Maine Commission on Radon

Report on

Resolve, to Direct a Comprehensive

Examination of the Health Threat of Radon

and its Derivatives upon Maine Citizens

January 15, 1988

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Dimensions of Maine's Problem

Next to cigarette smoke, radon is the NUMBER ONE pollutant in homes today. Several recently released studies estimate that the lung cancer risks from airborne radon exceed 1 in 50 compared with other pollutant risks of 1 in 10,000 to 1 in 1,000,000.

There is no reliable method for predicting where high indoor radon levels may occur in Maine. Fundamental knowledge is incomplete on the impact of geological factors, construction techniques and living patterns and their contribution to high radon levels.

The best information available suggests that one in every four homes may have high radon levels, but only a test (or more importantly several tests) on an individual home is conclusive.

Action

Public health concerns mandate that Maine develop near and long–term strategy.

Near–Term Actions (within 1–2 years)

Initiate a public awareness program to reach as many people as possible.

To initiate training for radon assessment and mitigation companies using a modification of the format prescribed in EPA's program of instruction.

Encourage the University of Maine Cooperative Extension Service to continue it's outreach program of radon education.

Encourage screening for air and water radon in home sale contracts.

Require mandatory radon notification/disclosure in all residential structure purchase/sale contracts.

Encourage communities with existing building codes to include radon mitigation features, particularly for new construction.

Initiate a statewide radon survey of school buildings utilizing science teachers and students.

Initiate a radon survey of public buildings.

Investigate the need for and methodology for low interest radon remediation loans. (Has not been well received in other states.)

Require all private laboratories to provide air and water radon test results, to DHS for a statewide data base. The data provided will contain only the results and the town to insure confidentiality for the homeowners.

Continue to participate in epidemological and geological studies.

Long–Term Action (2–5 years)

Explore the use of community building inspectors and code enforcement officials to approve radon reduction features in new construction in those towns which issue building permits.

If found necessary, initiate mandatory certification of radon assessment and remediation firms. (Three states have found this necessary.)

Develop a one–half hour speaker packet for use by various organizations.

Begin new studies to determine whether high radon risk areas can be identified from existing geological and soils information.

Conclusions

The U.S. Environmental Protection Agency (EPA) has made it clear that the states are going to have the prime responsibility of dealing with radon.

The University of Maine has made, and continues to make, significant contributions in the areas of research and public service.

Public health reasons notwithstanding, the real estate community and the code enforcement community will play major roles in the area of radon reduction.

Present Maine law establishes the legal obligation of a real estate professional to a buyer or seller regarding undiscovered or latent material defects or adverse features of a property.

The private sector is best suited for radon assessment and correction of individual homes (contrasted to state–operated programs).

- –Fast start up
- –Expand to fill the demand
- –Confidentiality for homeowners
- –Testing and correction costs are directly borne by homeowner

Role of the state should be:

- –Provide initial training in radon assessment and mitigation
- –Serve as a clearinghouse
- –Provide public information
- –Provide second opinions
- –Provide test devices at low cost
- –Provide a quality assurance program for water testing laboratories
- –Conduct radon research

Since EPA has not yet established a public water supply drinking water standard and will only provide guidelines for radon concentrations in air and in private water supplies, it is premature to establish binding standards at this time. The Department of Human Services (DHS) is presently using 20,000 pCi/L as an action level for private water supplies. It is likely that when the EPA standard for public water supplies is adopted it will be in the range of 100 to 1000 pCi/L.

INDOOR AIR RADON

I. SUMMARY

Radon is a colorless, odorless gas formed by the radioactive decay of uranium. It is found in soils, rocks and some ground water supplies, and can enter a house through various routes. Levels of radon in a home depend on the type of home construction and the amount of radon present in the underlying soil, soil permeability, building characteristics, as well as the amount of radon present in the water supply.

Concern about radon has increased sharply in recent months. A preliminary survey conducted by the EPA in the past year indicates that as many as 8 million, or 12 percent, of homes nationwide may contain dangerous levels of radon. The agency estimates that between 5,000 and 20,000 people each year die from lung cancer related to radon exposure. Congress and several states have initiated programs to deal with this problem.

Maine has been aware of problems with radon in water since the late 1950's. The Department of Human Services and the University of Maine has conducted most of the research in the areas of measuring and removing radon in drinking water.

