United States Environmental Protection Agency | Office of Research and Development Washington DC 20460 | Air and Energy Engineering Research Laboratory Research Triangle Park NC 27711 | Office of Environmental Engineering and Technology Demonstration Washington DC 20460

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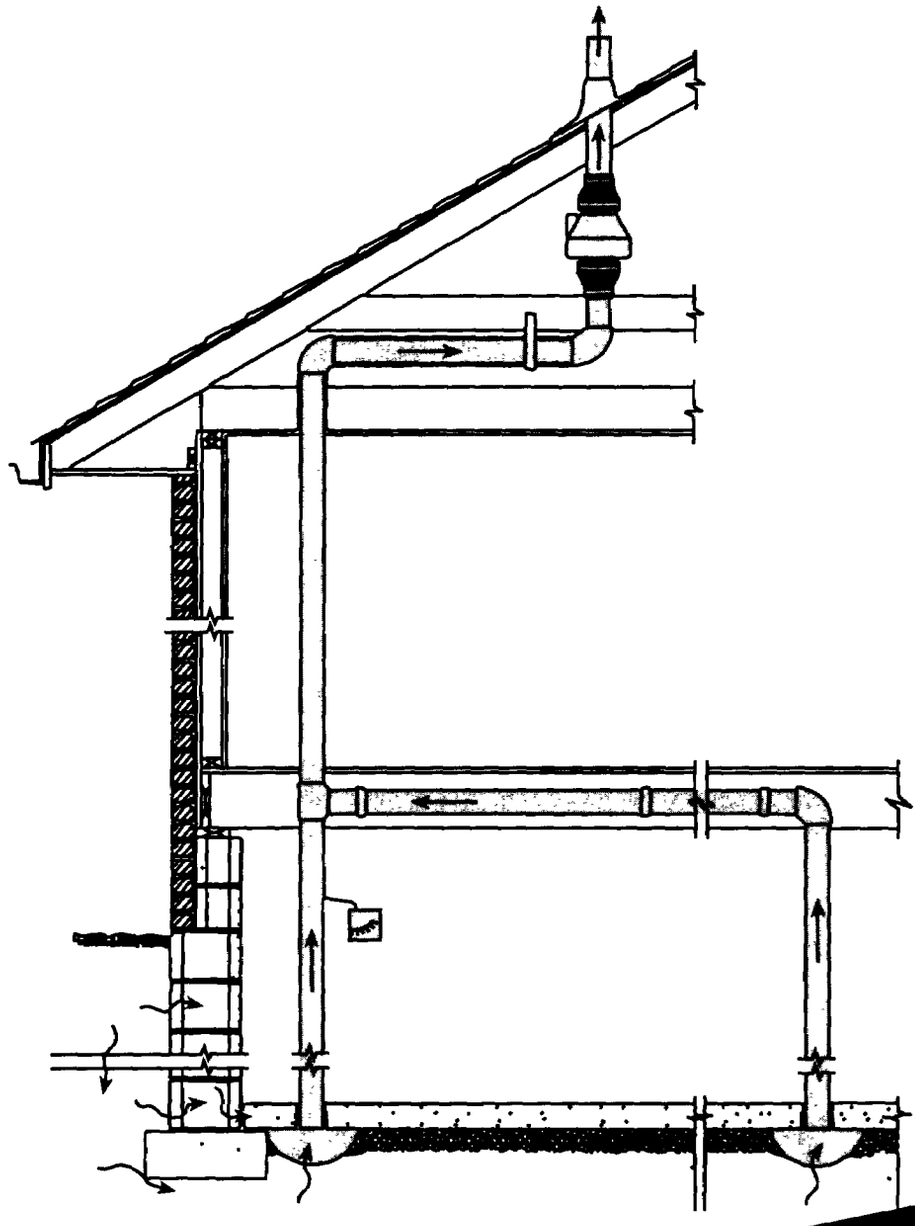
EPA

Radon Mitigation Research



Improved Technology for Environmental Protection

Radon mitigation technology developed by EPA's Air and Energy Engineering Research Laboratory (AEERL) has been the basis for the installation of radon mitigation systems in over 300,000 U.S. homes.[1] This has resulted in over 100 lives saved per year. If the technology is applied to mitigate radon levels in all U.S. homes with radon levels above the EPA guideline of 4 pCi/L, an estimated 2200 lives would be saved annually.[2]

This brochure summarizes the impact that AEERL's research has had on radon mitigation in the U.S. It also includes background information on radon and AEERL's future research plans.

