ES/ESH-51
POEF-3051

Portsmouth Gaseous Diffusion Plant Annual Site Environmental Report Summary for 1993

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Oak Ridge Operations
P.O. Box 2001
Oak Ridge, Tennessee 37831—

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Distribution

PORTSMOUTH ANNUAL SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1993

Enclosed for your information is a copy of the *Portsmouth Annual Site Environmental Report for 1993*. This report includes the results from on-site and off-site environmental monitoring activities, describes actions to comply with environmental regulations, and discusses the overall environmental impacts of Department of Energy (DOE) activities on the surrounding area. This report is prepared annually for distribution to the public; news media; and local, state, and federal agencies. The report was prepared for the DOE by our contractor Martin Marietta Energy Systems, Inc. (Energy Systems).

This years report is somewhat different than previous reports. An attempt was made to streamline the document and provide more summary information. The detailed data has been incorporated into a separate report. Likewise, a summary "pamphlet" is available this year. Its purpose is to convey key environmental monitoring information to those without a technical background. Comments on this report are welcome, all of which would be considered during the writing of the next report. There is a comment sheet and mailing address at the end of the report.

The monitoring data and subsequent data analyses have been collected and performed in accordance with controlled operating procedures. Likewise, both DOE and Energy Systems personnel have reviewed this document for accuracy. To the best of my knowledge, this report accurately summarizes and discusses the results of the 1993 environmental monitoring program.

If you have any questions or desire additional information, please contact Melda Rafferty at 614-897-5521 or James Donnelly at 615-574-6260.

Sincerely,

E. W. Gillespie, Site Manager
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Portsmouth Gaseous Diffusion Plant
Annual Site Environmental Report for 1993
(ES/ESH-50, POEF-3050)
Comment Sheet

The annual site environmental report (ASER) is undergoing a transition to a more concise, single-volume format. The writers and production staff welcome comments, all of which will be considered during the writing of the next report. Please fill out this sheet and fax it to 615-574-6965 or mail it to the following address:

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Portsmouth Gaseous Diffusion Plant
Annual Site Environmental Report Summary for 1993
(ES/ESH-51, POEF-3051)
Comment Sheet

This summary is the first such document published in addition to the annual site environmental report (ASER). The writers and production staff welcome comments, all of which will be considered during the writing of the next report summary. Please fill out this sheet and fax it to 615-574-6965 or mail it to the following address:

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PREFACE

This pamphlet contains summaries of the environmental programs at the Portsmouth Gaseous Diffusion Plant, including environmental monitoring and results and the impact of plant operations on the environment and the public for 1993. More detailed information on the material summarized in this pamphlet is available in the *Portsmouth Gaseous Diffusion Plant Annual Site Environmental Report for 1993*. The data used to compile the annual site environmental report and this summary pamphlet are published in the *Portsmouth Gaseous Diffusion Plant Annual Site Environmental Data for 1993*. This document is a collection of tables containing effluent monitoring, environmental surveillance, and dose calculation data for 1993.

To obtain copies of any of these documents, contact

Environmental Management
P.O. Box 628
Building X7725, MS-7556
Portsmouth Gaseous Diffusion Plant
Piketon, OH 45661
Telephone: 614-897-3032

CONTENTS

ABOUT THE PORTSMOUTH GASEOUS DIFFUSION PLANT

The Portsmouth plant is one of two U.S. Department of Energy (DOE)-owned, contractor-managed uranium enrichment facilities. As of July 1, 1993, responsibility for implementing environmental compliance was split between DOE, as site owner and operator of waste management and environmental remediation projects, and the United States Enrichment Corporation (USEC), a government-owned corporation formed by the National Energy Policy Act of 1992 to take over the nation's uranium enrichment business. The management contractor for DOE is Martin Marietta Energy Systems, Inc. Martin Marietta Utility Services, Inc., provides management services for USEC. The Nuclear Regulatory Commission is scheduled to assume direct oversight of USEC operations in October 1995. Until then, DOE is providing oversight of activities regulated by the Nuclear Regulatory Commission.

The Portsmouth facility is located on about six square miles in Pike County, Ohio (Figure 1). The County has approximately 24,250 residents. The total population within 50 miles of the plant is about 900,000. Figure 2 shows the plant site and its immediate surroundings.

The main process at the Portsmouth facility has been the separation of uranium isotopes through gaseous diffusion. The fuel produced by this process (enriched uranium) consists of a specific proportion of uranium isotopes that is favorable for extending controlled chain-reaction fission in nuclear power reactors. Until 1992, the plant also produced highly enriched uranium for U.S. Navy nuclear reactors. Portsmouth stopped producing highly enriched uranium in 1992 and began decontaminating the associated process equipment to safely place it in long-term shutdown.

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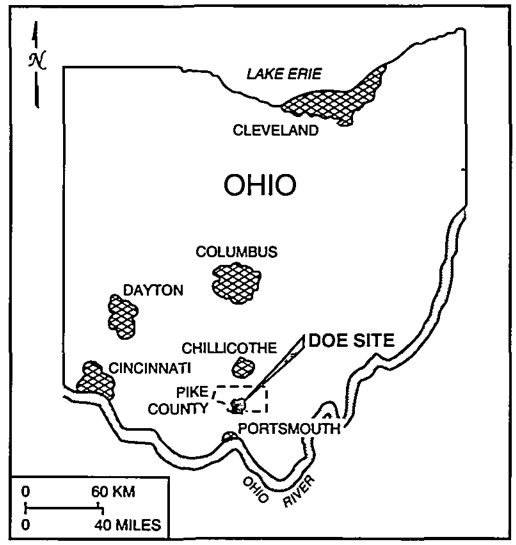

Figure 1. Location of the Portsmouth site within the state of Ohio.

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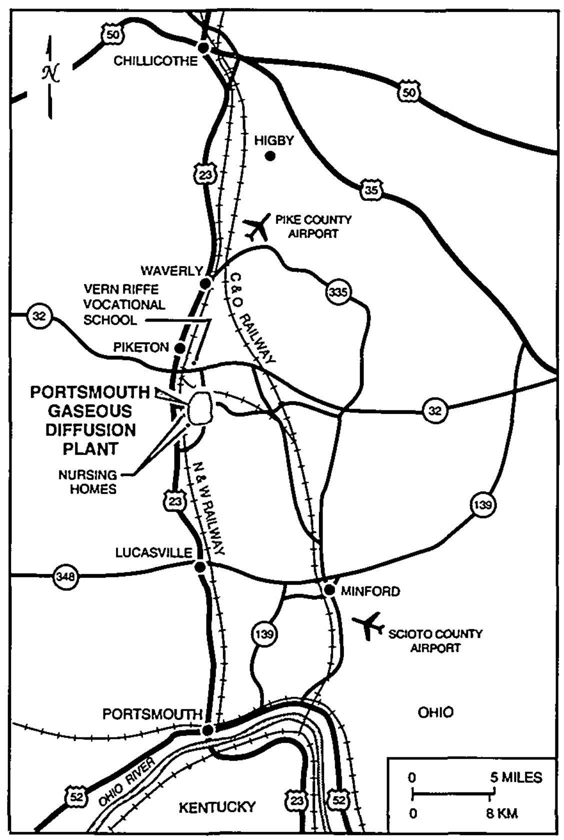

Figure 2. Location of the Portsmouth site in relation to the geographic region.