II. BACKGROUND

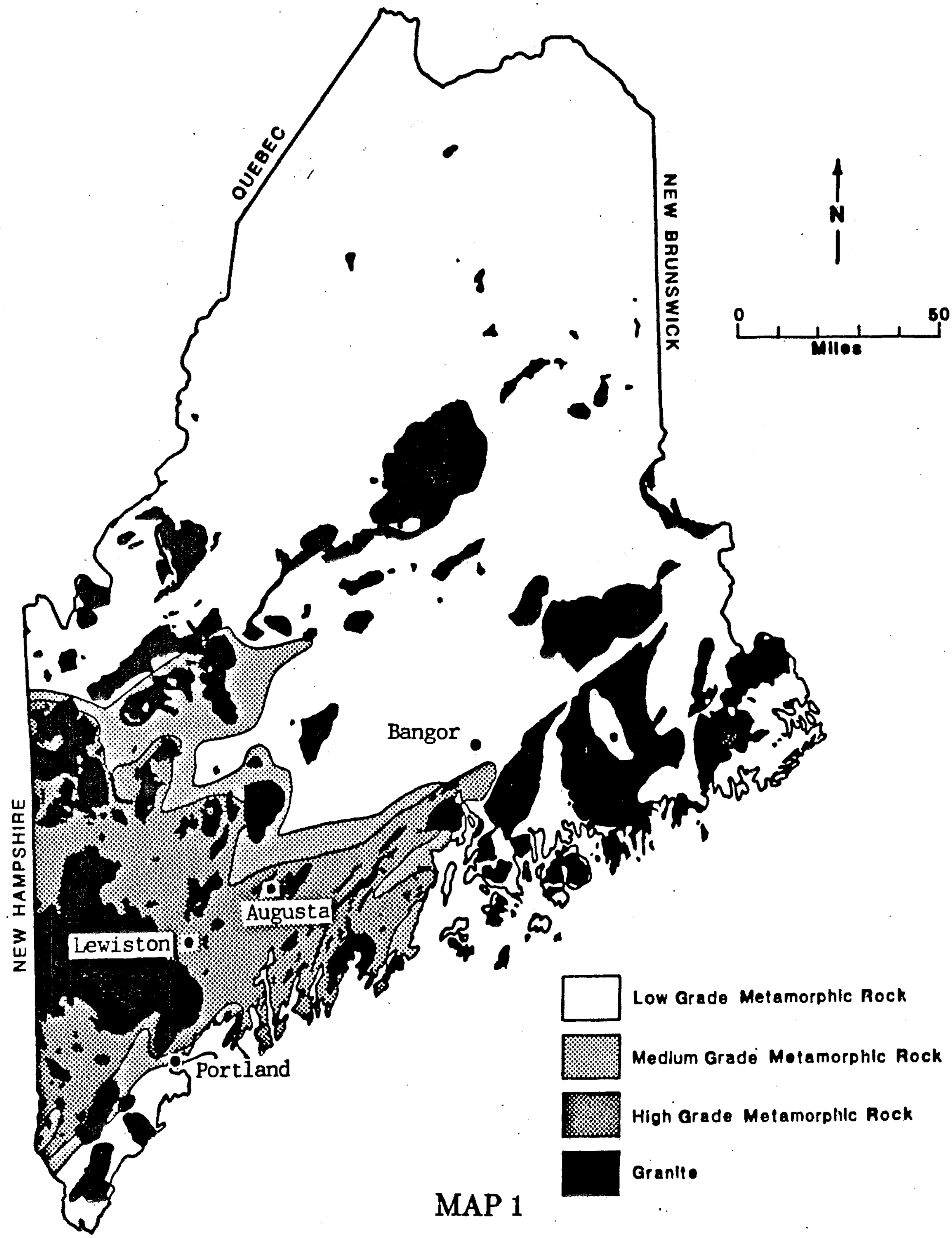
A. Sources and Characteristics of Radon

Radon is an invisible, odorless, radioactive gas produced by the decay of uranium in rock and soil.

As uranium decays, it produces radium, which in turn releases radon gas. Once released, radon migrates through permeable rocks and soil, eventually escaping into the atmosphere, buildings and/or ground water.

High radon levels are likely to occur where there are significant amounts of uranium. Rocks that may have higher than average concentrations of uranium include granite and high grade metamorphic rocks. MAP 1. shows the granite and high grade metamorphic rock, where water radon levels are most likely to be high. The granite areas also have the highest average air radon levels, although high air radon levels have been found in other areas.

Soils can also be a source of radon. Soil permeability plays an important role in determining whether or not the radon produced will be able to move indoors. Homes built on the more permeable soils (sand and gravel) tend to have higher average radon levels than those homes built on till or clay.



