1. PUBLIC HEALTH STATEMENT

This public health statement tells you about americium and the effects of exposure.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites make up the National Priorities List (NPL) and are the sites targeted for long-term federal cleanup activities. Americium has been found in at least 8 of the 1,636 current or former NPL sites. However, the total number of NPL sites evaluated for americium is not known. As more sites are evaluated, the sites at which americium is found may increase. This information is important because exposure to americium may harm you and because these sites may be sources of exposure.

When a substance is released from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. This release does not always lead to exposure. You are normally exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance, or by skin contact. However, since americium is radioactive, you can also be exposed to its radiation if you are near it.

External or internal exposure to radiation may occur from natural or man-made sources. Naturally occurring sources of radiation are cosmic radiation from space or naturally occurring radioactive materials in our body or in soil, air, water, or building materials. Man-made sources of radiation are found in consumer products, industrial equipment, atom bomb fallout, and to a smaller extent, from hospital waste and nuclear reactors.

If you are exposed to americium, many factors determine whether you'll be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with it. You must also consider the other chemicals or radioactive materials you're exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

1.1 WHAT IS AMERICIUM?

Americium (pronounced, ˌam-əˈrish(ē)-ˈəm) is a human-made, radioactive element. There are no naturally occurring or stable isotopes of americium. Pure americium is a silvery metal. There are two important isotopes of americium, americium 241 and americium 243, also written as ^{241}Am and ^{243}Am, and read as americium two-forty-one and americium two-forty-three. Both isotopes have the same chemical behavior in the environment.

Quantities of americium, as well as other radioactive elements, can be measured in units of mass (grams), but are usually measured in terms of their radioactivity (curies or becquerels). Both the curie (Ci) and the becquerel (Bq) tell us how much a radioactive material decays every second. The becquerel is a new international unit and the curie is a traditional unit; both units are currently used in the United States. A becquerel is the amount of radioactive material in which 1 atom transforms every second, and a curie is the amount of radioactive material in which 37 billion atoms transform every second.

Each radioactive isotope of an element, including americium, constantly gives off radiation, which changes it into an isotope of a different element or a different isotope of the same element. This newly formed nuclide may be stable or radioactive. This process is called radioactive decay. ^{241}Am and ^{243}Am give off alpha particles (sometimes referred to as alpha radiation) and change into neptunium 237 (^{237}Np) and neptunium 239 (^{239}Np), respectively. Neptunium is also radioactive, so isotopes of this element also give off radiation and change into isotopes of other elements. This process continues and eventually ends when stable isotopes of bismuth and lead are formed.

Half-life is the term that is used to describe the rate of the decay process. Specifically, the half-life is the time it takes for half of the atoms of a radionuclide to undergo radioactive decay and change it into a different isotope. The half-life of ^{241}Am is 432 years. The half-life of ^{243}Am is 7,370 years.

Specific activity is a term that describes the relative rates of decay of the same mass of different radioactive materials. If you have 1 gram of each isotope of americium side by side, the specific activities would be 3.4 curies per gram for ^{241}Am and 0.2 curies per gram for ^{243}Am. Thus, for the same mass, ^{241}Am is about 17 times more radioactive (i.e., its specific activity would be 17 times higher) than that of ^{243}Am. The higher the specific activity of a radioisotope, the faster it is decaying.

The predominant commercial use of ^{241}Am is in ionization-type smoke detectors. This application relies on the alpha particles that are produced when the isotope decays as an ionization source. A typical household smoke detector contains 0.9 microcuries (μCi; a μCi is one millionth of a curie) or 33,000 Bq of ^{241}Am, and 1 g of americium dioxide is sufficient to make 5,000 smoke detectors. ^{241}Am is also used for industrial gauging applications and in medical diagnostic devices. There are research applications, but no commercial applications for ^{243}Am. This will change if the United States and Russia turn nuclear warheads into power reactor fuel by making a mixed oxide fuel of uranium and plutonium. This fuel, called MOX, will contain both ^{241}Am and ^{243}Am, and the plan is to use it to make electricity. Once used, the spent nuclear fuel is to be sent for disposal.

For more information about the properties and uses of americium, see Chapters 4, 5, and 6.

1.2 WHAT HAPPENS TO AMERICIUM WHEN IT ENTERS THE ENVIRONMENT?

^{241}Am can be released to the environment from nuclear reactors, nuclear explosions, and accidents, as well as from manufacturing products containing americium (such as smoke detectors). Americium is a byproduct of plutonium production. ^{241}Am is formed from the radioactive decay of plutonium 241 (^{241}Pu), which itself is produced from uranium 238 (^{238}U) while it is inside an operating nuclear reactor. In the absence of clean-up procedures, radioactive decay is the only way for decreasing the amount of americium in the environment. Because ^{241}Am has a long half-life, it will be present in the environment for a long time. Since ^{241}Pu can be released along with ^{241}Am in the decay process, the amount of ^{241}Am will slowly increase for decades, even in the absence of additional ^{241}Am releases, and then slowly decrease.