ENVIRONMENTAL PROGRAMS AT THE PORTSMOUTH FACILITY

The goal of the environmental programs at Portsmouth is to ensure that the plant operates in such a way that the quality of the surrounding environment and human health is maintained. Environmental programs at Portsmouth include waste management, environmental restoration, public awareness, and the focus of this document, environmental monitoring. Special studies related to maintaining environmental quality are also conducted.

Waste Management Program

The Portsmouth Waste Management Program directs the safe storage, treatment, and disposal of waste generated from operations and from environmental restoration projects. The main goal is to ensure that waste materials do not migrate into the environment.

Waste management requirements are varied and often complex because of the variety of wastes generated by Portsmouth facility activities. DOE orders and U.S. Environmental Protection Agency (USEPA) and Ohio Department of Health regulations must be satisfied to ensure compliance of waste management activities. Supplemental policies have been implemented for management of radioactive, hazardous (chemical), and mixed (radioactive and hazardous) wastes. These policies include

- minimizing wastes;
- characterizing and certifying wastes;
- reducing the volume of wastes and use of on-site storage when safe and cost effective until a final disposal option is identified;
- maintaining a comprehensive waste tracking and reporting system; and
- maintaining an effective plant-wide waste minimization training program.

Environmental Restoration Program

DOE established the Environmental Restoration Program to find, analyze, and correct site contamination problems as quickly and inexpensively as possible. The Environmental Restoration Program encompasses both inactive sites and active facilities. Options for correcting or mitigating contaminated sites and facilities include removal, stabilization, and treatment of contaminants.

Public Awareness Program

A comprehensive community relations and public participation program on the Environmental Restoration and Waste Management Program has been established since early 1990. The purpose of the program is to conduct a proactive public involvement program, with outreach components, to foster a spirit of openness and credibility among local citizens and various segments of the public. The program is also geared to provide the public with opportunities to become involved in the decisions affecting environmental issues at the plant.

DOE opened a public Environmental Information Center in February 1993 in an effort to provide public access to all documents used to drive decisions on remedial actions being taken at the plant. The information center has a full-time staff and is located about 10 miles north of the plant at 505 West Emmitt Avenue, Suite 3, Waverly, Ohio 45690. The center's hours are 10 a.m. to 4 p.m., Monday, Tuesday, Wednesday, and Friday and 9 a.m. to 12 noon on Thursday, or after hours by appointment (614-947-5093).

A group of about 45 key stakeholders, composed of elected officials, community leaders, environmentalists, and other individuals who have expressed an interest in the Environmental Restoration and Waste Management Program, is targeted for information and input on current activities and those actions under consideration at the plant. Semiannual public update meetings are also held, as well as public workshops on specific topics to keep the public informed and to receive their comments and questions. Periodically, fact sheets about major projects are written for the public, and semiannual newsletters are printed and distributed to more than 4000 recipients, including the community relations mailing list, neighbors within two-miles of the plant, and all plant employees and retirees.

Points of contact have been established for the public to obtain information or direct questions regarding the Environmental Restoration and Waste Management Program. The Environmental Restoration Program manager for DOE is the primary point of contact at 614-897-5512. The Martin Marietta Energy Systems, Inc., site manager and the community relations manager also provide information on the program.

ENVIRONMENTAL COMPLIANCE

The main agencies responsible for regulating environmental compliance at the Portsmouth site are the USEPA, the Ohio Environmental Protection Agency (OEPA), and the Ohio State Fire Marshal's Office. These agencies issue permits, review compliance reports, participate in joint monitoring programs, inspect facilities and operations, and oversee compliance with applicable environmental regulations. Portsmouth must comply with numerous federal and state laws, a few of which follow.

- Clean Air Act
- Clean Water Act
- Comprehensive Environmental Response, Compensation, and Liability Act
- Endangered Species Act
- Farmland Protection Policy Act
- Federal Facilities Compliance Act
- National Environmental Policy Act
- National Historic Preservation Act
- Resource Conservation and Recovery Act
- Safe Drinking Water Act
- Toxic Substances Control Act

Although much progress has been made toward achieving full regulatory compliance at the Portsmouth site, much remains to be accomplished. During 1993, 22 audits, appraisals, or inspections of Portsmouth environmental programs were conducted. Ongoing self-assessments conducted by Portsmouth staff continue to identify environmental issues. These issues are discussed openly with regulatory agencies to ensure that compliance with all environmental regulations will be attained.

ENVIRONMENTAL MONITORING

Basis for Environmental Monitoring

The operation of most industrial facilities involves processing and handling of materials that if released to the environment can cause harm. As a result of routine operations at the Portsmouth plant, radioactive contaminants and nonradioactive contaminants, such as chemicals and metals, are released to the environment. Portsmouth has an extensive environmental monitoring program to assess the effect of site activities on the environment and public health and to ensure that releases from the site do not exceed safe levels. The basis for evaluating releases includes scientific studies on the effects of radiation and hazardous materials, as well as allowable levels set by federal and state regulatory agencies. The major concern, however, is the health and safety of Portsmouth employees and the public in surrounding communities.

The environmental monitoring program at Portsmouth includes effluent monitoring and environmental surveillance. Effluent monitoring is the measurement of releases as they occur. Contaminants are released through either airborne emissions or liquids discharged from the plant. These releases occur as part of normal site operations, such as cooling water discharged from the uranium enrichment cascade operations or airborne releases from ventilation systems. In the event of system failure, this monitoring provides timely warning so that corrective action can be taken before releases reach an unsafe level. Environmental surveillance tracks the dispersion of materials into the environment after they have been released. This involves the collection of samples from various media, such as water, soil, grass, and food crops, and the analysis of these samples for certain radionuclides, chemicals, and metals. Deciding what to monitor and how to monitor it is based on

- environmental regulations,
- measurement capabilities,
- analyses of potential pathways for contaminants to reach and affect the public, and
- public concerns.

Because the primary mission of the Portsmouth plant is the processing of radiological materials, much of the environmental monitoring effort is directed toward radioactive

Monitoring versus surveillance

Per DOE Order 5400.5, *Radiation Protection of the Public and the Environment*:

Effluent monitoring is the collection and analysis of samples or measurements of liquid and gaseous effluents for purposes of characterizing and quantifying contaminants, assessing radiation exposure to members of the public, and demonstrating compliance with applicable standards.

Environmental surveillance is the collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media from DOE sites and their environs and the measurement of external radiation for purposes of demonstrating compliance with applicable standards, assessing radiation exposures to members of the public, and assessing effects, if any, on the local environment.

Monitoring occurs at the point of discharge, such as an air stack or drainage pipe, whereas surveillance involves looking for contaminants already present in the environment.

materials. Radioactive materials are regulated at the point of discharge and are monitored as they disperse into the surrounding environment. However, most of the radionuclides managed at the Portsmouth site are also naturally present in the environment, and the amounts released are so small that it quickly becomes difficult to distinguish them from radionuclides already present in the environment. For this reason, mathematical models are used to estimate how and in what quantities radionuclides are carried and dispersed into the environment.

These models are also used to help make the existing radiological monitoring program more effective. For example, predictions based on models can help in choosing the best locations for monitoring devices and in identifying the pathways of contaminant dispersal (that is, where and how contaminants could reach the environment) and the contaminants for which monitoring is most important. Modeling helps ensure the most efficient use of resources available for sampling and analysis and helps verify that sampling is being performed adequately.