Map of Maine Showing the Metamorphic Grade of the Bedrock

The average water radon levels are generally higher in the high grade metamorphic rock. The average air and water levels are highest in granite.

B. Radon in Air

Every home in Maine has some level of radon gas in its air. In Maine one out of four homes are believed to have levels high enough to require some type of action to reduce radon levels.

Radon gas can seep into a home through cracks in the foundation, areas around drainage pipes, sump pumps, and other openings in the foundation or walls.

The concentration of indoor radon found to date in Maine ranges from background to 500 picocuries per liter of air (pCi/L).

The only way to know what radon levels are is to have an air radon test. EPA has developed "A Citizen's Guide to Radon" to provide homeowners with the facts about radon and to help them evaluate their personal risk if they should find elevated levels in their homes.

C. Radon in Water

In addition to radon in soil and rock, radon can also be found in water. Public drinking water supplies drawing from surface sources contain very little radon and are consequently a negligible source of indoor radon. Private drinking water supplies drawing from ground water, particularly wells drilled in bedrock, can contain significant concentration of radon and can be a major source of indoor radon. All public water supplies have been tested, but are not presently regulated for radon.

Radon is released into the home air when the water is used for household activities. Uses such as baths or showers, washing clothes or dishes, flushing toilets, or cooking, in which the water is aerated or heated, can be sources of release into the home. Radon can be removed from water by aeration or with granulated activated carbon filters. The use of carbon filters are not encouraged because of the build–up of decay products. Ongoing and future work should provide more specific recommendations.

Compared to indoor levels of radon from other sources, radon in water may not always be a major health problem because the amounts of radon in water needs to be very large before it can pose an airborne health risk.

The following are a few facts concerning radon in water:

The concentration of radon in Maine ground water supplies ranges from 200 to 1,800,000 picocuries per liter of water (pCi/L). Some of the highest known radon levels in water occur in Maine.

EPA estimates that 10,000 pCi/L of radon in water will result in an average air radon concentration of about 1 pCi/L.

The EPA Office of Drinking Water is developing a drinking water standard for radon in 1988 and is expected to publish an advance notice of proposed rulemaking soon.

D. Risks from Radon

The primary health risk associated with radon in water is from the inhalation of the gas as it is released from the water. Although the sources are different, the health effects are the same from radon in both water and soil———an increased risk of lung cancer.

Why is radon's decaying process hazardous to human health? As radon decays, it produces several different decay products, or progeny. Two of the short–lived decay products emit alpha particles. When these decay products become attached to dust particles in a home and are inhaled, they become deposited in the upper section of the lungs. Like inhaling cigarette smoke, inhaling the radon progeny has long–term effects that may result in lung cancer. It is the alpha particles that cause the problem by damaging individual cells and potentially modifying their behavior.

Data linking radon to lung cancer have been accumulated over four decades. Unlike most cancer risk studies, which have historically drawn analogies from the effects of carcinogens on laboratory animals, radon studies document the effect of radon decay products on human beings. Hard rock miners, who tend to be exposed to high levels of radon while they work, show five to ten times greater incidence of lung cancer than the general population. A study made in Sweden shows that the occurrence of lung cancer in women who have been exposed to high levels of radon is double that of the general population.

Estimated life time risks from inhaling radon from soil gas or released from water in the home are as follows.

Radon Concentration in air (pCi/L)	Risk of Lung Cancer 70 year lifetime exposure
200	44–77 in 100
20	6–21 in 100
4	1–5 in 100

Estimated life time risks from inhaling radon released only from water in the home are as follows:

Radon Concentration in water (pCi/L)	Risk of Lung Cancer (70 year lifetime exposure)
100,000	3–12 in 100
10,000	3–13 in 1,000
1,000	3–13 in 10,000
100	3–13 in 100,000

E. Areas with Potentially High Radon Levels

At this time, there is no completely reliable method for predicting where high indoor radon levels will occur.

Geological factors determine an area's potential to generate radon. Higher–than–normal uranium or radium deposits, soil permeability, and moisture contribute to the presence of high radon levels and its hazard potential.

However, not every house in a given area is affected to the same degree. One house may show high levels of radon while the house next door does not. Because radon is a non–reactive gas, it moves easily through the open spaces in the soil and may enter the home through cracks in the foundation or cinder blocks or through sump holes, drain pipes, or spaces around pipes.