Background

Radon is the second leading cause of lung cancer deaths in the *U.S.*[3] In order to reduce the public health risk from radon exposure, EPA's Air and Energy Engineering Research Laboratory (AEERL) is conducting research to develop and demonstrate cost-effective radon mitigation technologies. These improved technologies for environmental protection in homes, schools, and other large buildings are communicated to radon mitigators, builders, school facility personnel, architects, engineers, homeowners, and federal, state, and local governments through technical guidance manuals, training courses, reports, and symposia.

The Radon Problem

Radon is a colorless and odorless radioactive gas that results from the decay of naturally occurring radium found in many soils and rocks. Because radon is a gas, it can move through the soil and enter homes and other buildings through openings in foundations. Radon can also enter buildings through radon-contaminated groundwater. Once radon enters a building, concentrations can build up to dangerous levels.

Radon is the largest source of exposure to ionizing radiation in the U.S. (Figure 1). EPA estimates approximately 13,600 lung cancer deaths per year from indoor radon exposure.[2] These estimates are based on extensive epidemiological evidence from about 20 different studies of lung cancer in occupationally exposed uranium miners. In addition, independent evaluations by the International Agency for Research on Cancer, the International Commission on Radiological Protection, and the National Council on Radiation Protection and Measurement have reached comparable conclusions on the significance of the indoor radon problem.

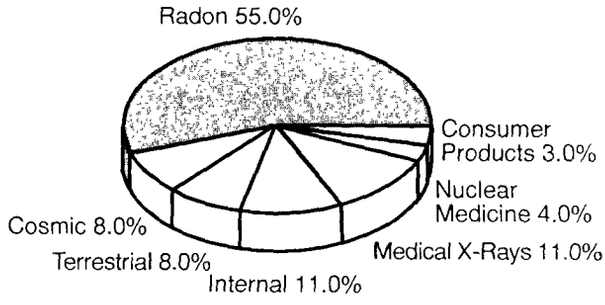


Figure 1 Radon - a Naturally Occurring Radioactive Gas - is the Largest Source of Exposure from Ionizing Radiation in the U.S.

A 1990 EPA Science Advisory Board Report on "Reducing Risk: Setting Priorities and Strategies for Environmental Protection"[4] ranked radon as one of the most significant environmental health risks facing the Nation.

EPA's Radon Action Program

EPA's Office of Radiation and Indoor Air (ORIA) is responsible for implementing the Radon Action Program, a non-regulatory approach to reduce the public's risk to indoor radon. The program has four components (Figure 2):

1) *Problem Assessment - EPA's ORIA has undertaken radon surveys at both the national and state levels to determine the magnitude and distribution of the radon problem (see map in Figure 3).*
2) *Mitigation and Prevention - EPA's AEERL conducts research to develop and demonstrate cost-effective radon mitigation and prevention technologies.*

