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PUBLIC POLICY CONSIDERATIONS AND THE DEVELOPMENT OF A CODE FOR THE CONTROL OF RADON IN RESIDENCES

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SYNOPSIS

Building codes that address radon control in residential buildings are a relatively new development in the larger trend toward increased efforts to understand and control indoor air quality. A residential radon construction standard has been developed in the Pacific Northwest region of the United States. The Northwest Residential Radon Standard (NRRS) seeks to provide a measured public policy response that is commensurate with current knowledge of both the health risk and the state of building science. This paper reviews the range of potential public policy responses available to deal with radon as a public health problem, describes the policy framework upon which the NRRS is structured, and explains the development process.

Time and budget constraints limited the scope of the NRRS to identifying that minimum set of measures necessary to reliably achieve radon reductions without impairing structural integrity, capability to control other indoor air pollutants, occupant comfort, or energy efficiency. Though it looks more favorably at measures that enhance the linkages between durability, indoor air quality, and comfort; it does not require them unless they are part of the minimum set of requirements necessary for radon control. The NRRS, then, serves to provide a useful interim step toward the larger goal of a systemic approach.

1. INTRODUCTION

The NRRS was developed under the auspices of the Washington State Energy Office with funding support from the Bonneville Power Administration(BPA), a federal regional power-marketing agency.

Radon is an indoor pollutant requiring a different policy response than some other indoor contaminants. As an external pollutant source, radon is dependent on certain aspects of building science for control. There is a need for governmental intervention to increase public awareness of the issue, encourage voluntary action by individuals, and create the opportunity for individuals to live free of high radon exposures.

Ventilation and infiltration play a critical role in the design and construction of residential buildings capable of controlling many pollutants, including indoor radon concentrations. A whole systems approach which attempted to optimize residential buildings for durability, health and safety, comfort, and energy efficiency would include measures addressing envelope tightness, ventilation systems, and their pressure impacts.

Though the NRRS looks more favorably at measures that enhance the linkages between durability, indoor air quality, and comfort; it does not require them unless they are a part of the minimum set of requirements necessary for radon control. As a result, the potential for optimizing net system performance and cost is not impaired, but it is also not realized by the NRRS. Better control of radon is possible, but it requires broader dispersion of already available information, further development of technical support, supportive changes in other building codes, and the different emphasis of a whole systems approach.

2. THE REGIONAL CONTEXT

The Pacific Northwest region encompasses several states in the Northwestern United States. The region is blessed with a large hydroelectric resource which historically provided abundant low-cost electricity. In the past decade the region has taken aggressive steps to preserve its hydroelectric resource and avoid the cost of new electrical generation capacity. A major component of this effort has been the acquisition of energy efficiency in buildings -- a conservation resource.

In 1980, the U.S Congress established the Northwest Power Planning Council, a regional body mandated to develop a regional plan for ensuring adequate supplies of electrical energy. The initial plan (and subsequent revisions) have emphasized conservation as the most cost effective resource in the region.[1]

The Power Council's plan encourages the Bonneville Power Administration -- the agency which manages and distributes much of the region's electricity -- to pursue the conservation resource aggressively. This region has long been recognized for the pioneering work of BPA, both in the transmission of electricity and for the development of public power in the United States. More recently, the BPA has pioneered the development of conservation resources. It is now estimated that BPA has spent $1 billion (U.S.) on conservation programs, purchasing electrical energy savings at an average cost of $.02-.03 per Kwh saved.[2]

Over the past decade, BPA has supported (through participating publicly-owned electric utilities) the weatherization of homes that use electricity for space heating. In about 1980, as a component of its weatherization activities, BPA began to study indoor air quality in homes. Initially, restrictions on available weatherization measures were imposed pending an Environmental Impact Statement. Then, in 1984 the EIS was completed, restrictions were softened, and indoor air quality information was provided to all program participants.[3]

Radon testing was initiated as part of BPA's indoor air quality effort. Participating electric utilities tested residences throughout their service territories for radon levels. Measurements were made with alpha track monitors for a minimum of three months during the heating season. The result is one of the largest data sets ever collected on radon levels in residential buildings. Over 32,800 residential sites in approximately 400 townships were measured in Oregon, Washington, Idaho, Montana, and Wyoming (see Figure 1). The average measured radon concentration in roughly one-half of the 400 townships was greater than 37 Bq/m^3. None of the townships had an average measured radon concentration at or below 7.4 Bq/m^3, the new long-term national goal enacted by the U.S. Congress. A few areas of the region show a large number of homes with elevated radon test results. Notable, is the Spokane River Valley region on the border of Washington State and Idaho. In the City of Spokane, Washington nearly half the homes tested at levels above 150 Bq/m^3.

