1. PUBLIC HEALTH STATEMENT

This public health statement tells you about perchlorates and the effects of exposure to them.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites are then placed on the National Priorities List (NPL) and are targeted for long-term federal clean-up activities. Perchlorates have been found in at least 8 of the 1,662 current or former NPL sites. Although the total number of NPL sites evaluated for these substances is not known, the possibility exists that the number of sites at which perchlorates are found may increase in the future as more sites are evaluated. This information is important because these sites may be sources of exposure and exposure to these substances 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 come in contact with it. You may be exposed by breathing, eating, or drinking the substance, or by skin contact.

If you are exposed to perchlorates, many factors will determine whether you will be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with them. You must also consider any other chemicals you are exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

1.1 WHAT ARE PERCHLORATES?

Perchlorates are colorless salts that have no odor. Five perchlorates are manufactured in large amounts; magnesium perchlorate, potassium perchlorate, ammonium perchlorate, sodium perchlorate, and lithium perchlorate. Perchlorates are found in the environment in two forms. If no water is present, as in a drum or on top of dry ground, then they will exist as solids. If water is present, then they will quickly dissolve. When perchlorates dissolve, they separate into two parts. One part has a positive charge, and the other part has a negative charge. The part with the

negative charge is called the perchlorate anion or just perchlorate. This is the part of the chemical that people look for in the environment or in your body.

Perchlorates can be very reactive chemicals. When they are heated to red hot, they begin to react. Once they begin to react, they produce a large amount of heat. This causes more of the perchlorates to begin reacting, which makes even more heat. This process repeats itself over and over until an explosion occurs. Because perchlorates react this way, they are used mainly in rocket motors, fireworks, and explosives.

Because perchlorates can react explosively, people did not expect to find them in the environment. But at normal Earth temperatures, perchlorates react much more slowly. We have learned only recently that perchlorates may last in the environment for a very long time.

One of the perchlorate salts, ammonium perchlorate, is produced in very large amounts because it is used in rockets. The solid booster rocket on the space shuttle is almost 70% ammonium perchlorate. Perchlorates are also used in explosives. It has been estimated that 90% of perchlorates that are produced are used for defense and aerospace activities. Because perchlorates are used for some military applications, many countries consider the amounts that they make confidential. This is one reason why we do not know the exact amount of perchlorates produced or used in the United States or around the world. No laws require private companies in the United States to provide information on the amount of perchlorates that they make or use. We also do not know the amount of perchlorates brought into the United States from other countries, although the largest amount probably comes from fireworks.

Other uses of perchlorates include fireworks, explosives, flares, gunpowder, temporary adhesives, electrolysis baths, batteries, drying agents, etching agents, and oxygen generating systems. They are also used for making other chemicals. Many years ago, perchlorates were used as a medication to treat an overreactive thyroid gland. Currently, perchlorates are used to prevent technetium uptake during medical imaging and as part of a treatment to counter the thyroid effects of the drug amiodarone.

Perchlorates occur naturally, for example, in the saltpeter deposits in Chile, South America. Chilean saltpeter is used to make fertilizer. In the past, the United States used a lot of this fertilizer on tobacco plants, but now uses very little.

You will find more information on the properties of perchlorates in Chapter 4. In Chapter 5, you will find more information on the uses of perchlorates and how they are made.

1.2 WHAT HAPPENS TO PERCHLORATES WHEN THEY ENTER THE ENVIRONMENT?

Before 1997, it was very hard to measure perchlorates in the environment. In 1997, a much better method was developed, and low levels of perchlorates in water and other media can now be measured. Scientists first began looking for perchlorates near hazardous waste sites where they had been used. They were surprised when they found them in many other places because they did not think perchlorates would last very long in the environment. Since then, scientists have been looking for perchlorates in water at more and more places. Perchlorates have recently been found in soil, plants, and animals located near perchlorate-contaminated areas.

Perchlorates entered the environment where rockets were made, tested, and taken apart. We also know that perchlorates will enter the environment if a rocket explodes or crashes. Factories that make or use perchlorates may also release them to soil and water. Some factories may even release perchlorate dusts, which can be blown away in the wind. Perchlorates probably also enter the environment if a factory using them, like a fireworks factory, accidentally explodes. We think that they may enter the environment in very small amounts from fireworks, explosives, flares, and similar products, but we don’t know for sure. Recent studies have reported that perchlorate contamination is being found in locations where it has not been known to be made, used, or released by humans. It is unclear how the perchlorate got there.

If perchlorates are released to the environment, they are expected to end up in soil or water (rivers, streams, lakes, and ponds). Perchlorates will be carried through soil by rainwater. As the rainwater soaks into the ground, the perchlorates will also soak into the ground. As they go deeper into the soil, they will eventually end up in groundwater (underground rivers). In arid climates, perchlorates would move through soil more slowly. The information we have so far indicates that perchlorates will last in water and soil for a very long time.