^{241}Am released to the atmosphere will be associated with particles and will settle to earth or be washed from the air in precipitation (e.g., rain, snow). ^{241}Am from atmospheric nuclear weapons tests may remain in the atmosphere for decades before settling to earth. For example, ^{241}Am released in nuclear accidents, like the accident at Chernobyl, will stay in the lower atmosphere and begin to settle to earth near the site from which it was released. Larger particles will settle out more quickly and over a smaller area; smaller particles may remain in the atmosphere for several months and travel far from where they were released. Precipitation removes particles from the air more rapidly.

^{241}Am released into water from nuclear facilities will tend to stick to particles in the water or the sediment. ^{241}Am deposited on soil is so strongly attached to soil particles that it does not travel very far into the ground. Ultimately, most americium ends up in soil or sediment.

While plants may take up ^{241}Am from the soil, the amount taken up is small, especially in the parts of the plant that are most often eaten (i.e., the fruit, grain, and seeds). While fish may take up ^{241}Am, the amount that builds up in the flesh is very small. Most of the ^{241}Am found in shellfish like shrimp or mussels is contained in the shell, rather than in the edible parts of the animal. For more information about what happens to americium in the environment, see Chapter 6.

1.3 HOW MIGHT I BE EXPOSED TO AMERICIUM?

You may be exposed to ^{241}Am by breathing air, drinking water, or eating food containing ^{241}Am; however, the levels of ^{241}Am in air, water, soil, and food are generally very low, and of little health consequence.

People working at sites where nuclear waste is stored, in nuclear power plants, or in other nuclear facilities that handle ^{241}Am may be exposed to higher levels of americium than the general population. People living near these sites also may be exposed to elevated levels of americium. People who produce or handle ^{241}Am in smoke detectors or other devices may be

exposed to higher levels. In the case of a nuclear accident, exposure could occur by breathing or eating dust containing ^{241}Am. Even at sites that contain measurable levels of radioactive contamination, the amount of ^{241}Am that is taken up into plant and animal tissue is so small that it is of little concern. You can find more information on how you may be exposed to americium in Chapter 6.

1.4 HOW CAN AMERICIUM ENTER AND LEAVE MY BODY?

Americium can enter your body from the air you breathe, the food you eat, or the water you drink, or from contact with your skin. If you breathe in air that contains americium, some forms of americium that dissolve easily in lung fluid stay in your lungs for hours or days. Other forms that do not dissolve easily in lung fluid might stay in your lungs for months or years. Some americium that enters your lungs may get into your blood. If you swallow americium, a very small amount of what enters your digestive tract may also enter your blood. Most of the americium entering your blood leaves your body in your urine and feces. Of the small amount that stays in your body, most goes to your bones, where it can remain for many decades; a smaller amount goes into your liver and other organs, where it may remain for a few years as the body clears it.

1.5 HOW CAN AMERICIUM AFFECT MY HEALTH?

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

One way to see if a chemical will hurt people is to learn how the chemical is absorbed, used, and released by the body. In the case of a radioactive chemical, it is also important to gather information concerning the radiation dose and dose rate to the body. For some chemicals, animal testing may be necessary. Animal testing may also be used to identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method to get information needed to make wise decisions to protect public health. Scientists have the

responsibility to treat research animals with care and compassion. Laws today protect the welfare of research animals, and scientists must comply with strict animal care guidelines.

In the process of radioactive decay, americium releases alpha particles and gamma rays. Alpha particles are relatively high energy particles, but travel only extremely short distances and do not penetrate the skin. However, if americium is taken into the body and enters body tissues, alpha particles may produce damage to nearby cells. Gamma rays can travel much greater distances and can penetrate the entire body. Since alpha particles do not penetrate the skin and the gamma rays released from americium sources are relatively low in energy, external exposure to americium is not usually considered to be a danger to your health.

The radiation from americium is the primary cause of adverse health effects from absorbed americium. Upon entering the body by any route of exposure, americium moves relatively rapidly through the body and is deposited on the surfaces of the bones where it remains for a long time. As americium undergoes radioactive decay in the bone, alpha particles collide with nearby cell matter and give all of their energy to this cell matter. The gamma rays released by decaying americium can travel much farther before hitting cellular material, and many of these gamma rays leave the body without hitting or damaging any cell matter. The dose from this alpha and gamma radiation can cause changes in the genetic material of these cells that could result in health effects such as bone cancers. Exposure to extremely high levels of americium, as has been reported in some animal studies, has resulted in damage to organs such as the lungs, liver, kidneys, and thyroid. It is rare, however, that a person would be exposed to amounts of americium large enough to cause harmful effects in these organs.

1.6 HOW CAN AMERICIUM AFFECT CHILDREN?

This section discusses potential health effects from exposures during the period from conception to maturity at 18 years of age in humans.