How are Workers and the Public Being Protected?

Each process operations building at the Portsmouth site is equipped with alarms that automatically warn employees of significant increases in radiation levels. Dosimeters, or radiation-sensitive personnel badges, are worn by all employees and visitors entering any plant-site limited area. Protective clothing and respiratory equipment are worn during work assignments involving an increased risk of contacting radioactive materials, and workers are monitored for contamination when leaving restricted areas. Employees undergo extensive training so that they understand operating procedures and all emergency and safety requirements.

A public warning system has also been in place at the plant since 1988. In the unlikely event of a significant environmental release with the potential to go off-site, the public warning sirens would be activated to notify all residents within a 2-mile radius of the plant. Local emergency preparedness agencies and area media would also be notified simultaneously.

Environmental Regulations

Numerous state and federal regulations, such as the Clean Air Act and Clean Water Act, limit the amount of radioactive and nonradioactive contaminants the Portsmouth plant is allowed to discharge. These regulations determine much of what is monitored at the site. Compliance with these regulations is overseen by several agencies, including the USEPA and the OEPA. Portsmouth is accountable to state and federal regulators and must supply valid data on releases.

Nonradiological discharges to air are regulated by the OEPA under state Permit-To-Operate regulations. These regulations authorize the OEPA to "register" sources that are too small to have a significant environmental impact in lieu of issuing a formal permit. Most of the nonradiological airborne emission sources at the Portsmouth site are either registered or are in the process of being registered with the OEPA. Radiological discharges to air are regulated by the USEPA under the National Emission Standards for Hazardous Air Pollutants and by DOE orders.

Nonradiological liquid discharges are regulated by the OEPA under the National Pollutant Discharge Elimination System (NPDES) regulations. Radiological liquid discharges are regulated by DOE orders 5400.1, *General Environmental Protection Program*, and 5400.5, *Radiation Protection of the Public and the Environment*.

Quality Assurance and Quality Control

When monitoring releases and measuring radiation in the environment, the reliability of the data is of the utmost importance. To ensure that the monitoring and measurement results are accurate, Portsmouth has a quality assurance and quality control program that is based on guidelines from the USEPA, the American Society for Testing and Materials, and other federal and state agencies. Portsmouth staff administer numerous quality control programs to ensure reliability of the data on a day-to-day basis. Portsmouth also participates actively in quality control programs administered by agencies outside the plant, such as the USEPA and the National Institute of Occupational Safety and Health. These agencies prepare and distribute test samples for participating laboratories to analyze. The agencies then compile and evaluate the results and report to each laboratory on the accuracy of that laboratory's analyses. In 1993 the Portsmouth laboratory performed over 2000 external control measurements; the percentage of acceptable results was 98.3%.

Special Studies

In the summer and fall of 1993, DOE began preparing a baseline ecological risk assessment for the Portsmouth site. Included as part of the risk assessment were a wetland survey, a threatened and endangered plant survey, a threatened and endangered animal survey, and a bat survey. The wetland survey identified a number of areas considered wetland or emergent wetland; these areas were delineated and mapped in April 1994. The threatened and endangered plant survey began April 4, 1994, and was completed in October. Endangered animal survey results indicated the presence of several state-listed and possibly one federally listed threatened and endangered species within the Portsmouth reservation boundary. The bat survey was completed in September 1994.

In addition, a wildflower project has been initiated to reduce maintenance costs and risks associated with mowing banks that are slumping or that are too steep to mow safely. An added benefit is that the wildflower areas will be aesthetically pleasing for plant employees and visitors to the plant.

DOE is also developing a programmatic agreement with the State Historical Preservation Office. Structures of historic architectural importance, local archaeology, and cultural resources such as the Mt. Gilead Cemetery will be the topics of discussion.

NONRADIOLOGICAL MONITORING AND SURVEILLANCE

The nonradiological monitoring program is designed to ensure that airborne and liquid releases are safe and within regulatory limits. Based on regulatory guidelines, the Portsmouth program focuses on monitoring of airborne and liquid releases and surveillance of the environment. Surveillance includes routine sampling of air, surface water (site streams and the Scioto River), drinking water, groundwater, sediment (from streambeds) and soil, vegetation (grass), and fish. Environmental sampling is conducted on-site and up to 10 miles outside the property line.

Air Monitoring

Pollutants released into the atmosphere from the Portsmouth site include standard industrial pollutants such as smoke, fly ash, sulfur dioxide, gaseous fluorides, gasoline and diesel fuel vapors, cleaning solvent vapors, and chlorofluorocarbons (CFCs). Smoke and sulfur dioxide from the coal-fired steam plant account for the largest amount of nonradiological air pollutants released from the site. In 1993, Portsmouth achieved 100% compliance with all air permit limits. Ambient gaseous fluoride samples are collected weekly. Applicable standards for gaseous fluorides have not been issued in Ohio; however, results are well below standards established in the neighboring states of Kentucky and Tennessee.

Chemical releases are regulated under the Superfund Amendments and Reauthorization Act. In 1993, approximately 348,000 pounds of chemicals regulated under this act were released to the environment, 99% of which was CFC-114, the primary coolant used in the uranium enrichment cascade. Part of the Portsmouth pollution prevention program is the study of possible substitutes for CFC-114.

Surface Water Monitoring

Treated effluents either discharge to surface streams that pass through the reservation to the Scioto River or are piped directly to the Scioto River. Nonradiological releases to surface waters are best summarized by the extent of compliance with the plant NPDES permit limits, which was 99.4% overall in 1993.

Residential Drinking Water Sampling

Results from the Off-Site Residential Drinking Water Monitoring Program indicate that plant operations have had no adverse chemical effects on residential drinking water sources in the area.

Sediment and Soil Sampling

Sediment samples taken in fall 1993 were analyzed for polychlorinated biphenyls (PCBs), mercury, and other parameters. No PCBs were found. Trace concentrations of mercury were detected in a few samples, including one from the Scioto River, upstream of discharges from the Portsmouth plant. None of the results indicated that discharges from the Portsmouth facility were having a significant impact on the environment.

Vegetation and Fish Sampling

Vegetation samples were analyzed for fluoride concentrations, and all were within normal ranges. Fish tissues were analyzed for chromium and PCBs. No detectable levels of chromium were found, and PCB concentrations in on-site fish samples ranged from undetectable (<0.2 parts per million) to 3.2 parts per million. Analyses revealing the detectable PCB concentrations are believed to be the result of a PCB-contaminated site that was cleaned up in the mid-1980s.

CHEMICAL DOSE TO THE PUBLIC

Varying amounts of chemicals were released to the environment from Portsmouth operations in 1993. Since the early 1980s, Portsmouth has voluntarily monitored and tracked ambient concentrations of gaseous fluorides in the atmosphere for comparison to ambient air quality standards. These standards are the national or state standards for the maximum concentrations of airborne pollutants that are not expected to adversely affect the public health or public welfare. Because neither the USEPA nor the OEPA have established standards for gaseous fluorides, Portsmouth uses standards set by the states of Tennessee and Kentucky. In 1993, all of the measured gaseous fluoride concentrations in ambient air were within applicable Tennessee and Kentucky ambient air quality standards.