Air and soil pressure differences contribute to the potential of radon entering a home. Rain and snow produce pressure differentials in soil that allow radon to flow more easily through cracks in a basement. Negative pressure conditions generally exist in a home and tend to literally suck air and gas in from the surrounding soil. In the winter, a vacuum created by home heating helps draw soil gas in from the ground; in the summer, attic fans will do the same. Furnaces, dryers, and fireplaces may contribute to the problem by drawing air for combustion while increasing negative pressure.

The most straightforward way to obtain a statistical distribution of radon concentration in Maine homes is to test a number of randomly selected homes. These measurements should be made free of charge to avoid economic biases. Such surveys involving large numbers of homes are, therefore, very expensive.

EPA recently completed such surveys in ten (10) states. The results of those screening measurements are as follows:

State	% of Homes over 4 pCi/L
Connecticut	19
Rhode Island	19
Alabama	6
Tennessee	16
Kentucky	17
Kansas	25
Michigan	9
Wisconsin	27
Colorado	39
Wyoming	26

The Terradex Corporation has analyzed 1496 long–term measurements from Maine homes and found 23% of the homes to have air radon levels over 4 pCi/L. It should be noted that 80% of Terradex measurements were made in the lived–in portions of the home and long–term radon levels found in the lived–in portions of a home tend to be approximately 50% of the short–term initial screening tests used by EPA in their survey. These measurements were made by homeowners who purchased their own testing kits. The Terradex data is biased because testing devices are more likely to be purchased by the higher income earners than by the poor, by the educated than by the uneducated, owners of new homes vs old homes, and by others who have reason to believe that their home may have high levels of radon.

F. Assessing and Measuring Radon

The only way to know if a home contains a high level of radon is to test for it. Since radon cannot be seen or smelled, special equipment is needed to detect it. Homeowners can purchase radon detection devices and do the tests themselves or they can employ a private contractor. Measurements must be made under specified conditions to ensure their accuracy. These conditions have been outlined in EPA's Radon Measurement Protocols.

Air Testing Devices

Testing devices are available to the homeowner by mail or directly from private distributors. Homeowners may call 289–3826 to obtain information on testing devices. The most widely used detectors are:

Alpha Track which consists of an alpha–sensitive plastic strip that is etched with detectable tracks as alpha particles make contact. The strip is hung like flypaper and, after one to six months (a three–month minimum preferred), is sent to a laboratory for analysis. A trained microscopist has to literally count the alpha tracks etched on the film. The accuracy of the alpha track depends on the size of the test area and the time allotted for testing. The larger the test area and the longer the exposure, the more accurate the results are. This test is excellent for providing information about the average radon levels in a home. Typical testing fee is $25 per test kit.

Charcoal canisters provide accurate information in a reasonably short period of time. Canisters, usually four inches in diameter, are filled with charcoal granules and placed at each living level of the house, starting with the basement. After two to seven days of exposure, they are sealed and sent to a laboratory for analysis. Most charcoal canister testing measures the level of gamma radiation, which directly correlates to the level of radon collected in the canister. This, in turn, relates directly to the radon levels for the area and time period in which the canister was exposed. Typical testing fees range from $12 to $22 per test kit.

Other testing devices used mostly by private contractors include:

Continuous Radon Monitors – Air passes through a filter into a scintillation cell. Alpha particles are emitted and detected by a special electronic tube. This device can be programmed and measurements can be made at regular intervals.

Continuous Working Level Monitors – Radon decay products are measured by a solid–state alpha detector which counts the alpha particles emitted. This device can be programmed and measurements can be made at regular intervals.

Grab Radon (Rn) Sampling – A small sample of air is drawn into a flask. Alpha particles emitted produce light pulses which are counted by a special electronic tube.

Grab Working Level (WL) Sampling – Radon decay products are collected in a known volume of air. Alpha particles emitted are then counted by a phosphor and photomultiplier tube assembly.

Water Test Kits

Radon is collected in a small volume of water, sealed and shipped to a laboratory where the radon is measured using a liquid scintillation device. Typical testing fees ranges from $22 to $30 per test kit.

Measurement Procedures

Taking a radon measurement is the first step in determining whether or not a home has a radon problem. EPA recommends a quick and inexpensive initial screening. If the results indicate the possibility of high radon levels, then follow–up measurements should be taken to provide a more precise picture of the distribution and levels of radon throughout the home. Some vendors may offer special prices for multiple detectors and consumers may want to supplement the initial screening test and determine levels throughout the home.

The EPA has developed testing protocols providing detailed information on proper testing procedures. These "Measurement Protocols" are available from EPA or from state officials.