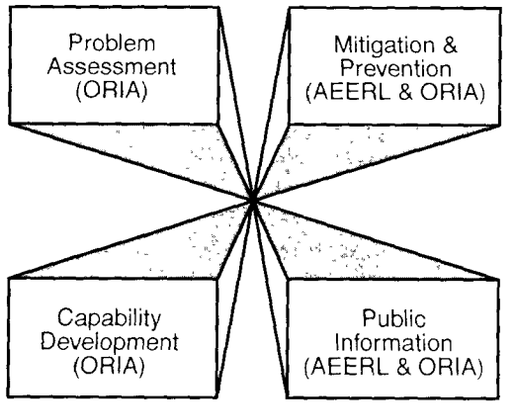


Figure 2 Components of EPA's Radon Action Program

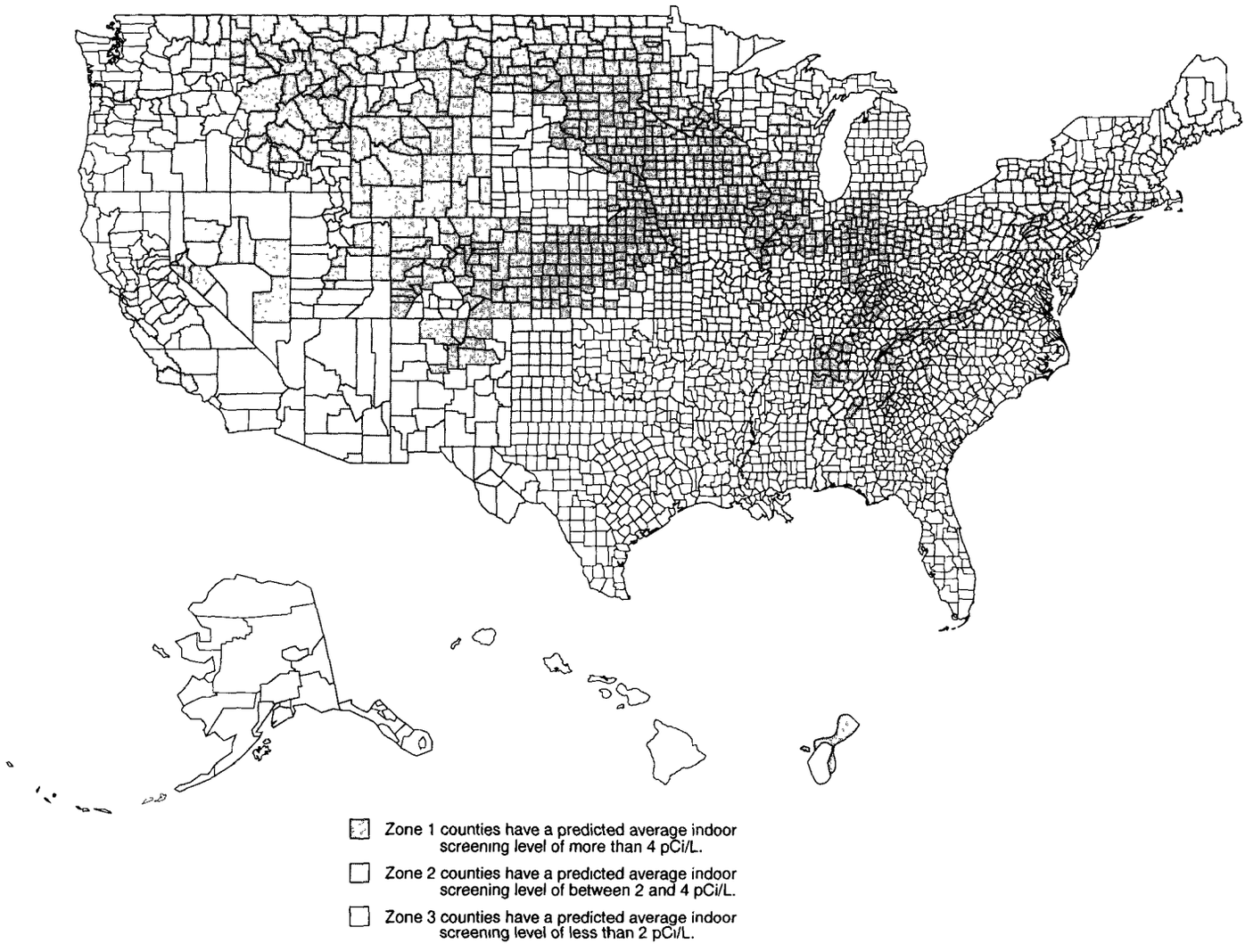


Figure 3 EPA Map of Radon Zones

EPA's ORIA conducts mitigation demonstration projects and has developed radon-resistant model construction standards for homes.