The USEPA has set standards for acceptable daily intakes of various waterborne chemicals. These standards were used to calculate the maximum possible exposure to chemicals for members of the public. Locations where water is discharged (outfalls) are not readily accessible to the general public; therefore, direct ingestion of water from outfalls is unlikely. Although it is possible for a member of the public to ingest water from either Big Beaver Creek or Big Run Creek, both of these water bodies run through active agricultural operations (i.e., farms and cattle pastures) along their entire length between the Portsmouth site and the Scioto River and are classified as unsuitable for use as potable water sources because of agricultural runoff. Consequently, the first realistic location for a member of the public to be routinely exposed to liquid discharges from Portsmouth is the Scioto River, although no identified drinking water intakes are located in the Scioto River downstream of the Portsmouth plant.

The average chemical concentrations for three discharges from NPDES outfalls were found to be in excess of acceptable daily intakes if the discharged waters were to be used for drinking water. However, two of these concentrations were not discharged to the local environment but were discharged to other outfalls. The third "excess" concentration was for iron in the discharge from NPDES outfall 002. Iron in this outfall is from rainwater running off a nearby coal pile. The average iron concentration was in compliance with the NPDES permit limit for this outfall.

RADIOLOGICAL MONITORING AND SURVEILLANCE

As stated earlier, because the primary mission of the Portsmouth facility is processing radioactive materials, much of the environmental monitoring effort is directed toward radioactive materials. To determine the possible effect of radiation on the environment and people, radiation must be measured. To understand how radiation is measured, it's necessary to understand what radiation is.

Radiation and How It's Measured

All matter is made up of extremely small particles called atoms. Atoms are bundles of even smaller particles called protons, neutrons, and electrons. When an atom has protons and neutrons in a balanced proportion, it is stable, or nonradioactive. Atoms that don't have a balanced proportion break apart, or decay. When an unstable atom decays, it releases energy as particles and rays. This released energy is called radiation.

Activity

When radiation is measured, what is actually being measured is the rate of radioactive decay, or activity. Because activity varies among radioisotopes, one gram of one radioactive substance may contain the same amount of activity as several tons of another substance. Activity is expressed in curies (Ci). One curie equals 37,000,000,000 atom disintegrations (decay events) per second.

DOSE

Absorbed Dose

When radiation interacts with matter, some of the energy is absorbed; the total amount of energy absorbed per unit mass is expressed in rads. The health effects of radiation are proportional to the absorbed dose. However, the proportion is different for different types of radiation. Consequently, limits for radiation exposure are normally expressed in relation to a standard radiation type (i.e., as dose equivalents).

Units of Radiation Measure

Radiation measurements in this pamphlet are expressed in the U.S. Customary System. The following information is provided for persons who want to convert the measurements to the metric system.

U.S. Customary System	Metric System	Conversion
Activity		
curie (Ci)	becquerel (Bq)	1 Ci = 3.7×10^{10} Bq
Absorbed dose		
rad (radiation absorbed dose)	gray (Gy)	1 rad = 0.01 Gy
Dose equivalent		
rem (roentgen equivalent man)	sievert (Sv)	1 rem = 0.01 Sv

Dose Equivalent

The potential biological damage caused by exposure to and absorption of radiation is expressed in rems. One rem of any type of radiation has the same total damaging effect. The dose equivalent is equal to the absorbed dose from each type of radiation multiplied by a "quality factor." The quality factors have been set by international organizations so that an equal number of rems means an equal effect on health regardless of the type of radiation involved. Because a rem represents a fairly large dose, the millirem (mrem), 1/1000 of a rem, is usually used to express the low levels of damage caused by radiation in the environment.

Committed Dose Equivalent

Normally, the largest part of a person's radiation dose is from radioactive material that he or she has swallowed or inhaled. This material will continue to expose the person until it passes back out of the body, which may take longer than a single year. Therefore the committed dose equivalent, expressed in rem, is the total dose equivalent that a person is expected to receive over time from radioactive material that was swallowed or inhaled.

Effective Dose Equivalent

When radioactive materials are swallowed or inhaled, each organ can receive different, often very different, radiation exposures. Therefore, the effective dose equivalent (EDE) to an individual, expressed in rems or millirems, is an average of the committed dose equivalents to eleven major organs plus the dose equivalent caused by radiation from outside the body. EDE is used to express dose in terms of the potential health impact. Use of the EDE allows dose from different types of radiation and doses to different parts of the body to be expressed on the same basis.

PATHWAYS OF RADIATION

ORNL-DWG 94M-5235

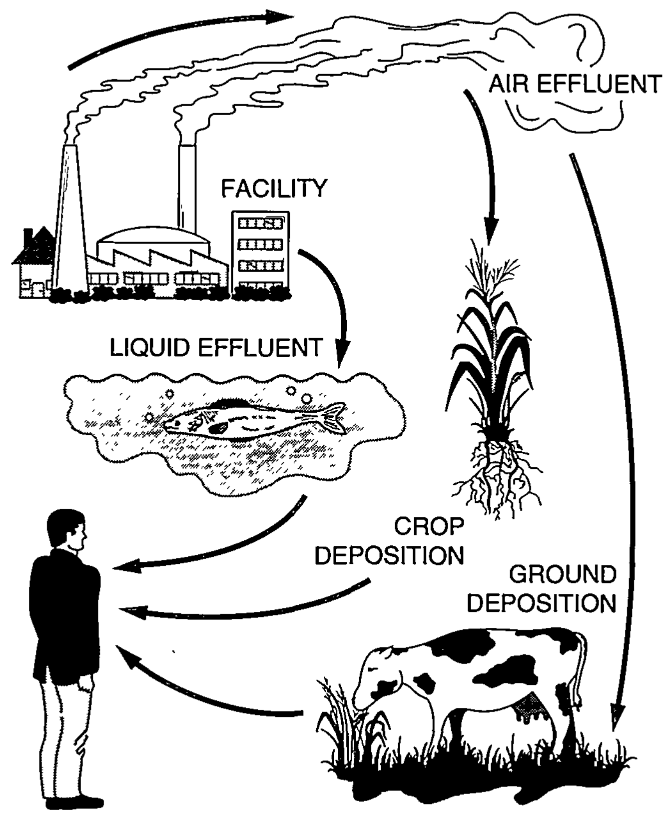

Figure 3. Possible radiation pathways. People can be exposed to radioactivity released from a nuclear facility in many ways. Radioactivity can leave the facility in airborne or liquid effluents and end up in the food people eat, the water they drink, or the air they breathe.

Radiation and radioactive material in the environment can reach people through many routes, or pathways (see Figure 3). For example, radioactive material in the air could fall on a pasture. The grass then could be eaten by cows, and the radioactive material on the grass would show up in the cow's milk. Thus, people drinking the milk would be exposed to this radiation. People also could simply inhale the radioactive material while it is still in the air. When radioactive materials occur in water, fish could absorb the materials, and people who ate the fish then would be exposed. People swimming in the water would also be exposed.

Although radioactivity is not affected by chemistry, the behavior of a radioactive substance in the body is. Consequently, a curie of two different radioactive substances, or even of the same substance in different chemical forms or passing through different pathways, can cause very different committed dose equivalents.