As part of the Pacific Northwest's aggressive pursuit of energy efficiency savings, the Northwest Power Planning Council developed the Model Conservation Standards (MCS) for the construction of new buildings. These standards require higher insulation levels in the building envelope, tighter building construction to reduce air leakage, ventilation provided by mechanical systems, and certain indoor air

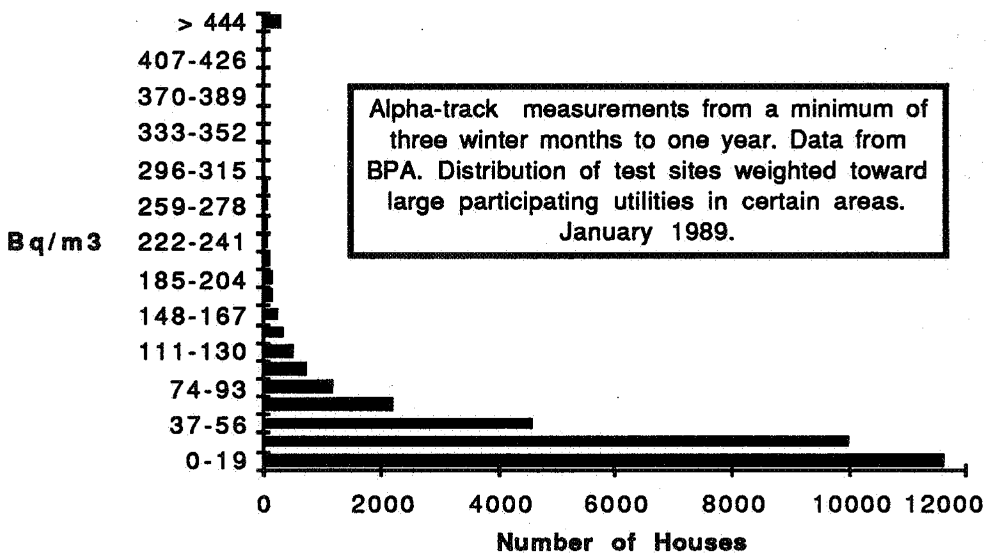

Figure 1. Distribution of 32,885 Radon Measurements in the PNW

pollutant control measures. Roughly 25 building code jurisdictions in the region have adopted the MCS.

The MCS are the first adopted and enforced standards in the U.S. that begin to address radon. In addition to specific requirements for sub-slab gravel and crawlspace ventilation, the MCS contain an appendix which specifies technical measures to be incorporated into certain residential buildings.

These standards implicitly recognize that more stringent energy codes do not necessarily create elevated radon levels. In fact they may provide opportunities to decrease the probability.

In 1987, BPA became interested in the development of a model radon code for new residential construction. In the summer of 1988, BPA contracted with the Washington State Energy Office's Energy Extension Service to research and develop a model radon code.

The Washington Energy Extension Service(WEES) has had an active public education program on indoor air quality for the past decade. When radon became an issue of public concern, WEES had been able to respond quickly with educational services. In a one year effort WEES developed the Northwest Residential Radon Standard.

3. A REGULATORY APPROACH - LOOKING FOR PRECEDENT

The task of determining an appropriate public policy response to the public health issue of radon presents interesting challenges. As an indoor air pollutant that largely originates from outside the building, radon is categorically different from many other indoor contaminants. It is not generated by occupant activity and it is not responsive, in large part, to behavioral adjustments by the occupant. In this light, radon appears as a more appropriate pollutant for some level of regulation.

The range of policy options for addressing public health threats are quite diverse (see Figure 2). At one end of the continuum, society does nothing. This, of course,