3) *Capability Development - EPA's ORIA is* transferring new *technologies to state and local governments and the private sector.*
4) *Public Information - Both ORIA and AEERL communicate radon information and guidance to the public through brochures, technical guidance manuals, input to EPA training courses, reports, and symposia.*

Radon Mitigation Research

AEERL research focuses on radon mitigation and radon prevention for homes, schools, and other large buildings. AEERL has researched, developed, and demonstrated several radon reduction techniques, including: soil depressurization, sealing, building ventilation, building pressurization, and water systems.

Soil Depressurization-Suction pipes are installed beneath the building foundation, and a fan is used to pull the radon-containing soil gas away from the building before it can enter. Soil depressurization is the most effective technique both for reducing radon levels in existing buildings and for preventing elevated radon levels in new construction (Figure 4).

Sealing-Sealing cracks and other openings in the foundation can help prevent radon from entering a building. While sealing alone is often not sufficient to

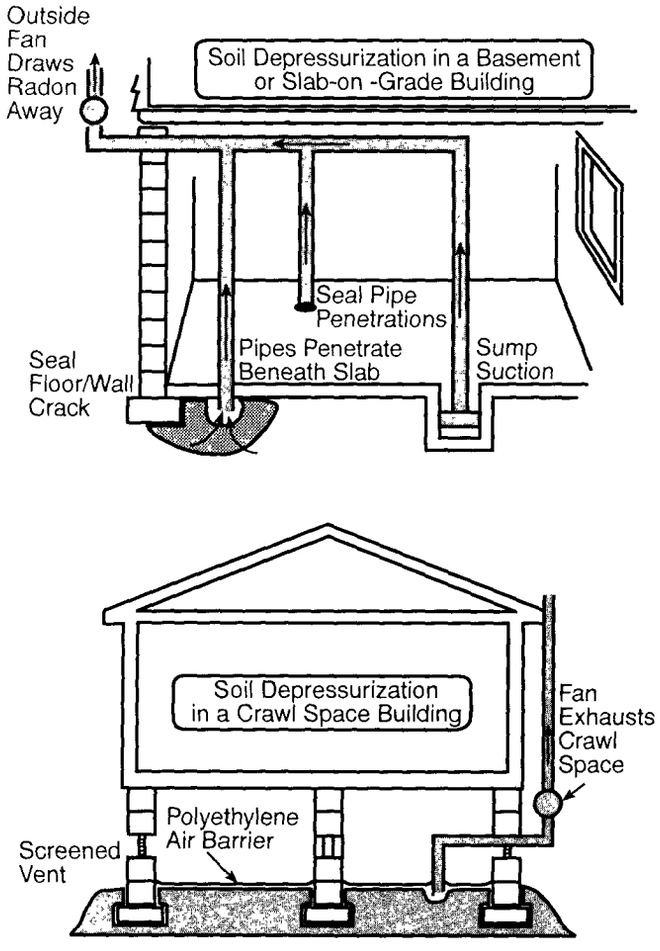


Figure 4 Radon Mitigation Soil Depresurization Techniques

mitigate the radon problem, it is typically included as a component of most radon control techniques.

Building Ventilation-Opening windows, doors, and vents on lower levels or supplying conditioned outdoor air to the building will help to lower radon levels by dilution and by reducing negative pressures in the building.

Building Pressurization-Building pressurization uses a separate fan (such as a heat recovery ventilator) or an existing building ventilation system to create positive pressure which prevents the entry of radon-containing soil gas.

Water Systems-Radon can be removed from water by aeration before it enters the building.

AEERL has conducted radon mitigation and prevention research in 19 states. This research has directly resulted in radon diagnosis and/or radon mitigation in 190 houses, 49 schools, and 7 large commercial buildings. The research also has far reaching effects, leading to the development of radon mitigation techniques that can be used to reduce levels in the estimated 6 million homes with radon levels above the EPA guideline of 4 pCi/L.[2]

Additional outputs from AEERL's radon research program are:

- *Development of technology to cost-effectively prevent elevated radon levels in new construction of large buildings,*
- *Providing expertise and technical support to develop model building standards for new construction,*
- *Reducing highly elevated levels in radon "hot spots" in eastern Pennsylvania, New Jersey, and Tennessee, and*
- *Development of nationally recognized expertise in radon mitigation cost analysis.*

Program Impact

According to a 1993 study by the Conference of Radiation Control Program Directors, over 300,000 homes have already been mitigated for radon. The technologies used to mitigate these homes have largely been developed and disseminated by AEERL.