At the Portsmouth facility, essentially all of the radiation dose to the public is from the elements uranium and technetium. Of the two, 1 curie of uranium will cause committed dose equivalents 100 times greater than 1 curie of technetium if swallowed, and 1000 times greater if inhaled. Because of this, Portsmouth has always considered controlling uranium emissions to be far more important than controlling technetium emissions.

CALCULATING DOSE

With modern technology, very small amounts of radionuclides can be detected in environmental samples. However, many of the radionuclides released from the Portsmouth plant are at such low concentrations when dispersed into the environment that they cannot be measured by routine laboratory methods. Also, it is sometimes difficult to tell if a radionuclide in the environment comes from the Portsmouth site or from another source. These factors make it difficult to directly measure public exposure to radioactive materials released from the site. Therefore, mathematical models are used to estimate the concentrations of radionuclides present in the environment as a result of releases to air and water from the Portsmouth plant (Figure 4).

Basically, all airborne and liquid discharges from the Portsmouth plant are monitored. Beginning with these measurements and factoring in many other conditions (e.g., wind direction, flow rates, and, in some cases, actual measurements from environmental samples), estimated concentrations are calculated. These estimated concentrations are used to calculate estimated doses from site releases.

When calculating maximum doses from releases to the air and water from Portsmouth operations, the concept of a hypothetical individual who receives the maximum exposure from all pathways is used. This maximally exposed individual:

- for air pathways, lives at the most exposed point on the Portsmouth boundary 365 days a year and consumes milk, meat, and vegetables produced within 50 miles of the plant; and
- for liquid pathways, drinks 190 gallons of untreated river water, eats 46 pounds of fish caught in the Scioto River, swims for 27 hours in the river, boats for 105 hours on the river, and occupies the shoreline for 69 hours during the year.

Portsmouth uses the concept of the maximally exposed individual when estimating its contribution to the dose to the off-site population to ensure that the estimate is the highest any one individual could have received as a result of site operations. In reality, however, no individual actually receives this high a dose from Portsmouth operations.

ORNL-DWG 94M-9703

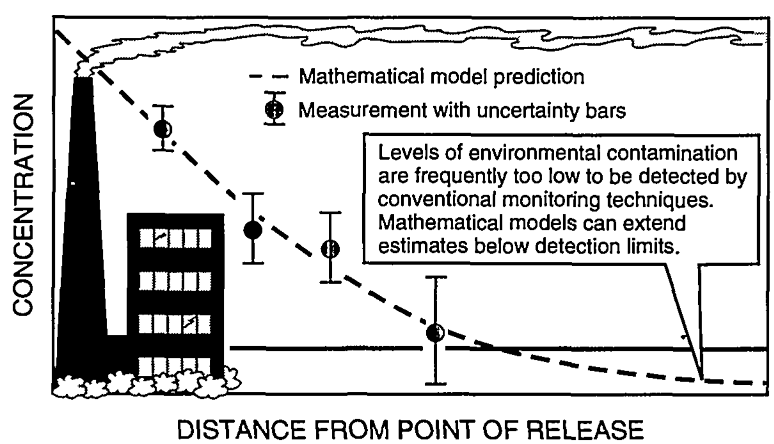

Figure 4. Radionuclide movement comparison: measured versus calculated. Once radionuclides are released, they often disperse into the environment in concentrations too small to be measured by routine laboratory methods. Therefore, concentrations of these radionuclides must be determined by using mathematical models designed to calculate how much of a radionuclide could be present in a given medium based on known physical parameters, such as weather conditions.

Uncertainty in Dose Calculations

With calculated estimates of dose, as with any estimate, there is a level of uncertainty and many different parameters must be taken into account. To calculate estimated doses to the public, Portsmouth uses standard radiation transport and dose models developed for the commercial nuclear industry and approved by the U.S. Nuclear Regulatory Commission. These computer-based models are regularly tested and verified to ensure that they provide proper and conservative (i.e., the maximum possible) estimates. They are also routinely updated to keep the uncertainty of the dose estimates as low as possible when site-specific conditions, such as weather patterns or river flow, change.

1993 RADIOLOGICAL MONITORING RESULTS

The radiological monitoring program at Portsmouth includes monitoring of airborne and liquid releases and environmental surveillance. Environmental surveillance includes sampling for direct (gamma) radiation levels and sampling of air, surface water, drinking water, groundwater, soil and creek and river sediments, vegetation (grass), food crops, and fish. Environmental sampling is conducted on-site and up to 10 miles outside the property line. Ambient monitoring results in 1993 indicated that Portsmouth operations were not having a significant environmental impact outside the reservation boundaries.

Airborne and Liquid Releases

Airborne radionuclides are the main source of any radiation dose received by the public from plant operations. Radionuclides released to air in 1993 totaled 7.9 curies, 7.8 curies of which were technetium. Figure 5 shows the five-year trend for airborne radionuclides.

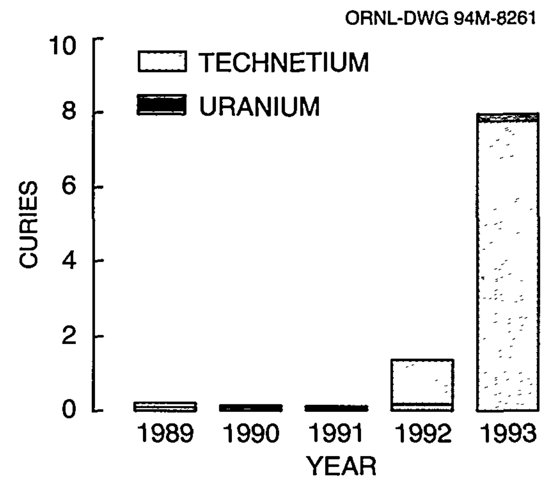

Figure 5. Airborne radionuclides discharged from the Portsmouth site, 1989–1993.

In 1992, Portsmouth ended production of highly enriched uranium and began decontamination of associated process equipment. The decontamination process was expected to generate some additional gaseous technetium, but the amount generated was beyond original predictions. By late 1992, gaseous technetium had accumulated to a level that overwhelmed the emission control systems, which were designed for gaseous uranium. By mid-1993, Portsmouth had modified the control systems and reduced technetium emissions to the usual levels.

Radiological analyses of liquid effluents are performed on samples taken from the same locations as nonradiological effluent samples. Treated effluents either discharge to surface streams that pass through the reservation to the Scioto River or are piped directly to the Scioto River. A total of 0.72 curies of radionuclides was released to surface water in 1993, well below all applicable USEPA and DOE standards. Figure 6 shows the five-year trend for radionuclides discharged to water.

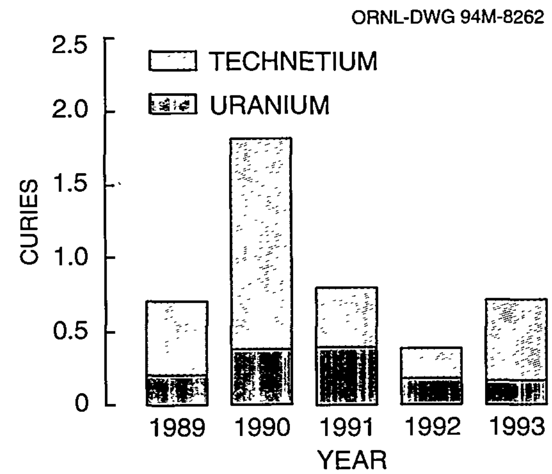

Figure 6. Waterborne radionuclides discharged from the Portsmouth site, 1989–1993.