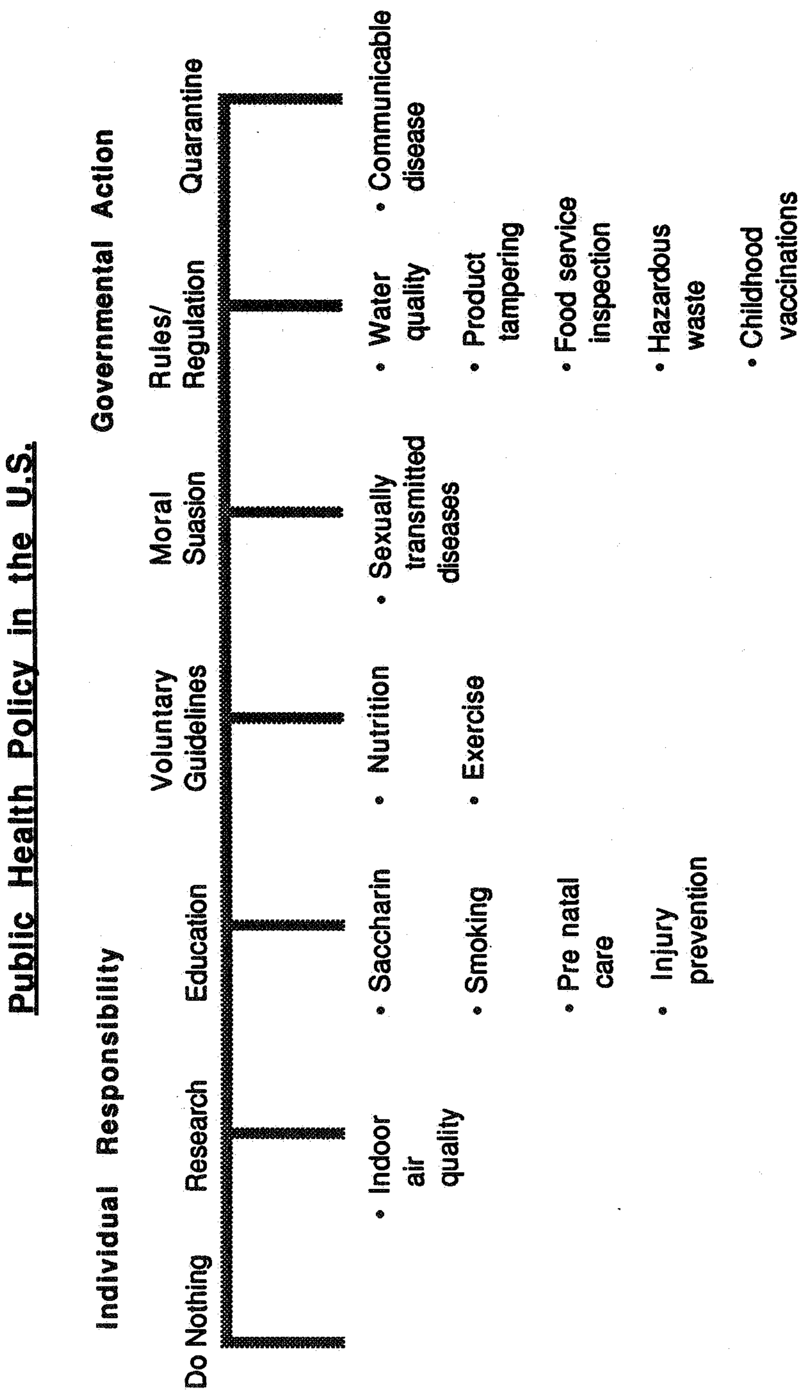

Figure 2. Public Health Policy Options in the U.S.

maximizes individual freedom, but may do little to protect the public good. At the other end of the continuum is the more draconian measure of quarantine, obviously reserved for only the most severe of public health threats. A number of potential policy responses exist along this continuum. Some possible responses include funding research, public education, expanding administrative efforts within existing regulations, moral suasion, and various degrees of restrictive rules and regulations.[4]

There are multiple levels of governmental response to health issues, and policy responses vary in the United States for different public health issues. It is illustrative to look at some health issues in light of the governmental response. Saccharin use and tobacco smoking rely almost exclusively on personal choice and public education (Though in the case of tobacco smoke, local communities are becoming more aggressive in regulating where the activity can take place). Childhood vaccinations and AIDS are two well publicized health issues that have received a stronger regulatory response. Though in both cases there remain elements of personal choice, the public health response has relied heavily upon administrative regulations (e.g. public schools require evidence of vaccination before enrolling children) and moral suasion. A most notable recent example was a produce tampering case (spring 1989) in which two Chilean grapes were found to be tainted with cyanide. The public health response was swift and aggressive: All Chilean produce was pulled from retail shelves throughout the United States.

4. THE SHARED RESPONSIBILITY VALUE

There has been very little regulatory control of radon in buildings in the United States. As such, the project required at the outset many value choices about both the technical structure and policy framework of the code. The fact that a code would be developed at all assumed that the problem was serious enough to warrant *intervention by government - but at what point in the regulatory continuum?*

WEES assumed public health in the area of radon is a shared responsibility between individuals and government. Unlike outdoor air quality (where the costs and benefits of clean air cannot be rationally apportioned to an individual, and attained through voluntary individual action[5]); the benefits that accrue to the individual from voluntary actions to maintain healthy indoor air are clear. WEES assumed it was the role of government to <u>empower</u> individual choice by providing:

- education about radon health effects, measurement, control, etc.
- access to necessary resources by nurturing the development of necessary technology.
- quality control through industry coordination and regulation.
- regulation necessary to <u>provide the opportunity</u> to live in healthier indoor air (including construction standards).

