PUBLIC HEALTH STATEMENT
1,4-Dioxane
CAS#: 123-91-1

Division of Toxicology **September 2004**

This Public Health Statement is the summary chapter from the Toxicological Profile for 1,4-Dioxane. It is one in a series of Public Health Statements about hazardous substances and their health effects. A shorter version, the ToxFAQs™ is also available. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present. For more information, call the ATSDR Information Center at 1-888-422-8737.

This public health statement tells you about 1,4-dioxane and the effects of exposure to it.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. EPA then places these sites on the National Priorities List (NPL) and targets them for federal long-term cleanup activities. 1,4-Dioxane has been found in at least 27 of the 1,647 current or former NPL sites. Although the total number of NPL sites evaluated for this substance is not known, the number of sites at which 1,4-dioxane is found could increase as more sites are evaluated. This information is important because these sites may be sources of exposure, and exposure to this substance may harm you.

When a substance is released either from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. Such a release does not always lead to exposure. You can be exposed to a substance only when you contact it—by breathing, eating, or drinking the substance or by skin contact.

Many factors determine whether exposure to 1,4-dioxane will harm you. These factors include the dose (how much), the duration (how long), and the way you contact it. You also must consider any other chemicals to which you are exposed and your age, sex, diet, family traits, lifestyle, and state of health.

1.1 WHAT IS 1,4-DIOXANE?

1,4-Dioxane is clear liquid that dissolves in water at all concentrations. It is used primarily as a solvent in the manufacture of chemicals and as a laboratory reagent; 1,4-dioxane also has various other uses that take advantage of its solvent properties.
1,4-Dioxane is a trace contaminant of some chemicals used in cosmetics, detergents, and shampoos. However, manufacturers now reduce 1,4-dioxane from these chemicals to low levels before these chemicals are made into products used in the home.

1.2 WHAT HAPPENS TO 1,4-DIOXANE WHEN IT ENTERS THE ENVIRONMENT?

1,4-Dioxane can be released into the air, water, and soil at places where it is produced or used as a solvent. In air, 1,4-dioxane is present as a vapor. It does not react directly with sunlight. However, in the atmosphere, sunlight can form reactive compounds that can change 1,4-dioxane into different compounds. In water, 1,4-dioxane is stable and does not degrade; therefore, fish and plants will not accumulate it in their tissues. In soil,

1,4-dioxane does not stick to soil particles, so it can move from soil into groundwater.

1.3 HOW MIGHT I BE EXPOSED TO 1,4-DIOXANE?

You can be exposed to 1,4-dioxane when you breath air, eat food, or drink water contaminated with it. However, current levels of 1,4-dioxane in air, drinking water, and food samples are unknown. In the mid 1980s, levels of 1,4-dioxane in outdoor air ranged from 0.1 to 0.4 µg/m^3 (or 1–4 10 millionths of a gram of 1,4-dioxane per 1 cubic meter of air). Levels in outdoor air also can be expressed as 0.03–0.11 parts per billion in units of volume (or ppbv). For indoor air, the average concentrations of 1,4-dioxane were 10 times higher than in outdoor air at levels of 4 µg/m^3 (or 4 millionths of 1 gram of 1,4-dioxane per 1 cubic meter of air). Levels in indoor air also can be expressed as ppbv. In the 1970s, drinking water sampled in the United States reportedly contained 1 µg/L (1 µg/L is 1 millionth gram of 1,4-dioxane per 1 liter of water [or ppb]). However, contaminated wells that may have been used as a source of drinking water have been reported to contain 1 mg per liter (1 ppm). 1,4-Dioxane has been detected in food vapors, which suggests that 1,4-dioxane may be a natural ingredient in some foods. Vapors from chicken, meat, tomato, and small shrimp have been reported to contain 1,4-dioxane. However, the amounts of 1,4-dioxane in other foods are not known.

Tap water can contain 1,4-dioxane, so you also can be exposed to 1,4-dioxane during activities such showering, bathing, and laundering. Exposure to 1,4-dioxane in tap water by breathing in during showering or other indoor activities can result in higher exposures to 1,4-dioxane than from drinking water.

Your skin may contact 1,4-dioxane when you use cosmetics, detergents, and shampoos containing 1,4-dioxane. In 1985, the Food and Drug Administration (FDA) requested that manufacturers limit the level of 1,4-dioxane in cosmetic products to levels not greater than 10 milligrams of 1,4-dioxane per kilogram of product (10 mg/kg or 10 ppm). However, during 1992–1997, the average concentration of 1,4-dioxane in some cosmetic products reportedly ranged from 14 to 79 mg/kg.

