1. PUBLIC HEALTH STATEMENT

This public health statement tells you about radon and the effects of exposure to it.

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. The presence of radon at any site could be a consequence of its natural occurrence in the environment; its production from substances in anthropogenic hazardous waste; or both. These sites may be sources of exposure and exposure to this substance may be harmful.

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 exposed to a substance when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance, or by skin contact. External exposure to radiation may occur from natural or man-made sources. Radon is a naturally-occurring radioactive gas that changes into other radioactive substances, called progeny. Since radon and its progeny are present together in rock, soil, water, air, and construction materials, you will be exposed to the low-level radiation they give off just by being near them. Naturally occurring sources of radiation include radon and other radioactive elements in air, water, soil, or building materials, as well as cosmic radiation from space. Man-made radioactive materials are found in consumer products, industrial equipment, nuclear medicine patients, and to a smaller extent from atomic bomb fallout, hospital waste, and nuclear reactors.

The results of the 1992 EPA National Residential Radon Survey estimated that 1 in 15 homes had an elevated radon level (i.e., a level at or above the EPA action level of 4 picocuries per liter of air). At the time, an estimated 5.8 million homes had an elevated radon level. The source of radon in homes is from naturally occurring (geologic) sources.

When you are exposed to radon 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

it. 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 IS RADON?

Radioactive gas	Radon (Rn) is a naturally occurring colorless, odorless, tasteless radioactive gas that occurs in differing atomic structure with the same atomic number but different atomic mass, called isotopes. As radon undergoes radioactive decay, it gives off radiation and becomes another radioactive element. This is repeated several times until it becomes stable lead. The elements that radon changes into are called radon daughters or radon progeny. The radiation given off is alpha particles, beta particles, and gamma rays. This radiation gives a radiation dose to people when they are exposed to radon. Radon is measured in terms of its activity (curies or becquerels). Both the curie (Ci) and the becquerel (Bq) tell us how much a radioactive material decays every second (1 Ci = 37 billion Bq = 37 billion decays per second). The radiation dose from radon and its progeny is measured in terms of the energy that they impart to tissue (in units called gray or rem for public exposure, or working levels for occupational exposure).
Natural product of the environment	Radon isotopes are formed naturally through the radioactive decay of uranium or thorium. Uranium and thorium (solids) are found in rocks, soil, air, and water. Uranium and thorium decay to other elements such as radium (a solid), which in turn decays into radon (a gas). Uranium and thorium have been present since the earth was formed and have very long half-lives (4.5 billion years for uranium and 14 billion years for thorium). The half-life is the time it takes for half of the atoms of a radionuclide (radioactive element) to undergo radioactive decay and change it into a different element, some of which are radioactive and some are stable. Because of the long half-lives of uranium, thorium, and radium, and since they constantly decay into radon, all of these elements will continue to exist indefinitely at about the same levels as they do now. Radon has no commercial uses other than as a radiation standard for calibrating radon monitoring equipment in support of environmental surveys of homes and other buildings.

Exists in various forms called isotopes and decays to other radioactive isotopes	The most common radon isotope is radon-222 (^{222}Rn). An atom of ^{222}Rn gives off an alpha particle (which is the size of a helium atom without electrons), transforming into an atom of polonium-218 (^{218}Po), which later gives off an alpha particle of its own, transforming into an atom of radioactive lead (^{214}Pb). The final step in the radioactive decay of radon progeny results in the formation of an atom of stable lead which is not radioactive. The half-life of ^{222}Rn is 3.82 days. Some of the radon decay products have the following half-lives: ^{218}Po is 3.05 minutes; ^{214}Pb is 26.8 minutes; and ^{210}Pb is 22.2 years.

More information about the properties of radon can be found in Chapters 4, 5, and 6.

1.2 WHAT HAPPENS TO RADON WHEN IT ENTERS THE ENVIRONMENT?

Moves to air, groundwater, and surface water	Radon gas in rocks and soil can move to air, groundwater, and surface water. Decay products of ^{222}Rn, such as ^{218}Po and ^{214}Pb, are solids that can attach to particles in the air and be transported this way in the atmosphere. They can be deposited on land or water by settling or by rain. Radon will undergo radioactive decay in the environment.

For more information on radon in the environment, see Chapter 6 (Potential for Human Exposure).

1.3 HOW MIGHT I BE EXPOSED TO RADON AND RADON PROGENY?

Air	Since radon progeny are often attached to dust, you are exposed to them primarily by breathing them in. They are present in nearly all air. Depending on the size of the particles, the radioactive particulates can deposit in your lungs and impart a radiation dose to the lung tissue. Background levels of radon in outdoor air are generally quite low (0.4 picocuries/L average activity of radon in outdoor air in the United States), but can vary based on time of day, location, and the underlying soil geology. Background levels also vary as a result of meteorological conditions, such as precipitation and temperature inversions. Temperature inversions occur when the air temperature increases with elevation above the ground. In indoor locations, such as homes, schools, or office buildings, levels of radon and radon progeny are generally higher than outdoor levels. House construction can affect radon levels; however, radon levels can be elevated in homes of all types: old homes, new homes, drafty homes, insulated

	homes, homes with basements, and homes without basements. Local geology, construction materials, and how the home was built are among the factors that can affect radon levels in homes. Radon typically moves up through the ground to the air above and into the home through cracks and other holes in the foundation, in part due to convective flow. Your home traps radon inside, where it can build up. Any home may have elevated radon levels. The only way to know if you are exposed to elevated household radon levels is to have your home tested.
Water	You may be exposed to radon and radon progeny by coming into contact with surfacewater or groundwater that contains radon or by drinking water from wells that contain radon. Radon in water can become airborne. In general, domestic water from a well with a concentration of 10,000 pCi/L of radon is estimated to contribute about 1 pCi/L of radon to the indoor air.