WEES assumed the individual's freedom of choice should be preserved to the extent possible, and that it was the individual's responsibility to:

- recognize the value of healthy indoor air.
- choose whether or not to live in it.

Therefore, the NRRS was structured as a governmental intervention that enables voluntary action. It regulates the building in order to enable radon control and preserve the individual's option to live in a healthier indoor environment. It stops short of requiring an individual to test or mitigate in order to continue to live in that environment. Because it is a construction standard, its scope is very focused and it addresses but one of several important regional and national issues with regard to radon and health.

5. SCIENTIFIC UNCERTAINTIES AND POLICY MOMENTUM

The issue of radon as an indoor air contaminant has a relatively brief history. In the U.S., an ever-increasing understanding of radon as a threat to public health has generated governmental activity at federal, state, and local levels.

At the federal level, the U.S.EPA issued action guidelines to the public for mitigation activity based on radon test results. As research more firmly established radon as a public health threat and as the public's awareness of the radon issue increased, governmental response also increased. The U.S. Environmental Protection Agency recommended the testing of all homes. The U.S. Surgeon-General issued a report on the health threat presented by radon. He encouraged all Americans to test their homes. The U.S. Congress recently passed legislation that provided funds to the states for radon programs, established a long-term national goal to lower radon levels in buildings to outdoor levels (7.4 Bq/m^3), and mandated the development of National Model Construction Standards by June 1990.

Despite increased levels of governmental activity in the area of radon, some uncertainty remains:

- estimates of the level of risk to human health at various exposure levels still vary.
- measurement protocols need improvement.
- we do not have long-term experience with the techniques of radon control and several technical questions remain unanswered (and probably unasked).

It is within this environment of scientific uncertainty and governmental desire to respond to the perceived threat, that the NRRS had to be developed.

WEES is confident that techniques required by the NRRS represent a reasonable and appropriate "good practice" standard at this time. It is redemonstrably evident that the radon control approaches required by the NRRS are very effective. Several radon mitigators utilize these techniques in the mitigation of existing residential buildings and guarantee their performance. However, it should be clearly understood that new information will likely emerge that results in the need for these measures to change.

6. THE VALUE OF A SYSTEMS APPROACH

The control measures required by the NRRS are intended to represent the minimum set of measures necessary to reliably achieve radon reductions <u>without impairing</u> structural integrity, capability to control other indoor air pollutants, occupant comfort, or energy efficiency. These measures are designed to mesh with current building practices, materials, and building codes. Hence, the NRRS requires:

1. practical techniques that reduce the number of openings available for soil gas transport to the indoor air.
2. a pressure difference control system designed to override other house/soil pressure differences contributing to soil gas transport.

However, it does not require:

1. as-tight-as-possible building envelope construction.
2. mechanical ventilation in all residential occupancies.
3. decoupling of all combustion appliances from the indoor air.
4. attention to pressure difference control in design of HVAC systems.

These additional measures serve multiple purposes and cannot always be justified for one purpose alone. For example:

- Mechanical ventilation (properly installed) would contribute to further reduction of indoor radon but its contribution is more than an order of magnitude less than that of the sub slab depressurization system capability required by the NRRS. Yet mechanical ventilation would enhance the control of other indoor air pollutants and increase occupant comfort, if installed in a tight house.
- Envelope tightness could reduce the volume rate of soil gas transport by enhancing pressure difference control capability at minimal energy cost. It would also enhance mechanical ventilation effectiveness, moisture control, comfort, and energy efficiency.

These and other measures could contribute significantly to further radon reductions. However, they would serve multiple purposes and the costs should be appropriately proportioned. A reciprocal effect is that part of the cost of the required radon control measures, such as substructure/crawlspace sealing and sub slab depressurization, could be charged to comfort, control of other indoor air pollutants, control of moisture(several tons/heating season from the soil), and control of other soil gas pollutants. (Jim White, of Canada Mortgage and Housing Corporation, reported that garbage gasses have been measured several kilometers away from land fill sites. Also some bacteria, fungi, and viruses found in soils can produce serious health problems[6]).

A whole systems approach which attempted to optimize residential buildings for durability, health and safety, comfort, and energy efficiency would include at least the additional measures listed above. Such an approach would further rationalize the cost of radon control. The increased durability, safety, comfort, and energy efficiency could increase the net value of residential buildings.

Because of these limitations the proposed NRRS is not an optimal standard. Better control of radon is possible, but it requires broader dispersion of already available information, further development of technical support, supportive changes in other building codes, and the different emphasis of a whole systems approach.