1.4 HOW CAN 1,4-DIOXANE ENTER AND LEAVE MY BODY?

1,4-Dioxane can enter the body by contact of the skin with products that contain it or with contaminated soil, by breathing vapors that escape from liquids that contain 1,4-dioxane (as may happen when showering with contaminated water), or by eating contaminated food. Studies in volunteers have shown that after inhalation of vapors of 1,4-dioxane, almost all of the 1,4-dioxane that enters the lungs can pass to the blood stream. Studies in animals have shown that the same can occur with 1,4-dioxane that is swallowed and reaches the stomach. Much smaller amounts of 1,4-dioxane can pass to the bloodstream if it contacts your skin. Once in the bloodstream, 1,4-dioxane is distributed throughout the body and is rapidly converted into other chemicals, or metabolites, which quickly leave the body in the

urine. Neither 1,4-dioxane nor its metabolites build up in the body.

1.5 HOW CAN 1,4-DIOXANE AFFECT MY HEALTH?

Scientists use many tests to protect the public from harmful effects of toxic chemicals and to find ways to treat people who have been harmed.

One way to learn whether a chemical will harm people is to determine how the body absorbs, uses, and releases the chemical. For some chemicals, animal testing may be necessary. Animal testing can help identify health problems, such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method for getting information needed to make wise decisions that protect public health. Scientists have the responsibility to treat research animals with care and compassion. Scientists must comply with strict animal-care guidelines because laws today protect the welfare of research animals.

Few studies are available that provide information about the effects of 1,4-dioxane in humans. Acute accidental exposure to high amounts of vapors of 1,4-dioxane that have caused death in people have been reported. In these cases, skin contact with the chemical also probably occurred. Autopsies of these patients showed extensive damage to the liver and kidneys. Volunteers who breathed controlled low levels of 1,4-dioxane vapors for short periods (minutes to hours) complained of irritation of the eyes and the nose. A few studies of workers exposed to 1,4-dioxane for long periods did not show any significant harmful health effects. Studies in animals have shown that breathing vapors of 1,4-dioxane, swallowing liquid 1,4-dioxane or contaminated drinking water, or having skin contact with liquid 1,4-dioxane also affects mainly the liver and kidneys. Animals that breathed high amounts of 1,4-dioxane also became drowsy. Scientists do not know whether 1,4-dioxane affects reproduction or the ability to fight infections in people or animals. The limited number of studies of workers did not indicate whether 1,4-dioxane causes cancer in humans. However, laboratory rats and mice that drank water containing 1,4-dioxane during most of their lives developed liver cancer; the rats also developed cancer inside the nose. Scientists are debating the degree to which the findings in rats and mice apply to exposure situations commonly encountered by people. On the basis of inadequate evidence in humans and sufficient evidence in experimental animals, the International Agency for Research on Cancer has determined that 1,4-dioxane is possibly carcinogenic to humans. The U.S. Department of Health and Human Services considers 1,4-dioxane as reasonably anticipated to be a human carcinogen on the basis of sufficient evidence of carcinogenicity in experimental animals. EPA has established that 1,4-dioxane is a probable human carcinogen on the basis of inadequate evidence in people and sufficient evidence in animals. It should be pointed out that the limited environmental monitoring data available suggest that the levels of 1,4-dioxane to which the general population might be exposed through contact or use of consumer products (including food), or that are normally found in environmental media, are generally significantly lower than those used in studies with experimental animals.

1.6 HOW CAN 1,4-DIOXANE AFFECT CHILDREN?

This section discusses potential health problems in people from exposures during conception to maturity (18 years of age).

Children can be exposed to 1,4-dioxane from contaminated air and food, and from drinking contaminated well or tap water; from showering or bathing with contaminated water; and from using consumer products that contain small amounts of 1,4-dioxane; however, based on available measurements, these risks are very low. It should be noted that exposure to 1,4-dioxane by breathing in evaporated contaminated water during showering or other indoor activities can result in higher exposures to 1,4-dioxane compared to drinking the tap water.

Children play outdoors and can be exposed if they touch or eat contaminated soil or place dirty objects in their mouths.

There are no studies of children exposed to 1,4-dioxane. However, children might experience health problems similar to those in adults if they were exposed to high concentrations of 1,4-dioxane. 1,4-Dioxane could harm children's liver and kidneys, depending on the amount of 1,4-dioxane entering the body.

Scientists do not know whether exposure of pregnant women to 1,4-dioxane can harm the unborn child, or if so, what levels of maternal exposure might harm the fetus. Not enough animal studies are available that can help predict what might happen in people. 1,4-Dioxane does not build up in the body, but a nursing mother exposed to a high amount of 1,4-dioxane might pass it to the infant in breast milk. However, scientists do not know whether this occurs in people or animals.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO 1,4-DIOXANE?