Further information on how you might be exposed to radon and radon progeny is given in Chapter 6.

1.4 HOW CAN RADON AND RADON PROGENY ENTER AND LEAVE MY BODY?

When they are inhaled or swallowed	Radon and its radioactive progeny can enter your body when you breathe them in or swallow them. Most of the inhaled radon gas is breathed out again. Some of the radon progeny, both unattached and attached to dust, may remain in your lungs and undergo radioactive decay. The radiation released during this process passes into lung tissue and can cause lung damage. Some of the radon that you swallow with drinking water passes through the walls of your stomach and intestine. After radon enters your blood stream most of the radon quickly moves to the lungs where you breathe most of it out. Radon that is not breathed out goes to other organs and fat tissue where it may remain and undergo decay.

Further information on how radon and radon progeny enter and leave the body is given in Chapter 3.

1.5 HOW CAN RADON AND RADON PROGENY AFFECT MY HEALTH?

This section looks at studies concerning potential health effects in animal and human studies.

Lung cancer	Lung cancer is essentially the only health effect associated with exposure to radon and radon progeny. Many scientists believe that long-term exposure to elevated levels of radon and radon progeny in air increases your chance of getting lung cancer. Smoking cigarettes greatly increases your chance of developing lung cancer if you are exposed to radon and radon progeny at the same levels as people who do not smoke. The greater your exposure to radon, especially if you smoke cigarettes, the greater your chance of developing lung cancer.

More information on the health effects of radon and radon progeny is presented in Chapters 2 and 3.

1.6 HOW CAN RADON AND RADON PROGENY AFFECT CHILDREN?

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

Differences between children and adults	Smaller lungs and faster breathing rates in children may result in higher estimated radiation doses to the lungs of children relative to adults. However, limited information from children employed as miners in China do not provide evidence of increased susceptibility to the effects of exposure to radon and radon progeny.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO RADON AND RADON PROGENY?

Reduce indoor exposure levels	Indoor radon levels can be reduced by the installation of a sub-slab suction (depressurization) system, also known as an active soil depressurization system (ASD). A radon vent fan connected to the suction pipe(s) draws the radon gas from below the house and releases it into the outdoor air, while simultaneously creating a negative pressure (vacuum) beneath the slab. Sealing of openings to the soil can improve the operation and efficiency of the ASD system. Certified radon mitigation experts can be located by contacting your state health or environmental program. If the ASD does not reduce levels sufficiently, consider reversing the fan direction to pressurize the subslab, and then compare the results and use the more effective method. Measures to prevent high radon levels in new home construction are expected to be effective at reducing radon-related lung cancer deaths, but remediating old homes with high radon levels may be less effective. If you smoke in your home, stopping will reduce the radiation dose from radon since smoke particles help increase the radiation dose.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO RADON AND RADON PROGENY?

Radon progeny in urine and in lung and bone tissues	Radon in human tissues is not detectable by routine medical testing. Some radon progeny can be detected in urine and in lung and bone tissue. Tests for these products are not generally available to the public and are of limited value since they cannot be used to accurately determine how much radon you were exposed to, nor can they be used to predict whether you will develop harmful health effects.

Further information on how radon and radon progeny can be measured in exposed humans is presented in Chapters 3 and 7.

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 the FDA.

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, a 24-hour day, or a work-year), 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.

Air	EPA recommends actions that can be taken to reduce radon levels if measured indoor levels of radon are 4 or more pCi per liter (pCi/L) of air. This is the same as 148 Becquerels per cubic meter [Bq/m^3] of air in the international system. EPA also notes that radon levels less than 4 pCi/L still pose a health risk and can be reduced in many cases, and that smoking increases the risk from radon. The EPA recommends using a certified radon mitigation specialist if indoor radon levels need to be reduced to ensure that appropriate methods are used to reduce radon levels. The Mine Safety and Health Administration (MSHA) has adopted an exposure limit of 4 Working Level Months (WLM) per year for people who work in underground mines (WLMs basically combine the concentration of radon progeny in mine air with the portion that is attached to dust in the air and the length of exposure inside the mine). The Nuclear Regulatory Commission published a table of allowable exposure to radon by workers and allowable releases of radon to the environment by its licensees.
Water	EPA does not have a drinking water limit for radon.

EPA maintains a website (http://www.epa.gov/radon) that provides extensive information on radon for the general public. Additional information on governmental regulations regarding radon and radon progeny can be found 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, 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 1-800-CDCINFO (1-800-232-4636), by e-mail at cdcinfo@cdc.gov, or by writing to:

Agency for Toxic Substances and Disease Registry
Division of Toxicology and Human Health Sciences (proposed)
1600 Clifton Road NE
Mailstop F-62
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/