WEES is encouraged to think that the NRRS serves to provide a useful step toward the larger goal of a systemic approach.

7. **INTRA-REGIONAL VARIABILITY**

Radon exposures in some areas of the Pacific Northwest are relatively low: in some areas relatively high: in some areas unknown. It was an original intention that the NRRS would be offered to the region for optional adoption by local jurisdictions. Jurisdictions that were sufficiently concerned could adopt the NRRS.

8. **FLEXIBILITY - THE ROLE OF A DUAL PATH STANDARD**

The national model codes of the U.S., such as the Uniform Building Code, are performance codes. Performance codes specify levels of performance rather than specific materials or procedures. You must attain the end goal but are free to choose the means of attainment. Performance codes allow flexibility, cost optimization, and readily allow the development of new and improved materials and systems.

On the other hand, a prescriptive standard requires installation of certain materials and systems. It specifies a path that must be taken. Prescriptive standards/codes are simpler and easier to follow, but they lack the flexibility of performance codes, as well as the potentials for innovation and cost reduction.

The Council of American Building Officials (CABO), an umbrella organization of the three national model code organizations, distributes the CABO One and Two Family Dwelling Code. It is a prescriptive code. According to Dick Kuchnicki, President of CABO, the One and Two Family Dwelling Code was developed as a response to builders' requests for a prescriptive standard for residential construction.[7] Currently the National Association of Homebuilders favors a prescriptive standard for radon control if and only if it relieves builder liability. However, not all builders concur. Some would like to see a performance standard, because it allows them the flexibility to determine the most cost effective path.

Jim Gross, Deputy Director of the Center for Building Research, of the National Institute of Standards and Technology, has encouraged a dual path standard: a performance standard with the option of specified measures "deemed to satisfy" the standard.[8] This seems the most practical approach. The proposed NRRS follows this dual path pattern.

The NRRS seeks to provide increased protection for all new and significantly remodeled residential occupancies in any jurisdiction of the Pacific Northwest that chooses to adopt it. It seeks to limit exposure to indoor radon for occupants by requiring for every such occupancy either:

- demonstration of post-construction tested indoor radon levels at or below 150 Bq/m^3, or
- installation of certain specified materials and systems during construction that reduce the potential for elevated indoor radon and establish the capability to further reduce radon levels should the owner desire.

Option 1 (Chapter 3 of the NRRS) is a <u>performance</u> requirement. If the building does not meet the performance specification it must be modified until it does. There are no specified control requirements to be met during construction. It allows both flexibility and the demonstration and use of new and different approaches to controlling radon.

Option 2 (Chapter 4 of the NRRS) specifies certain prescriptive requirements, primarily substructure and crawlspace sealing, and the rough-in of a sub slab depressurization system. If the prescribed measures are correctly installed there are no future responsibilities for radon control.

9. NEED FOR A LONG-TERM MEASUREMENT TEST

The performance path of the NRRS requires verification that the performance goal has been reached. The intent is to ensure, within a reasonable level of certainty, that a building will perform as required.

The EPA's Interim Protocols for Screening and Follow-up Radon and Radon Decay Product Measurements state that "The EPA does not recommend taking any significant remedial action on the basis of a single screening measurement." [9] The screening measurement is a short term test.

The short-term test can be a reasonably accurate measure of the radon levels during the actual test period, but the range and period of variation is too great to enable a reasonably accurate measure of the long-term average radon levels. Arthur Scott of American Atcon Inc. has suggested that the decision level of a short-term (3 day charcoal for example) radon test is really very different from that of a long-term test (6 to 12 month alpha track), and that short-term tests are not being interpreted correctly. Short-term tests cannot predict long-term averages. He indicated that if a long-term average radon exposure is really 185 Bq/m^3, then the probability of a short-term test result of 37 Bq/m^3 is the same as the probability of a short-term test result of 750 Bq/m^3. [10]

Currently the short-term test is being misinterpreted in many sectors. William Ethier, an attorney for the National Association of Homebuilders, recently suggested at the National Radon Conference (Cincinnati, March 1989), that utilization of a short-term test to imply that radon levels are below 150 Bq/m^3 and therefore acceptable, could provide reasonable grounds for a claim of fraud or misrepresentation if a long-term test later showed levels over 150 Bq/m^3. According to Ethier, NAHB takes the position that short-term tests should not be part of a real estate transfer contract.[11]

In its report to the U.S. House of Representatives, the U.S. Committee on Energy and Commerce noted concern "about people making decisions not to mitigate based on low readings from short-term radon tests. Accordingly, the Committee expects EPA to evaluate the appropriate use of results from short- and long-term tests by the public. In particular, the Committee expects EPA to consider whether the Agency should recommend that only results from long-term tests should be used."[12]

The EPA screening protocol would be inappropriate for the NRRS, because of its reliance on short-term measurements. One NRRS reviewer suggested that a separate measurement protocol be developed, rather than rely on the EPA screening protocol. Another reviewer cautioned that developing a protocol outside that of the EPA might make it difficult to compare the results to measurements elsewhere.