Radon reduction technologies developed by AEERL are used extensively by the radon mitigation industry (Figure 5). In fact, 900 radon mitigators are currently listed as

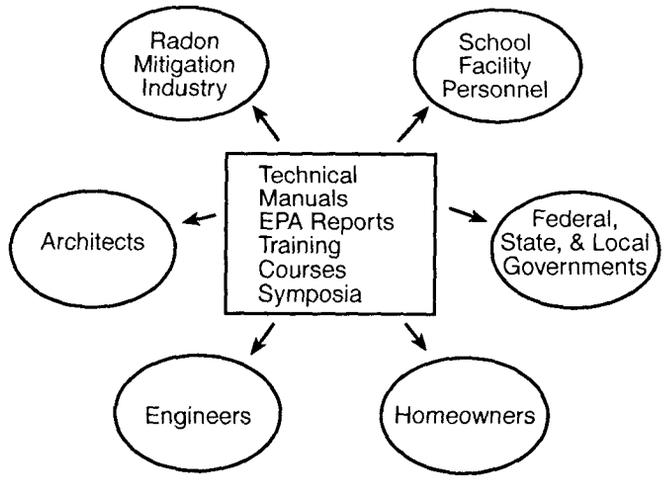


Figure 5 AEERL's Research Results Are Widely Used

part of EPA's Radon Contractor Proficiency Program. These technologies developed and demonstrated by AEERL are also used extensively by school facility personnel, architects, engineers, homeowners, and federal, state, and local governments responsible for implementing radon programs. The results of AEERL's radon mitigation research are communicated through technical guidance manuals, technical support for national radon training courses, reports, and symposia .

The technologies developed and demonstrated by AEERL's research program have had a major impact on reducing radon exposure for the population most at risk from radon: those exposed to highly elevated radon levels, above 4 pCi/L.

These technologies have consistently reduced radon levels to below 4 pCi/L in most cases and to below 2 pCi/L in many cases. Installation of AEERL's demonstrated technology in all of the estimated 6 million U.S. homes with radon levels above 4 pCi/L would avoid approximately 2200 radon-induced lung cancer deaths annually.[2]

Costs for installing radon mitigation systems are relatively low. This is critical since homeowners bear the burden of the mitigation costs. Typical radon reductions and installation and operating costs for these various techniques are shown in Table 1. These estimates are for existing homes. Costs for schools and other large buildings would typically be higher and vary widely. Installation during home construction would normally be less. EPA recommends that passive systems (i.e., without a fan) be installed in areas of high radon potential as designated by EPA's map of radon zones (Figure 3). These systems cost $350-$500. Current AEERL research is investigating innovative techniques for radon mitigation in order to lower the installation and operating costs.

Table 1[5] Radon Reductions & Costs for Common Mitigation Techniques

Radon Mitigation Technique	Typical Radon Reduction %	Typical Range of Contractor Installation Costs in Houses	Typical Annual Operating Cost Range in Houses
Soil Depressurization	80-99	$800 - 2500	$75 - 175
Natural Ventilation	Variable	$200 - 500 (If additional vents installed)	$100 - 700
Heat Recovery Ventilation	25 - 75	$1200 - 2500	$50 - 500 (continuous)
House (Basement) Pressurization	50 - 99	$500 - 1500	$150 - 500
Sealing of Radon Entry Routes	0 - 50	$100 - 2000	None
Water Systems	95 - 99	$3000 - 4500	$40 - 90

Note: The fan electricity and heating/cooling loss cost ranges are based on assumptions for climate, house size, and fuel costs.

Future Plans

Reducing indoor radon levels to 4 pCi/L still does not solve the entire health risk from indoor radon exposure. This is because a significant percentage (78%) of lung cancer deaths[6] are attributed to radon levels above ambient (about 0.4 pCi/L). (See Figure 6.)