Proper placement of these devices is critical for accurate test results. Directions should describe the preferred locations and conditions for detector placement.

At the end of the testing period, the devices must be sealed and returned to the distributor for analysis.

Once test results are received, the homeowner should find the "Citizen's Guide to Radon" (available from EPA/DHS) helpful in interpreting their results.

Quality Assurance

The testing method by which radon measurements are taken is meaningless unless performed under the proper conditions. Since large–scale radon measurement of residential structures is a new industry, careful choice of testing companies is essential. The EPA has established the Radon Measurement Proficiency Program (RMP) that serves to verify the qualifications and capabilities of laboratories and businesses involved in the measurement of firms to make indoor radon measurements. This is not a federal certification program; companies voluntarily conduct tests on standard samples in order to be included on a list circulated to states and interested persons. A list of the firms and laboratories participating in the RMP can be obtained from the Department of Human Services at 207 289–3826, EPA's Regional Offices or by calling Research Triangle Institute, EPA's contractor for the program, at 1–800–334–8571, extension 7131.

Units of Measurements

Radon is measured in terms of picocuries per liter of air (pCi/L). One pCi/L represents the decay of two radon atoms per minute in a liter of air.

Radon decay products are measured in terms of working levels (WL). One WL of radon decay products roughly corresponds to the amount of decay products released by 200 pCi/L of radon in air.

Action Levels

Current federal guidelines issued by the EPA recommend remedial action be considered with varying degrees of urgency in any dwelling as follow–up air radon levels exceed 4 pCi/L. For example, EPA suggests remedial action to be taken within a few years for follow–up levels between 4 and 20 pCi/L. Remedial action within several months is recommended for follow–up levels between 20 and 200 pCi/L, with immediate remedial action for follow–up levels in excess of 200 pCi/L.

G. Air Radon Corrective Measures

A variety of methods exist for reducing indoor radon levels. Site and structural conditions play an important role in determining the success or failure of radon mitigation techniques. In general, the following approaches (listed in order of importance) can be used:

Prevention in New Construction – Among the techniques being studied to prevent radon entry in newly constructed houses are laying drain tiles, installing a plastic liner between the aggregate and the concrete slab, pouring monolithic slab and footings, sealing utility penetrations or installing sub–slab ventilation systems.

Sub–Slab Ventilation – Sub–Slab ventilation prevents radon from entering the home by drawing the gas away from the foundation before it can enter the basement. Active ventilation techniques include hollow block wall ventilation, sub–slab ventilation, drain tile suction, as well as wall and sub–slab ventilation. Care must be taken when installing these methods to seal major openings that could reduce suction.

Home Ventilation – This method involves increasing a home's air exchange rate (the rate at which incoming fresh air replaces existing air) either naturally by opening windows or vents or mechanically through use of fans. Fans should be located so that fresh, outdoor air is brought into the basement.

Sealing Off Entry Routes – To reduce radon gas entry into a home, the homeowner can place barriers between the source material and the living space itself. This can include several techniques such as covering exposed earth with concrete or with a gas–proof liner, sealing cracks and holes in concrete walls and floors, covering sumps and placing a removable plug in uptrapped floor drains.

To assist the public in locating a mitigation specialist, EPA has developed the Radon Diagnosis and Mitigation Training Program. In addition, EPA has conducted three–day training courses for state employees and private contractors. DHS plans to oversee a similar effort in Maine.

No single technique can be relied upon to consistently reduce indoor radon levels in every house. Each house must be evaluated to determine the source and potential entry routes before any mitigation approach is adopted. Air radon levels have been successfully reduced in a number of houses and research is continuing on a variety of mitigation techniques. More information on these techniques is provided in a booklet published by EPA, called "Radon Reduction Techniques: A Homeowner's Guide."

III. STATE/FEDERAL LEGISLATION

The federal and some state legislatures are considering or have passed legislation relating to various aspects of the indoor radon problem.

A. State Legislation

States are pursuing or considering a variety of legislative approaches to the radon problem. Ten states have enacted legislation covering a wide range of activities including creating statewide task forces, establishing radon programs, developing certification requirements for measurement and mitigation firms, and creating low–interest loan programs.

Proposed state legislation includes bills requiring certification of measurement and mitigation companies, provisions for testing schools, and authorization of funds for state radon programs.

A report released by EPA in August, 1987 summarizes state radon activities.

B. Federal Legislation

There are currently several bills in Congress relating to indoor radon activities. Two companion bills, s.744 and H.R. 2837, contain very similar provisions.