A longer term measurement is necessary in order to attain a reasonable estimate of the building's actual performance and to avoid cheating by "smart" testers, who could affect results by coordinating test periods with rainfall, weather systems, and other factors. This requires addressing the additional difficulty of testing after occupancy. However there is a positive side to this: the occupant has the least incentive for fraud (unless he or she is preparing for resale).

The NRRS requires a long-term test by specifying adherence to certain EPA follow-up measurement protocols. According to the EPA's Interim Protocols for Screening and Follow-up Radon and Radon Decay Product Measurements, "The purpose of the follow-up measurement is to estimate the long-term average radon or radon decay product concentrations in general living areas with sufficient confidence to allow an informed decision to be made about risk and the need for remedial action." [13]

10. SHOULD WE REQUIRE MONITORING FOR ALL RESIDENTIAL BUILDINGS?

Currently the NRRS requires monitoring only for the performance path because it is the responsibility of the builder to meet the performance standard. It does not require monitoring for the prescriptive path because the builder completes his or her responsibility upon complying with specifications which are "deemed to satisfy" the standard. Once the builder has met the requirements of this standard his or her responsibilities have been completed. At this point the responsibility for addressing indoor radon is passed to the owner. The proposed NRRS stops short of governing the owner or occupant.

Neither compliance path guarantees that, for any given residential building, future indoor radon levels will be below 150 Bq/m^3. If a building has conformed to the prescriptive path, the owner or occupant will not know radon exposures until he or she tests. If a building has conformed to the performance path, there is no certainty that future events will not alter long-term average radon levels. Periodic measurements over the course of the useful life of any building, built to this standard, will be necessary if knowledge of radon exposures is desired.

For all governed buildings, the NRRS requires measures to:

- Inform all future occupants of the radon control measures taken.
- Strongly encourage them to test for radon.
- Provide them access to further information about health effects, testing, and mitigation.

Some NRRS reviewers recommended monitoring all new residential buildings. Other policy approaches were offered. For example, a member of EPA's National Radon Standards and Codes Work Group who has been involved in several mitigation demonstration projects, expressed a concern that the only workable way to reduce radon exposure in buildings is to have a standard that is at once both a performance and a prescriptive standard. Buildings would be built to specifications, tested, then mitigated if necessary. He felt that quality control was so essential, yet so lacking, that this approach might be necessary.

Testing following construction or remedial action, plus continued testing for several years afterward, is warranted by the lack of knowledge of:

- the short-term effects of specific measures in specific houses.
- the longevity of the effects of those measures.

WEES concluded that such follow-up testing should be encouraged (perhaps funded for research purposes), but not required.

11. THE NEED FOR EDUCATIONAL SERVICES

There is little system-wide coordination within the building industry. Many builders receive training on the job and then must make do with what they have learned from this rather local sphere of influence. There is significant variation in construction methods by both geographical area and climate.

In addition, builders must survive in an economic milieu in which emphasis on first costs forces builders to resist any increase in housing costs. Builders face a forest of regulation and will, in many cases, be less than eager to comply with additional regulations.

Educational and technical support services will be of significant value. While no radically new construction techniques are required, many are new to large portions of the residential sector.

An example is the Soil Gas Retarder Membrane required by the NRRS. Many reviewers supported its inclusion, considering it feasible and reasonable. Others were concerned about both the difficulty and cost incurred by having this technique as a requirement. It has become clear from several discussions that perceptions about this issue vary widely within the building trades.

Successful (and unsuccessful) experiences with the sub slab membrane are closely linked to perceptions about correct concrete practices, and these perceptions also seem to vary widely.

More stringent aggregate specifications and sealing techniques may also require educational services in the residential sector.

12. THE NRRS DEVELOPMENT PROCESS

Decisions about public health risks (in this case radon) can be extremely complicated. They involve elements of risk assessment, risk management, and risk communication. All too often, difficult decisions about risk assessment and risk management are made remotely by experts, then poorly communicated to the public. Often the result is conflict, with experts feeling misunderstood and the public feeling misused. Often both are right. Conflicts about health risk issues usually contain the underlying issues of equity and control. "Public participation" is usually too late, and does not involve the kind of information and power sharing necessary for the realization of enduring policies. Risk communication, with the goal of an actively concerned public, and within a context of real openness to public input, is vitally important. It may be difficult but it is both possible and necessary.