More information on what happens to perchlorates in the environment can be found in Chapter 6.

1.3 HOW MIGHT I BE EXPOSED TO PERCHLORATES?

You may be exposed to perchlorates if you drink water or eat food that is contaminated with it. Most contaminated water supplies are found near hazardous waste sites where perchlorates have been found. Perchlorates have been found in lakes, rivers, and underground wells near these sites. In a few places, they have also been found in tap water at very low levels. During a survey of about 3,600 public water systems located across the United States, perchlorate was detected above 4 parts per billion (ppb) in about 2% of drinking water samples and in about 4% of systems. There is currently no cost efficient way to remove perchlorates from large drinking water supplies. New methods are actively being developed to solve this problem.

You may be exposed to perchlorates if you live near a factory where they are made. You may also be exposed to perchlorates if you live near a factory that makes fireworks, flares, or other explosive devices. Gunpowder contains perchlorates, and you may be exposed to small amounts of perchlorates if you reload your own ammunition. A variety of different tobacco products have been found to contain perchlorate, so you may be exposed if you chew tobacco. Perchlorates have also been found in food and milk.

If you live near a hazardous waste site, you may be exposed to higher levels of perchlorates than other people in the United States. If you live near a rocket manufacturing or testing facility, you may also be exposed to higher levels. As mentioned earlier, perchlorate is being found in small amounts in areas where it has not been known to be manufactured, used, or released by humans.

Exposure to perchlorates at these locations may be possible; however, the nature of this contamination and exposure is unclear and must be studied further.

You will find more information on how you might be exposed to perchlorates in Chapter 6.

1.4 HOW CAN PERCHLORATES ENTER AND LEAVE MY BODY?

Perchlorates can enter the body after you have swallowed food or water containing them. Since they easily dissolve in water, they quickly pass through the stomach and intestines and enter the bloodstream. If you breathe in air containing dust or droplets of perchlorate, it can pass though your lungs and enter the bloodstream. Perchlorates probably do not enter the body directly through the skin, but if present on your hands, hand-to-mouth-activity could contribute to oral exposure.

The blood stream carries perchlorate to all parts of the body. Perchlorate is not changed inside the body. A few internal organs (for example, the thyroid and salivary glands) can take up relatively large amounts of perchlorate out of the bloodstream. Perchlorate leaves these organs in a few hours. Perchlorate has also been found in breast milk.

When perchlorates are swallowed, a small percentage is eliminated in the feces. More than 90% of perchlorate taken in by mouth enters the bloodstream. In the blood, perchlorate passes into the kidneys, which then release it into the urine. The body begins to clear itself of perchlorate through the kidneys within 10 minutes of exposure. Most of the perchlorate that is taken in is eliminated in the first day.

More information on this subject is found in Chapter 3.

1.5 HOW CAN PERCHLORATES AFFECT MY HEALTH?

The main target organ for perchlorate toxicity in humans is the thyroid gland. Perchlorate partially inhibits the thyroid's uptake of iodine. Iodine is required as a building block for the synthesis of thyroid hormone. Thyroid hormones regulate certain body functions after they are released into the blood. People exposed to excessive amounts of perchlorate for a long time may develop a low level of thyroid activity. The medical name for this condition is hypothyroidism. Hypothyroidism can also be caused by conditions totally unrelated to perchlorates. In hypothyroidism, the lower amounts of thyroid hormones in your blood cause increases in pituitary hormones that can lead to a large increase in the size of the gland. The medical name for this condition is goiter. Because thyroid hormones perform important functions throughout the body, many normal body activities also are affected by the low hormone levels. Because perchlorates were known to lower thyroid hormone levels, at one time, perchlorates were given as a drug (more than 400 mg per day, which is many times higher than what is found in the environment) to treat people with overactive thyroid glands (a condition known as hyperthyroidism). Side effects seen in a small number of treated patients were skin rashes, nausea, and vomiting. A few patients developed severe shortages of blood cells, and some of them died. Healthy volunteers who took approximately 35 mg of perchlorate every day (equivalent to drinking 2 liters of water containing 17 ppm perchlorate every day) for 2 weeks showed no signs of abnormal functioning of their thyroid gland. A study of adults in Nevada found that the number of cases of thyroid disease in a group of people who drank water contaminated with perchlorate was no different than the number of cases found in a group of people who drank water without perchlorate. This means that levels of perchlorate in the water were probably not the cause of the thyroid disease. Two studies of people who worked for years in the production of perchlorate found no evidence of alterations in the workers' thyroids, livers, kidneys, or blood. One of these studies estimated that the workers may have taken up about 34 mg of perchlorate per day.

Scientists use many tests to protect the public from harmful effects of toxic chemicals and to find ways for treating persons 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 may also help identify health effects 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.