AEERL's long term research targets developing technologies to reduce indoor radon levels to ambient levels (0.4 pCi/L) at a low cost. These new, low cost technologies are crucial to motivating more home and large building owners to mitigate (an estimated 16 million homes in the U.S. have radon levels above 2 pCi/L), thus further reducing lung cancer risks in the U.S. If successful, EPA's ongoing research to reduce indoor radon to below 2 pCi/L could result in the prevention of up to 3,100 radon-induced lung cancer deaths annually.[2]

AEERL's research objectives are supported by the Indoor Radon Abatement Act[7] which states, "The national long-term goal of the United States with respect to radon is that the air within buildings should be as free of radon as the ambient air outside of buildings."

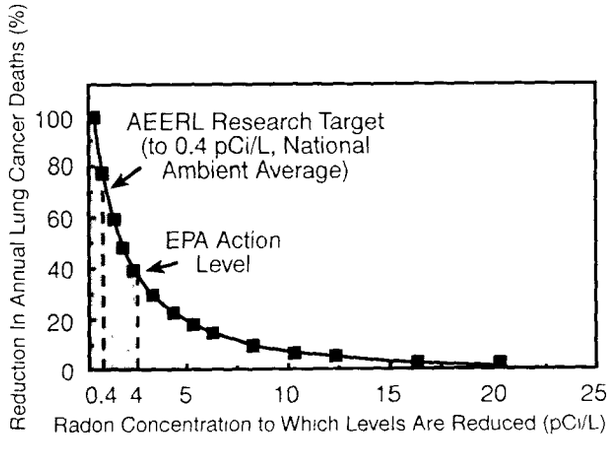


Figure 6 Reducing Radon Levels to Ambient (0.4 pCi/L) Will Avoid Approximately 78% of the Radon-Induced Lung Cancer Deaths

Ongoing and planned research includes:

- *Continued development and demonstration of innovative, low-cost radon mitigation techniques for buildings with radon levels in the 1 to 4 pCi/L range.*
- *Development of radon diagnostic and mitigation protocols for large buildings to reduce costs and provide technologies that are unique to large buildings.*

- *Technical support of building standards and codes for radon-resistant new construction. The emphasis of this research is on low cost passive systems in homes that are easy for builders to install.*

- *Development of American Society of Testing and Materials (ASTM) guidance for construction of radon resistant schools and other large buildings based on an AEERL technical guidance manual.*

AEERL Radon Publications

AEERL's technical guidance represents state-of-the-art technology in radon mitigation and radon prevention. EPA's Center for Environmental Research Information (CERI) has published and distributed over 150,000 copies of AEERL's eight technical guidance manuals on radon mitigation and prevention. AEERL has also prepared 42 technical reports and three editions of a homeowner's guide to radon reduction, distributed over 25,000 copies of four radon mitigation research newsletters, and sponsored four international symposia on radon and radon reduction techniques. This information is used by the radon mitigation industry, builders, school facility personnel, architects, engineers, homeowners, and federal, state, and local governments throughout the U.S. and internationally.

Key publications from EPA/AEERL's Radon Mitigation Branch include:

> *Radon Reduction Techniques for Existing Detached Houses, Technical Guidance (Third Edition) for Active Soil Depressurization Systems* (EPA/625/R-93/011, October 1993)
> *Radon Mitigation Research Updates* (EPA/600/N-93/013, August 1993; EPA/600/N-92/009, June 1992; EPA/600/9-91/038, November 1991; EPA/600/9-91/005, March 1991; EPA/600/9-90/048, December 1990)
> *Radon Prevention in the Design and Construction of Schools and Other Large Buildings* (EPA/625/R-92/016, January 1993)
> *Radon Resistant Construction Techniques for New Residential Construction-Technical Guidance* (EPA/625/2-91-032, February 1991)
> *Radon Reduction Techniques in Schools-Interim Technical Guidance* (EPA/520/1-89/020, NTIS PB 90-160086, 1989)
> *Application of Radon Reduction Methods* (Revised) (EPA/625/5-88-024, NTIS PB 89-205975, 1989)

Publications with NTIS numbers are available (prepaid) from the National Technical Information Service at: 5285 Port Royal Rd., Springfield, VA 22161; 703-487-4650 or 800-553-6847.

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