First, the bills authorize EPA to create a three year, $30 million grant program to help states develop and implement radon assessment and mitigation programs. The bills also direct EPA to establish programs to provide the public with information on firms or individuals that can reliably measure radon and/or construct and implement radon reduction methods, and to charge fees to companies that participate. Lastly, the bill provides for a study of radon in schools and directs various federal agencies to study radon in federal buildings.

In addition to these two bills, several other indoor radon initiatives have been introduced. Congressman Florio (NJ) introduced a bill (H.R. 3110) that would require EPA to establish a health–based standard for indoor exposure to radon. Other bills would allow tax credits or deductions for homeowners that install radon reduction methods in their homes.

IV. OBSERVATION AND TRENDS

Over the last two years, public awareness to indoor radon has increased substantially. As knowledge of the problem evolves, new issues are likely to grow in importance. Such issues include: predictive measurement techniques, mitigation in homes with high or moderate radon levels, health risk estimates, various regulatory or legal issues (certification, liability, and confidentiality), and radon prevention in new homes.

In states such as Maine where a widespread problem may exist, identification of exactly which houses have elevated levels is necessary before mitigation can begin. If geologic studies and work on new measurement techniques (e.g. soil gas testing) continue, the ability to predict high radon areas should improve.

Mitigation activities –– "fixing" the problem once it is located –– have significant technical, organizational, and resource–related questions still outstanding. Since mitigation is much more costly than testing, resource–related questions will be important. Four or five states are just beginning to tackle these problems. Since measurements can be completed fairly quickly, but mitigation is likely to proceed fairly slowly (due to unanswered technical questions and relatively greater resource requirements), it is possible to anticipate that mitigation will soon be a central issue.

State administrators that have already encountered high radon levels have frequently recommended mitigation of homes with radon levels over 20 pCi/L when this level has been confirmed with long–term measurements in the living–levels. However, the mitigation measures for the much larger number of homes likely to be in the 4 to 20 pCi/L range are subject to various interpretations. The tendency at these levels has been for state radon administrators to offer insight and information on the personal risk of the readings (given specific life styles) and to leave the mitigation decision in the homeowner's hands.

Relative to many other environmental health risks, the risk of exposure to radon is well understood. However, substantial uncertainty still remains.

Actions dealing with the certification of mitigation and measurement companies are likely to increase; however, mandatory certification may often require new legislative authority.

Difficult legal questions concerning confidentiality and liability, especially in the context of property transfers, remain largely unanswered. Should a homeowner who has tested his property be required to inform prospective buyers? Should a homeowner who has mitigated high levels of radon be required to inform prospective buyers (to ensure that the remediation is not accidentally defeated)? If the state has a measurement for a home in its data base, should it release this data to prospective buyers? Might this data become a form of evidence in litigation resulting from buyer/seller disagreements? If a test is conducted before transfer of real property, how should the results be interpreted? How can the quality of this type of test be ensured (closed condition, season, etc.)? Answers to these questions will be difficult; however, as measurement and mitigation activity increases, their importance is likely to grow. To date, two states (New Jersey and Pennsylvania) have passed legislation which maintains the confidentiality of measurements reported to the state.

Finally, prevention of elevated radon levels in new homes represents yet another area where future activity is likely to grow. Only two states have addressed this progrem in earnest: Florida, since the late 1970's, and New Jersey, relatively recently (with EPA and National Association of Home Builders). Study issues include changes to building codes, development of radon "resistant" construction techniques, and soil gas radon measurement.

V. PRACTICAL PROBLEMS

Several practical considerations seriously complicate the issues confronting real estate agents and homeowners.

First, although some geographic areas can clearly be identified as meriting inspection and testing of individual properties, there is no "bright line" to distinguish them from those that don't require it.

Second, testing is often unsatisfactory because the conditions and manner of testing affect the results. The validity of the test may be called into question when the results appear to the other party to be self–serving. A buyer who doesn't trust the seller's or agent's testing procedures may initiate his own test. Another difficulty is that the time involved in making the tests may delay the sale or result in its loss.

Third, even when the test results are regarded as valid, it is often difficult or impossible to obtain precise, definitive information on the health effects, impact on property value, or remediation costs. The prospective buyer given such test results will still need to know what they mean in terms of action he should take.

Finally, the purchase of a home is an extraordinarily significant, expensive, and personal experience. Injection of what most people regard as an unusual and unfamiliar consideration—the actual or potential presence of a possibly carcinogenic substance in the home—is frightening.

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