A good process can serve to align public perceptions with the perceptions of the scientific community. It can serve to eliminate the inappropriate extremes of either panic or apathy. It can empower a community with the sense that it can take charge and address the issues that confront it.

12.1 Participatory Process - Sequenced Input

The process for developing the NRRS was very participatory. Input was solicited from a diversity of economic sectors including realtors; builders and builder associations; technical specialists and generalists in the fields of building science, radon, and ventilation; consumer protection organizations; energy utilities; state and federal agencies; code organizations; and research organizations.

While broadly solicited, the input was sequenced: technical input was solicited first and the range of known technical solutions identified. Technical specifications had to meet criteria for control effectiveness, ease of implementation by typical tradesmen, availability of materials, cost, compatibility with comfort, and compatibility with other indoor air pollutant control techniques. Legal and policy related input followed.

12.2 Chronology - Initial Scoping

The effort began in June 1988. A literature search was conducted. Researchers, mitigators, and policymakers who were known to have radon-related experience were contacted by telephone. By July, 1988 referrals to additional resources had become very circular, and a sense of closure with regard to available national resources had developed.

The initial effort was very broad. Persons contacted were asked to identify and prioritize the radon issues that they perceived to be most important. They were then asked more specifically to identify those issues they thought were important to the development of construction standards for new residential construction, if they were aware of any efforts to develop construction standards, and if they knew of any standards already in place.

The U.S. Environmental Protection Agency is nationally recognized as the lead Federal resource for addressing indoor radon, and WEES assumed that all local, state, and regional efforts to address radon, particularly efforts to develop construction standards, would include communication with EPA regional offices. With assistance from EPA Region 10, all EPA regional radon representatives were contacted. They were all helpful, identifying issues of concern, key people, and any developing construction standards in their areas. Inquiries were also directed to the National Model Code organizations and the National Association of Homebuilders.

In August 1988 WEES visited and interviewed several radon researchers, mitigation contractors, and policymakers who were particularly knowledgeable about the techniques, costs, and policy issues pertinent to new residential construction. This included persons representing the National Association of Homebuilder's National Research Foundation; U.S. Geological Survey; U.S. EPA New Construction Division; New Jersey Department of Environmental Protection; Princeton University Center for Energy and Environmental Studies; Fairfax County, Virginia, a local jurisdiction actively addressing a known radon problem; Camroden Associates, a major radon research contractor; Garnet Homes, a large construction company voluntarily incorporating sophisticated radon control measures in all new home projects; R.F. Simon Co. and Buffalo Homes, two home construction contractors with significant radon mitigation experience.

WEES deliberately avoided the formulation of any specific code structure or provisions until the initial three months of research had been completed. In September, WEES attended, Reducing Radon In Structures, a three day technical training conducted by the U.S. EPA. After completion of this training the first tentative code design was formulated, internally reviewed, and gradually strengthened in technical detail.

12.3 Development Chronology - Technical and Legal Review

On October 1, 1988 an initial draft of the NRRS was completed and circulated for technical review. Circulation for legal review followed. More than 35 technical reviewers contributed comments about the initial draft. They included persons from the EPA; national research laboratories; university researchers; private sector builders, contractors, radon mitigators, tradesmen, engineers, architects and product suppliers; code officials and code organizations; builder associations; state energy offices; BPA; the Northwest Power Planning Council. The time allowed for the technical and legal review comment period had to be extended considerably longer than originally anticipated in order to obtain important and valuable review comments. The need for a longer review period may be in part due to the unanticipated intensity of activity in the radon industry in 1988, which included a national symposium, and the passage by the U.S. Congress on October 28, 1988 of the Indoor Radon Abatement Act which set a new national goal of indoor radon levels no higher than outdoors.

In January 1989, The U.S. Environmental Protection Agency asked WEES to contribute to EPA's effort to develop Model Construction Standards by June 1990 and partake in a National Radon Standards and Codes Work Group. The group included persons representing the national Model Code Organizations (ICBO, SBCCI, BOCA, and CABO), U.S HUD, National Institute of Building Sciences, National Institute of Standards and Technology, National Association of Home Builders, Canada Mortgage and Housing Corporation, members of an ASTM committee on radon, and representatives from states actively working on radon codes. In February WEES presented an introduction to the first draft of the NRRS to that group and received several constructive comments.

12.4 Development Chronology - Policy Review

The second draft of the NRRS was distributed March 30, 1989. It was circulated to a Policy Review Committee consisting of state and local officials in the general government, building code, and public health areas; policy level representatives from BPA, the Northwest Power Planning Council, utilities, and the shelter industry; the EPA National Radon Standards and Codes Work Group; the National Institute of Standards and Technology; the Canada Mortgage and Housing Corporation. The second draft was also recirculated to technical and legal reviewers as a courtesy copy.