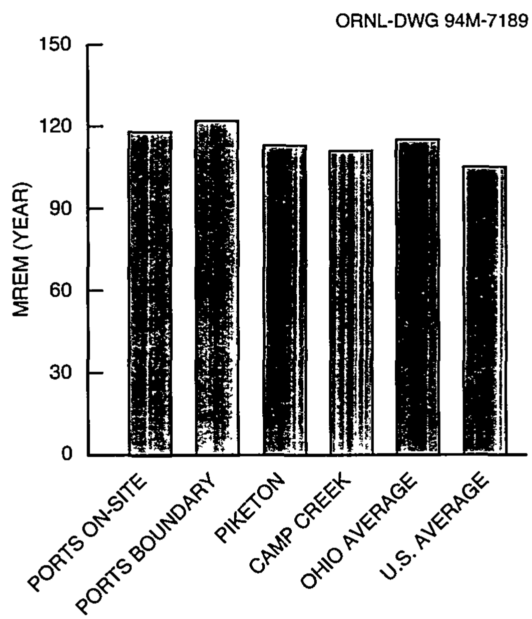

Figure 7. Average annual external gamma exposure on and around the Portsmouth site, for the state of Ohio, and for the United States as a whole.

External Gamma Radiation Monitoring

External gamma levels at and around the Portsmouth reservation are not significantly different from average radiation levels throughout Ohio (115 mrem per year). Gamma levels measured around the site averaged 118 mrem per year at the edge of the active plant area and 122 mrem per year around the reservation boundary. Figure 7 shows the annual average gamma external exposure on and around the Portsmouth site, for the state of Ohio, and for the United States as a whole. The gamma levels at the site boundary are higher than on-site levels because of geological formations surrounding the Portsmouth reservation that have higher concentrations of naturally occurring radioactive minerals.

Ambient Air Sampling

Gross alpha and beta activity in the air on and around the Portsmouth reservation during 1993 was not significantly affected by releases from the plant.

Annual average gross alpha activities at all monitoring locations accessible to the public (the USEPA definition of "ambient" includes public accessibility) were <0.005 picocuries per cubic meter (pCi/m^3). The maximum alpha activity measured at any of these locations was only 0.014 pCi/m^3. No standard exists for gross alpha activities in air, but an airborne uranium concentration equivalent to the USEPA dose standard of 10 mrem per year would produce an annual average gross alpha activity of 0.22 pCi/m^3.

Annual average gross beta activities at all property line and off-site monitoring locations were 0.051 pCi/m^3 or less, with a maximum beta activity of 0.165 pCi/m^3. On-site monitoring locations showed somewhat higher concentrations (up to 0.097 pCi/m^3 annual average) to the east and northeast of the main plant area. No standard exists for gross beta activities in air, but an airborne technetium-99 concentration equivalent to the USEPA dose standard of 10 mrem per year would produce an annual average gross beta activity of 2 pCi/m^3.

Surface Water Sampling

Uranium and technetium-99 concentrations and gross alpha and beta activities in surface water on and around the Portsmouth reservation were all well within applicable standards and posed no threat to human health or the environment. No significant difference appeared between upstream and downstream measurements for any of the measurement parameters, indicating no impact from plant discharges.

Residential Drinking Water Sampling

Portsmouth continued the Off-Site Residential Drinking Water Monitoring Program in 1993. Results from the program indicate that Portsmouth operations have had no adverse chemical or radiological effects on residential drinking water sources in the area.

Soil and Sediment Sampling

Stream sediments are sampled semiannually in parallel with surface water samples to measure whether waterborne releases are accumulating in local deposits. No radiological contamination was observed in sediments from Big Run Creek, the Scioto River, or the outfalls themselves. As in past years, minor uranium and technetium contamination was found in Little Beaver Creek sediments and minor technetium contamination was found in sediments from Big Beaver Creek. However, these contamination levels were not sufficient to warrant concern for human health.

Soil samples collected semiannually and analyzed for radiological parameters showed no significant contamination of the environment around the plant site. Analytical results for all external soil sample locations indicated that radiological parameters were within the normal range. All internal soil samples were uncontaminated, except for samples from one location that was known to be contaminated.

Vegetation, Food Crop, and Fish Sampling

Biological monitoring conducted in 1993 included sampling of vegetation, locally grown food crops, and fish from local streams. Vegetation samples were analyzed for uranium and technetium, and no significant environmental contamination was found. Food crops analyzed for uranium and gross alpha activity revealed no detectable activity. Fish tissues were analyzed for uranium, technetium, and gross alpha and gross beta activities, and no detectable activity was found.

RADIATION DOSE TO THE PUBLIC FROM PORTSMOUTH PLANT OPERATIONS

A comparison of maximum potential effective dose equivalents (EDEs) resulting from airborne emissions over the last five years is shown in Figure 8. The increase in annual doses for 1992 and 1993 was caused by the increased technetium emissions discussed previously. These increased doses are still well below the USEPA standard of 10 mrem per year for airborne radionuclides. Current dose rates have been reduced to levels comparable to the annual doses shown for 1989 and 1990. The calculated population dose (collective EDE) from airborne radionuclides was 0.38 person-rem per year to the nearest community and 11.6 person-rem per year to the total population within 50 miles of the plant. This number is a small fraction of the approximately 276,000 person-rem that this population received from natural sources of radiation in 1993. None of the potential doses calculated from Portsmouth operations is significant to public health.

The calculated EDE for persons drinking water and eating fish from the Scioto River throughout 1993 was only 0.007 mrem per year. This dose is well below the USEPA national standard of 4 mrem per year for radionuclides in drinking water as well as the DOE limit of 100 mrem per year for all exposure pathways. A comparison of maximum potential EDEs resulting from waterborne emissions over the past five years is shown in Figure 9.

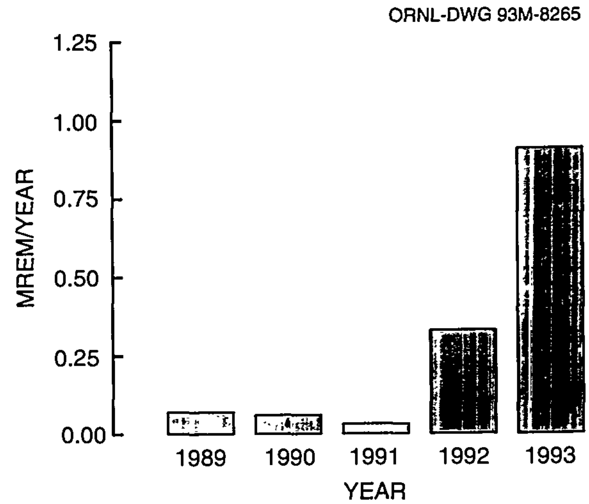

Figure 8. Maximum predicted individual effective dose equivalent from airborne radionuclides, 1989–1993. The USEPA limit is 10 mrem per year.