If your doctor finds that you (or a family member) have been exposed to substantial amounts of 1,4-dioxane, ask whether your children also might have been exposed. Your doctor might need to ask your state health department to investigate.

Families that drink water that could be contaminated with 1,4-dioxane can reduce the risk for exposure to 1,4-dioxane by drinking uncontaminated bottled water. Children who live near hazardous waste sites that might be contaminated with 1,4-dioxane should be discouraged from playing in mud and water near these sites because these sites might contain 1,4-dioxane. Children also should be discouraged from eating mud, and they should follow careful hand washing.

1,4-Dioxane may be a contaminant in cosmetics, detergents, and shampoos that contain the following ingredients (which may be listed on the product label): "PEG," "polyethylene," "polyethylene glycol," "polyoxyethylene," "-eth-," or "-oxynol-." Most manufacturers remove 1,4-dioxane from these ingredients to concentrations recommended by the FDA as safe. Thus, most products on the market today contain 1,4-dioxane in very small amounts or not at all. However, some cosmetics, detergents,

and shampoos may contain 1,4-dioxane at levels higher than recommended by FDA. Because products contaminated at concentrations higher than the FDA-recommended levels are not possible to determine without testing, families should avoid using products containing the ingredients listed above unless the manufacturer can guarantee that 1,4-dioxane is below the FDA-recommended level.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO 1,4-DIOXANE?

1,4-Dioxane and its breakdown products can be measured in your blood and urine, and positive results indicate you have been exposed to 1,4-dioxane. The tests are not routinely available at your doctor's office because they require special equipment, but the doctor can collect the samples and send them to a special laboratory. The tests need to be conducted within days after the exposure because 1,4-dioxane and its breakdown products leave the body fairly rapidly. These tests do not predict whether exposure to 1,4-dioxane will produce harmful health effects.

1.9 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

The federal government develops regulations and recommendations to protect public health. Regulations *can* be enforced by law. EPA, the Occupational Safety and Health Administration (OSHA), and FDA are some federal agencies that develop regulations for toxic substances.

Recommendations provide valuable guidelines to protect public health but *cannot* be enforced by law. The Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH) of the Centers for Disease Control (CDC) are two federal agencies that develop recommendations for toxic substances.

Regulations and recommendations can be expressed as "not-to-exceed" levels—in other words, levels of a toxic substance in air, water, soil, or food that do not exceed critical levels that are usually based on levels that affect animals; they are then adjusted to levels that will help protect people. Sometimes these not-to-exceed levels differ among federal agencies because the agencies used different exposure times (for example, an 8-hour workday or a 24-hour day), different animal studies, or other factors.

Recommendations and regulations are updated periodically as more information becomes available. For the most current information, check with the federal agency that provides it.

EPA recommends that the levels of 1,4-dioxane in drinking water that children drink for 1 day not exceed 4 milligrams per liter (mg/L) or 0.4 mg/L if they drink the water for 10 days. However, a federal drinking water standard (maximum contaminant level or MCL) is not available. EPA requires that any release to the environment of 100 pounds of 1,4-dioxane or more be reported EPA.

OSHA has established a workplace exposure limit for 1,4-dioxane of 360 mg/m^3 (100 ppm), for an 8-hour workday, 40 hours per week. NIOSH

recommends that workers not be exposed to more than 3.6 mg/m^3 (1 ppm) of 1,4-dioxane in the air over 30 minutes. NIOSH also recommends that a level of 1,800 mg/m^3 (500 ppm) of 1,4-dioxane in the air be considered as immediately dangerous to life and health.

FDA keeps a record of raw materials and products contaminated with 1,4-dioxane.

1.10 WHERE CAN I GET MORE INFORMATION?

If you have questions or concerns, please contact your community or state health or environmental quality department, or contact ATSDR at the address and phone number below.

ATSDR can tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses that result from exposure to hazardous substances.

Toxicological profiles are available on-line at www.atsdr.cdc.gov and on CD-ROM. You may request a copy of the ATSDR ToxProfiles™ CD-ROM by calling the toll-free information and technical assistance number at 1-888-42ATSDR (1-888-422-8737), by e-mailing atsdric@cdc.gov, or by writing to:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE
Mailstop F-32
Atlanta, GA 30333
Fax: 1-770-488-4178

For-profit organizations may request copies of final Toxicological Profiles

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
Phone: 1-800-553-6847 or 1-703-605-6000
Web site: http://www.ntis.gov/