The first draft of a generic Implementation Plan was completed in May and circulated for review by a local advisory committee. The Implementation Plan is a guidance document intended to assist local jurisdictions with considering, adopting and implementing the NRRS. The plan seeks to provide the conceptual framework for a reasonable, equitable, and informed process for consideration of the NRRS. It is not meant to encourage adoption of the NRRS. The intent is to encourage and enable a good choice.

The final Implementation Plan and final draft of the NRRS were completed in June 1989.

13. APPENDIX

The chart in this appendix outlines the structural organization of the NRRS. The NRRS is organized into five chapters. Major topics addressed by each chapter are detailed:

APPENDIX -- ORGANIZATIONAL OUTLINE OF THE NORTHWEST RESIDENTIAL RADON STANDARD

Chapter 1 — ADMIN. & ENFORCEMENT

- Title Intent & Scope
- Materials & Equipment
- Alternate Materials & Methods
- Plans & Specifications
- Enforcement, Inspections, & Fees
- Validity
- Violations
- Liability

Chapter 2 — DEFINITIONS

Chapter 3 — PERFORMANCE PATH

- Scope
- Financial Assurance Requirement
- Measurement
- Mitigation
- Verification of Mitigation
- Notification
- Written Description

Chapter 4 — PRESCRIPTIVE PATH

- Scope
- Floors in Contact With the Earth
  - aggregate
  - bulk water drainage
  - concrete floors
    - placement
    - strength
    - workability
    - air entrainment
    - curing
    - control joints
    - sealing joints/cracks
    - soil gas retarder
  - other floor assemblies
  - passive sub-slab depressurization
- Masonry Block Walls
  - continuous solid course
  - mortar joints
  - penetrations
  - waterproofing
  - continuous air barrier
- Concrete Walls
  - workability
  - sealing penetrations/joints/cracks
  - dampproofing
- Crawlspaces
  - continuously vented
  - intermittently vented
  - plenums
- Combinations of Floor Assemblies
- HVAC Systems
  - ductwork
  - condensate drains
- Sub-Slab Depressurization System
  - sealed pipe
  - perforated pipe
  - pipe characteristics
  - condensation/stack assist
  - fan location
  - fan wiring/circuit/label
  - pipe identification
  - system description

Chapter 5 — REFERENCED STANDARDS & DOCUMENTS

- Occupant Notice Document
- Referenced Documents

14. ACKNOWLEDGEMENTS

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15. REFERENCES

1. Northwest Power Planning Council, Portland, Oregon, USA. "Northwest Conservation and Electric Power Plan," Volume 1, 1983.

2. Northwest Power Planning Council, Portland, Oregon, USA. "Northwest Conservation and Electric Power Plan," Volume 1, 1986, p. 6-1.

3. Bonneville Power Administration, P.O. Box 3621, Portland, Oregon, USA. "Final EIS: The Expanded Residential Weatherization Program," August, 1984. DOE/EIS 0095F.

4. Spengler, John D. and Sexton, Ken. "Indoor Air Pollution: A Public Health Perspective," Science, Vol. 221, No. 4605, July 1983, p.14.

5. Spengler, John D. and Sexton, Ken. "Indoor Air Pollution: A Public Health Perspective," Science, Vol. 221, No. 4605, July 1983.

6. White, Jim H. "Radon--Just Another Soil Gas Pollutant?" 81st Annual Meeting of the Air Pollution Control Authority, Dallas TX, USA, June 1988, p.5.

7. Kuchnicki, Dick. Comments to National Radon Standards and Codes Work Group of the U.S. EPA , Washington D.C., February 1, 1989.

8. Gross, James. National Institute for Standards and Technology, Gaithersburg, Maryland, USA. Personal Communication.

9. U.S. Environmental Protection Agency, "Interim Protocols for Screening and Followup Radon and Radon Decay Product Measurement," No. 520/1/86-014. January 1987.

10. Scott, Arthur. American Atcon Inc., Box 164, Mississuaga, Ontario, L5L3A2, Canada. Personal communication.

11. Ethier, William. Comments at the March 1989 National Radon Conference, Cincinnati, Ohio, USA.

12. Committee on Energy and Commerce, Report (to accompany H.R.2837) to the U.S. House of Representatives, Report 100-1047, October 4, 1988.

13. U.S. Environmental Protection Agency, "Interim Protocols for Screening and Followup Radon and Radon Decay Product Measurement," No. 520/1/86-014. January 1987.