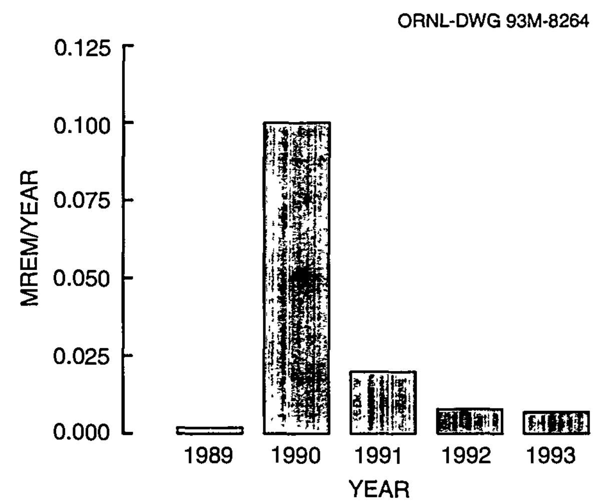

Figure 9. Maximum predicted individual effective dose equivalent from waterborne radionuclides, 1989–1993. The USEPA limit is 4 mrem per year.

Table 1 contains a summary of the annual dose from radiological contaminants that could be received by a member of the public living near the Portsmouth plant, assuming maximum exposure from all major pathways. The calculated maximum combined (internal and external) dose to an individual from Portsmouth activities during 1993 would be 0.92 mrem per year—much lower than the applicable DOE standard of 100 mrem per year from all radiation pathways. Figure 10 shows how the potential dose of 0.92 mrem per year compares with the DOE limit and the average dose from background radiation to residents in the Portsmouth area.

Table 1. Summary of potential radiological dose for 1993 from Portsmouth Gaseous Diffusion Plant

Worst-case combined exposure pathways

Pathway	Dose (mrem/year)[a,b]	Portion of total (%)	Standard (mrem/year)
Atmospheric releases[c]	0.91	99.2	10[d]
Ingestion of Scioto River water	0.0052	0.6	4[e]
Ingestion of fish from Scioto River	0.0015	0.2	NA
All other waterborne pathways			NA
Direct radiation	0	0	NA
Total annual dose above background—all pathways	0.92		100[f]

[a]Dose values were rounded to yield the correct number of significant digits based on all the 1993 data used to estimate the worst-case dose from all exposure pathways and from estimated significant figures in atmospheric releases per DOE/EH-0173T, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance.*

[b]1 mrem = 100 mSv.

[c]Includes ingestion of radionuclides released to the atmosphere via crops, dairy products, and meat.

[d]U.S. Environmental Protection Agency standard in Title 40, *Code of Federal Regulations*, Part 61 (40 CFR 61), Subpart H, "National Emission Standards for Hazardous Air Pollutants," December 1989.

[e]Title 40, CFR 141, "National Interim Primary Drinking Water Regulations." Under these regulations, persons consuming drinking water shall not receive an annual whole body dose of more than 4 mrem. DOE Order 5400.5, *Radiation Protection of the Public and the Environment,* interprets this dose as an effective dose equivalent of no more than 4 mrem.

[f]DOE standard for the sum of all pathways in DOE Order 5400.5.

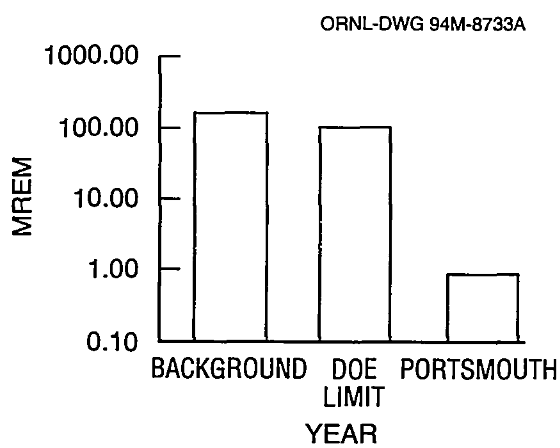

Figure 10. Comparison of combined dose from all exposure pathways from Portsmouth operations to background dose and DOE limit. Portsmouth's contribution to the dose of 0.92 mrem was 0.9% of the 100-mrem DOE limit and 0.3% of the 300-mrem background radiation.

PERSPECTIVE ON RADIATION AND DOSE

Most radiation occurs naturally, and everyone is exposed to it. Naturally occurring radiation is the largest contributor to the average individual's annual dose (see Figure 11).

Background Radiation

People have no control over the amount of natural radiation around them, which stays about the same over time. In fact, the natural radiation present in the environment today is not much different than it was hundreds of years ago. Sources of natural, or background, radiation include (1) internal radiation from food, potassium for example (everyone has approximately 500,000 radioactive atoms disintegrating in their bodies every minute); (2) radiation from the sun and cosmic radiation from outside the solar system; (3) and terrestrial radiation from the earth's rocks, soils, and minerals. Exposure to background radiation varies greatly depending on factors such as where a person lives and what materials were used in the building where that person lives.

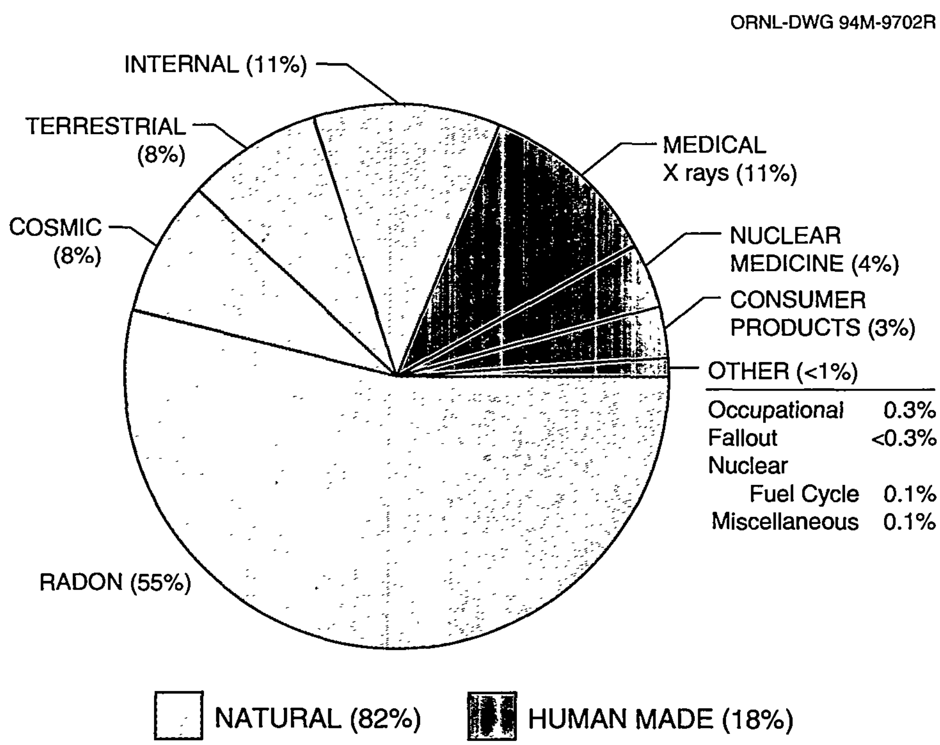

Figure 11. Sources of radiation. Radiation has always been present, and every person who has ever lived has been exposed. Although modern technology seems to have greatly increased the exposure rate, this is not necessarily the case. Exposure to human-made radiation varies greatly based on a given individual's product choices and medical treatments. In fact, exposure varies more based on where a person lives than on exposure to human-made sources. For example, the average individual in the United States receives 28 mrem per year from radioactive elements in the soil. However, the average dose from the soil in some areas of France is 350 mrem per year. Figure redrawn with permission from the National Council on Radiation Protection and Measurements, *Ionizing Radiation Exposure of the Population of the United States*, NCRP Report No. 93, 1987.