Americium accumulates in human bones and remains there for a long time. Americium emits radioactive alpha particles in the bone that can cause damage to the surrounding tissue. The

body normally repairs all of the damage, but if it fails, bone cancer could result after many years. If americium exposure to children occurs, the exposure to the radiation from americium may be for a longer period of time, causing a larger radiation dose over their lifetime and increasing the likelihood of producing cancer. However, there are no published data showing that children are more susceptible than adults to radiation-induced americium toxicity. A developing baby is expected to have some americium in its body. It could be affected by this americium while in the womb if the pregnant mother has high enough levels of americium in her blood.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO AMERICIUM?

If your doctor finds that you have been exposed to significant amounts of americium, ask whether your children might also be exposed. Your doctor might need to ask your state health department to investigate.

While discharges from nuclear waste sites, nuclear reactors, or plants that manufacture ionization smoke detectors or gauges containing americium are regulated, it is possible that higher-than-normal levels of americium may be in soil near a nuclear waste site, nuclear reactor, or plant that manufactures ionization smoke detectors or gauges containing americium. If you live near any of these types of nuclear or manufacturing sites, discourage your children from putting their hands in their mouths and engaging in other hand-to-mouth activities.

Discharge water and air emissions from facilities that make americium smoke detectors or gauges or produce plutonium for nuclear weapons may contain some americium. These operations are strictly regulated, but you can check local health advisories before consuming fish or other food from these waters. Nuclear reactors are not expected to discharge measurable amounts of americium.

Ionization smoke detectors that contain americium are safe when installed; however, you should not allow your children to play with these detectors. If the detectors are damaged or are no longer being used, they should be promptly returned to the manufacturer for disposal.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO AMERICIUM?

Physicians do not test for americium in their offices, but they can collect samples and send them to special laboratories or request that you be sent to such a laboratory. If you are exposed to a large dose of radiation from americium, your blood can be tested for signs of damage to the cell chromosomes. If americium were to enter your body from contaminated air, food, or water, the amount of americium (in Ci or Bq) can be estimated by measuring the radiation given off by the americium present in samples of blood, urine, teeth, or tissue. If in the lungs, the amount of americium can be estimated by measuring the americium gamma radiation that exits the body. Radiation detector systems used for these purposes are at a limited number of locations. The amount in your lungs and excretions fall sharply after exposure, so tests should be done as soon as possible.

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. Federal agencies that develop regulations for toxic substances include the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), the Food and Drug Administration (FDA), and the U.S. Nuclear Regulatory Commission (USNRC).

Recommendations provide valuable guidelines to protect public health but cannot be enforced by law. Federal organizations that develop recommendations for toxic substances include the Agency for Toxic Substances and Disease Registry (ATSDR), the National Institute for Occupational Safety and Health (NIOSH), and FDA.

Regulations and recommendations can be expressed in not-to-exceed levels in air, water, soil, or food that are usually based on levels that affect animals; then they are adjusted to help protect people. Sometimes these not-to-exceed levels differ among federal organizations because of

different exposure times (an 8-hour workday or a 24-hour day), the use of different animal studies, or other factors.

Recommendations and regulations are also periodically updated as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for americium include the following:

The USNRC established radiation dose limits to the public and to workers. To ensure that these limits are met, USNRC also set concentration limits for ^{241}Am in air, water, and sewer discharge that can be released from licensed facilities. This ensures that the annual radiation dose will not exceed 0.1 rem (0.001 sievert) to the public, or 5 rem (0.05 sievert) to the worker or 50 rem (0.5 sievert) to their bones. The concentration limits are 0.00000000000002 microcurie per milliliter ($2x10^{-14}$ μCi/mL) for air, 0.00000002 microcurie per milliliter ($2x10^{-8}$ μCi/mL) for water, and 0.0000002 microcurie per milliliter ($2x10^{-7}$ μCi/mL) for releases to sewers. The USNRC requires that intake of americium not exceed the specified annual limits on intake (ALI) for inhalation or oral routes of exposure. The occupational exposure limits are $6x10^{-3}$ μCi (ALI) for workers inhaling ^{241}Am and $8x10^{-1}$ μCi (ALI) for ingestion of ^{241}Am. The level of ^{241}Am in workplace air, specified as the derived air concentration (DAC), is not to exceed $3x10^{-12}$ μCi/mL (which can be adjusted to account for work weeks shorter or longer than 40 hours). The FDA has set a food contamination guideline of 2 Bq/kg per kilogram ($5.4x10^{-5}$ μCi/kg) for ^{241}Am to protect 3-month-old children. This is the population group that would receive the highest radiation dose from eating food that contains americium. The EPA has established a public drinking water limit of 15 picocurie per liter (pCi/L). This is for the sum of all radioactive materials that give off alpha radiation. ^{241}Am and ^{243}Am are examples, but drinking water normally contains other alpha emitters, such as uranium, thorium, and radium.

More information on regulations and guidelines is available in Chapter 8.

1.10 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns, please contact your community or state health or environmental quality department, your regional Nuclear Regulatory Commission office, or contact ATSDR at the address and phone number below.

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

Toxicological profiles are also 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 information and technical assistance toll-free number at 1-888-42ATSDR (1-888-422-8737), by email at 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 a copy of final profiles from the following:

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/