The thyroid gland is also the main target organ for perchlorate toxicity in animals. The thyroid changes caused by perchlorate in animals may lead to tumors in the thyroid after a long period. This has occurred after administering very high amounts of perchlorate to the animals. The National Academy of Sciences (NAS) concluded that based on the understanding of the biology of human and rodent thyroid tumors, it is unlikely that perchlorate poses a risk of thyroid cancer in humans. Perchlorates have not been classified for carcinogenic effects by the Department of Health and Human Services (DHHS), the EPA, or the International Agency for Research on Cancer (IARC).

The results from a few studies suggested that perchlorate does not affect the immune systems of animals, but further studies are necessary to confirm these results. Studies in animals also showed that perchlorate did not affect the reproductive organs or the animals' capacity to reproduce. NAS found that the usefulness of studies in animals for estimating the risk of adverse effects of perchlorate in humans is small.

1.6 HOW CAN PERCHLORATES AFFECT CHILDREN?

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

Children and developing fetuses may be more likely to be affected by perchlorate than adults because thyroid hormones are essential for normal growth and development. Two studies were conducted of newborn babies and school-age children from an area in a foreign country where

levels of perchlorate in the drinking water much higher than those detected in some U.S. water supplies. No evidence of abnormal thyroid function was found among the babies or the children. The mothers and the children may have taken approximately 0.2 mg of perchlorate per day in the drinking water. Some studies of newborn babies in areas from Arizona, California, and Nevada, where perchlorate has been found in the drinking water, have not provided convincing evidence of thyroid abnormalities associated with perchlorate.

Animal studies have shown a low level of thyroid activity in developing animals exposed to perchlorates through the placenta before birth or through the mother's milk after birth. One of these studies found thyroid effects in the young animals even when the mothers did not seem to have any effects. However, in this study, the pregnant animals were given amounts of perchlorate thousands of times higher than the amounts that people get from contaminated drinking water in the United States. Recent studies in which pregnant rats were given much lower amounts of perchlorate have confirmed that perchlorates can alter the thyroid gland in the newborn animals. This has generally occurred when perchlorate also affected the thyroid of the mothers. Two studies in rats also found alterations in some areas of the brain from pups born to rats exposed to perchlorate while pregnant, but there have been questions and concerns raised regarding the interpretation of these findings.

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

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

It is very unlikely that perchlorates are present in the average home or apartment. Perchlorates are only found in a very small number of items that people use every day. They are present in highway and marine signal flares, small fireworks, and gunpowder. Storing these items properly or removing them from the house will reduce your family's risk of exposure to perchlorates.

Perchlorates have been found at low levels in a few samples of tap water. They have generally not been found in drinking water. If you have concerns over the presence of perchlorate in your tap water, you may reduce the risk of exposure to your family by drinking bottled water.

If you live near a hazardous waste site or other area where perchlorates have been found, using bottled drinking water may reduce the risk to your family, particularly if you drink well water that may contain perchlorate. If you live in one of these areas, prevent your children from playing in dirt and from eating dirt. Make sure your children wash their hands frequently, and before eating. Discourage your children from putting their hands in their mouths or doing other hand-to-mouth activities.

If you work in a factory that makes or uses perchlorates, it is possible to carry perchlorate dust from work on your clothing, skin, or hair. You may then get perchlorate dust in your car, home, or other locations outside of work where family members might be exposed. You should know about this possibility if you work with perchlorates. Taking a shower will remove any perchlorate dust from your skin or hair. Washing your clothes will remove any perchlorates dust from them.

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

Methods to measure perchlorate in the body are not routinely available, but perchlorate can be measured in the urine. Because perchlorate leaves the body fairly rapidly (in a matter of hours), perchlorate in the urine can only indicate very recent exposure. Levels of thyroid hormones in the blood can be monitored. Such tests will tell you if your hormone levels are altered, but will not tell you the cause (exposure to perchlorate is only one of many possibilities). Medical tests can also measure the capacity of the thyroid gland to take iodide from the blood to manufacture thyroid hormones. Exposure to perchlorate can decrease this capacity, but so can exposure to other chemicals, as well as iodine deficiency and medical conditions unrelated to any exposure to chemicals.

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. The EPA, the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (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) are two federal organizations that develop recommendations for toxic substances.

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

Recommendations and regulations are also updated periodically 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 perchlorates include the following:

The EPA is currently undertaking efforts to determine if regulation of perchlorate in drinking water would represent a meaningful opportunity for reducing risks to human health. To support its decision, the EPA is gathering occurrence data at public water systems, evaluating the availability and cost of treatment technology, and assuring that analytical methods are available to monitor for perchlorate in water. See Chapter 8 for more information on regulations and advisories regarding perchlorates.

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, 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 that result 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 toll-free information and technical assistance number at 1-888-42ATSDR (1-888-422-8737), by e-mail at atsdric@cdc.gov, or by writing to:

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

Organizations for-profit may request copies of final Toxicological 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/