Human-Made Radiation

Sources of human-made radiation include consumer products, such as color televisions, cigarettes, camera lenses, smoke detectors, and fertilizers, and medical sources, such as X rays, diagnostic tests, and treatments. Human-made radioactive materials also include cesium-137 and strontium-90, which are present in the environment as a result of nuclear weapons testing that was conducted in past years. As with background radiation, exposure to human-made radiation varies greatly depending on individual choices, such as smoking and eating certain food products.

Comparison of Dose Levels

The dose received by a given individual can vary greatly from year to year depending on numerous factors. The dose that an average individual receives from natural exposure is more than 200 times greater than the dose that person receives from nuclear industry operations (see Table 2).

The average dose caused by background radiation also varies widely. In the United States, the average is about 300 mrem per year; however, some people in other parts of the world receive a dose more than four times this amount. For example, in some areas of Brazil, the dose to inhabitants can be more than 2000 mrem per year from background radiation. These variations are caused by several factors, most notably the type and amount of radionuclides in the soil (see Figure 12).

This diversity in background radiation, not human-made radiation, is responsible for the large differences in the dose to average individuals. Because people living in areas with high levels of background radiation do so without proven harm, it is assumed by most in the scientific community that the extremely small variations in dose caused by Portsmouth plant releases have inconsequential, if any, effect on humans. See Table 3 for a comparison of various dose levels.

Table 2. Average annual radiation dose in the United States

Radiation type	Average dose
Natural	
Cosmic	27 mrem
Internal	239 mrem
Terrestrial (mostly radon)	28 mrem
Human made	
Consumer products	10 mrem
Medical sources	53 mrem
Other (includes nuclear industry)	<1 mrem

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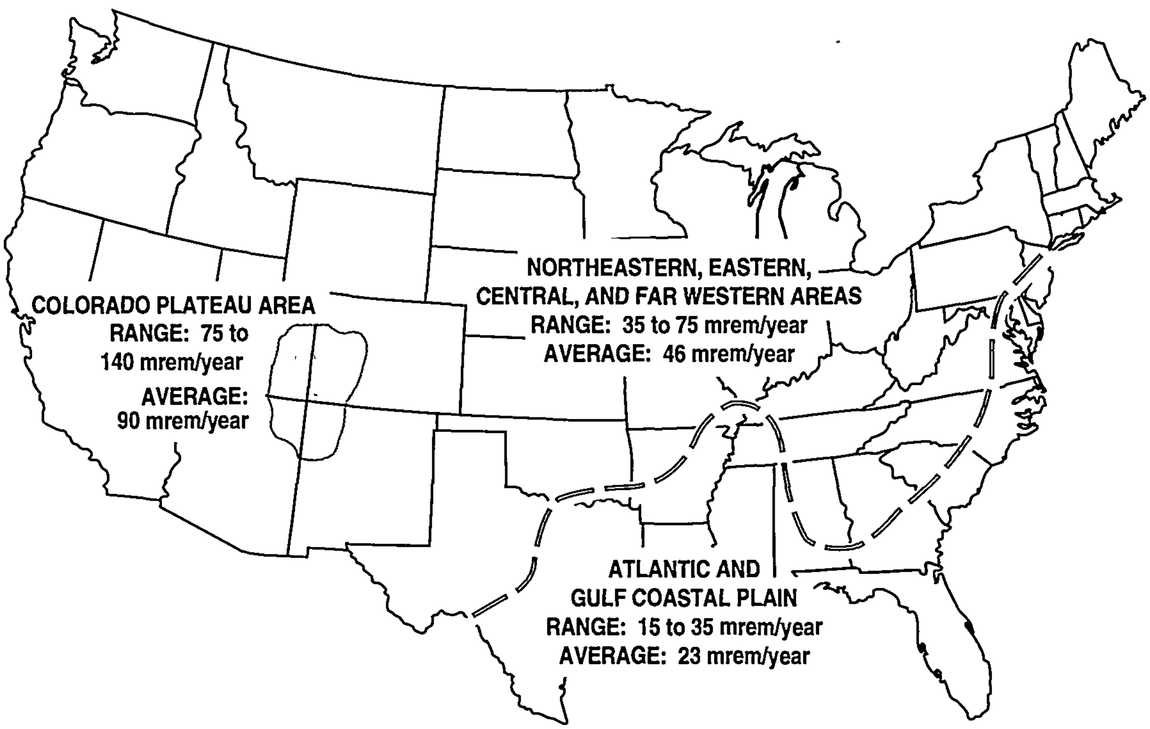

Figure 12. Average dose from terrestrial radiation in the United States. Large deposits of uranium and thorium ores in the southwest are responsible for the higher-than-average dose in the Colorado Plateau area. Figure redrawn with permission from the Subcommittee on Risks of Low-Level Ionizing Radiation, *Low-Level Radiation Effects: A Fact Book*, The Society of Nuclear Medicine, Inc., 1985.

Table 3. Comparison and description of various dose levels

Dose level	Description
1 mrem	Approximate daily dose from natural background radiation, including radon.
2.5 mrem	Cosmic dose to a person on a one-way airplane flight from New York to Los Angeles.
10 mrem	Annual exposure limit, set by the USEPA, for exposures from airborne emissions from operations of nuclear fuel cycle facilities, including power plants, uranium mines, and mills.
50 mrem	Average yearly dose from cosmic radiation received by people in the Portsmouth area.
46 mrem	Estimate of the largest dose any off-site person could have received from the March 28, 1979, Three Mile Island nuclear accident.
66 mrem	Average yearly dose to people in the United States from human-made sources.
100 mrem	Annual limit of dose from all DOE facilities to a member of the public who is not a radiation worker.
110 mrem	Average occupational dose received by U.S. commercial radiation workers in 1980.
244 mrem	Average dose from an upper gastrointestinal diagnostic X-ray series.
300 mrem	Average yearly dose to people in the United States from all sources of natural background radiation.
1 to 5 rem	Level at which USEPA Protective Action Guidelines state that public officials should take emergency action when this is a probable dose to a member of the public from a nuclear accident.
5 rem	Annual limit for occupational exposure of radiation workers set by the U.S. Nuclear Regulatory Commission and DOE.
10 rem	Estimated level at which an acute radiation dose would result in a lifetime excess risk of death from cancer of 0.8%.
25 rem	USEPA guideline for voluntary maximum dose to emergency workers for non-lifesaving work during an emergency.
75 rem	USEPA guideline for maximum dose to emergency workers volunteering for lifesaving work.
50 to 600 rem	Level at which doses received over a short period of time will produce radiation sickness in varying degrees. At the lower end of this range, people are expected to recover completely, given proper medical attention. At the top of this range, most people would die within 60 days.

Adapted from *Savannah River Site Environmental Report for 1993, Summary Pamphlet*, WSRC-TR-94-076, Westinghouse Savannah River Company, 1994.