (half-time of 8.0 days), suggesting that there was an acclimation of soil microbes occurring.

5.4 LEVELS MONITORED OR ESTIMATED IN THE ENVIRONMENT

5.4.1 Air

No studies were located with regard to concentrations of BCEE in ambient air. Based on the physical-chemical properties of BCEE, some release of BCEE into air from contaminated chemical waste sites or industrial settings is expected, but no quantitative data were located.

5.4.2 Water

In 1977, the EPA carried out an extensive study (the National Organics Monitoring Survey) of organic contaminants in finished drinking water supplies across the United States. BCEE was not detected in any samples in Phase I of the study, but the detection limit was only 5 μg/L. In phase II, the detection limit was lowered to 0.005 μg/L, and BCEE was detected in water from 13 of 113 cities sampled. The values ranged from 0.01 to 0.36 μg/L, with a mean concentration (for the 13 positive samples) of 0.1 μg/L (Dressman et al. 1977). In phase III of the Survey, BCEE was detected in drinking water from 8 of 110 cities, with a mean concentration of 0.024 μg/L. Trace quantities of BCEE have been reported in several rivers, including the Mississippi, the Delaware and the Kanawha (Staples et al. 1985; EPA 1987a). BCEE was detected in ground water at about 2% of waste disposal sites being investigated under Superfund, at a geometric mean concentration of around 840 μg/L (CLPSD 1988).

5. POTENTIAL FOR HUMAN EXPOSURE

5.4.3 Soil

BCEE was detected in soil at only 0.4% of waste sites monitored under Superfund, at geometric mean concentration of 140 ppb (CLPSD 1988).

5.4.4 Other Media

No studies were located regarding the occurrence of BCEE in food or other media.

5.5 GENERAL POPULATION AND OCCUPATIONAL EXPOSURE

The primary known source of exposure for the general population is via the water supply. The reports of quantities in several drinking water supplies provided a mean value of approximately 0.1 ppb. Ingestion of approximately 2 liters of water per day by an adult would provide a daily intake of 0.003 μg/kg/day of BCEE. Based on the slope factor of 1.1 $(mg/kg/day)^{-1}$ (see Section 2.2.2.8), this corresponds to an upperbound lifetime cancer risk from this source of about 3×10^{-6}.

No studies were located regarding exposure of workers to BCEE.

5.6 POPULATIONS WITH POTENTIALLY HIGH EXPOSURES

Even though there are no exposure data, those at greatest risk of exposure to BCEE are probably workers who are exposed to BCEE while on the job. Residents who live near waste sites or industrial facilities that permit escape of BCEE may also experience higher than average exposure to BCEE. Exposure would be most likely by ingestion of contaminated water, but inhalation exposure might also occur. The level and significance of such exposures can only be evaluated on a site-by site basis.

5.7 ADEQUACY OF THE DATABASE

Section 104(i)(5) of CERCLA, directs the Administrator of ATSDR (in consultation with the Administrator of EPA and agencies and programs of the Public Health Service) to assess whether adequate information on the health effects of BCEE is available. Where adequate information is not available, ATSDR, in cooperation with the National Toxicology Program (NTP), is required to assure the initiation of a program of research designed to determine these health effects (and techniques for developing methods to determine such health effects). The following

discussion highlights the availability, or absence, of exposure and toxicity information applicable to human health assessment. A statement of the relevance of identified data needs is also included. In a separate effort, ATSDR, in collaboration with NTP and EPA, will prioritize data needs across chemicals that have been profiled.

5.7.1 Data Needs

Physical and Chemical Properties. The physical and chemical properties of BCEE have been determined (Table 3-1), and further research on these properties does not appear to be essential.

Environmental Fate. Although there is information which provides a general prediction of the likely fate and transport of BCEE in the environment, quantitative data are not available for most fate processes. Reliable quantitative data on rates of volatilization from water and soil, atmospheric oxidation, hydrolysis in water, and biodegradation in soil and water would be useful in estimating likely concentrations of BCEE in air, soil and water around waste sites and other possible sources of BCEE emissions.

Exposure Levels in Environmental Media. Available data suggest that contamination of water may occur around chemical waste sites or industrial facilities where BCEE is present. For this reason, additional monitoring data on BCEE concentrations in water (both surface water and ground water) around such sites would be valuable. Monitoring of BCEE levels in air, soil, fish, and possibly other foods would be helpful in estimating the significance of exposures through these media.

Exposure Levels in Humans. Information on exposure of the general population to BCEE is limited. The compound has been reported in drinking water in some locations, but many water supplies have not been tested. It would appear that an increased monitoring of drinking water supplies for this compound would be beneficial. Similarly, data on typical occupational exposure levels and durations would be valuable in estimating doses to workers, and data on exposure levels around chemical waste sites would be valuable in determining whether nearby residents are likely to be subject to significant health risk.

5. POTENTIAL FOR HUMAN EXPOSURE

Exposure Registries. No registry exists for humans known to have been exposed to BCEE. Creation of such a registry would be valuable in collection of further information on the health effects of BCEE on humans, especially chronic effects (such as cancer) that do not become manifest at the time of exposure.

5.7.2 On-going Studies

No information was located regarding on-going studies on the environmental fate of BCEE, or on BCEE levels in the ambient environment. Remedial investigations being performed under Superfund at chemical waste sites will provide additional data on the occurrence of BCEE in water, soil and possibly in air at these locations, and on the levels of human exposure that result.