ENVIRONMENTAL PROTECTION AGENCY

40 CFR Parts 141 and 142

[WH–FRL–6462–8]

RIN 2040–AA94

National Primary Drinking Water Regulations; Radon-222

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice of proposed rulemaking.

SUMMARY: In this action, the Environmental Protection Agency (EPA) is proposing a multimedia approach to reducing radon risks in indoor air (where the problem is greatest), while protecting public health from the highest levels of radon in drinking water. Most radon enters indoor air from soil under homes and other buildings. Only approximately 1–2 percent comes from drinking water. The Agency is proposing a Maximum Contaminant Level Goal (MCLG) and National Primary Drinking Water Regulations (NPDWR) for radon-222 in public water supplies. Under the framework set forth in the 1996 amendments to the SDWA, EPA is also proposing an alternative maximum contaminant level (AMCL) and requirements for multimedia mitigation (MMM) programs to address radon in indoor air. Public water systems (PWS) are defined in the Safe Drinking Water Act (SDWA). This proposed rule applies to community water systems (CWS), a subset of PWSs. Under the proposed rule, CWSs may comply with the AMCL if they are in States that develop an EPA-approved MMM program or, in the absence of a State program, develop a State-approved CWS MMM program. This approach is intended to encourage States, Tribes, and CWSs to reduce the health risk of radon in the most cost-effective way. The Agency is also proposing a maximum contaminant level (MCL) for radon-222, to apply to CWSs in non-MMM States that choose not to implement a CWS MMM program. The proposal also includes monitoring, reporting, public notification, and consumer confidence report requirements for radon-222 in drinking water.

DATES: EPA must receive public comments, in writing, on the proposed regulations by January 3, 2000.

ADDRESSES: You may send written comments to the Radon-222, W–99–08 Comments Clerk, Water Docket (MC–4101); U.S. Environmental Protection Agency; 401 M Street, SW., Washington, DC 20460. Comments may be hand-delivered to the Water Docket, U.S. Environmental Protection Agency; 401 M Street, SW., East Tower Basement, Washington, DC 20460. Comments may be submitted electronically to *owdocket@epamail.epa.gov*. Electronic comments must be submitted as an ASCII, WP6.1, or WP8 file avoiding the use of special characters and any form of encryption. Electronic comments must be identified by the docket number W–99–08. Comments and data will also be accepted on disks in WP6.1, WP8, or ASCII format. Electronic comments on this action may be filed online at many Federal Depository libraries.

Please submit a copy of any references cited in your comments. Facsimiles (faxes) cannot be accepted. EPA would appreciate one original and three copies of your comments and enclosures (including any references). Commenters who would like EPA to acknowledge receipt of their comments should include a self-addressed, stamped envelope.

The proposed rule and supporting documents, including public comments, are available for review in the Water Docket at the address listed previously. The Docket also has several of the key supporting documents electronically available as PDF files. For information on how to access Docket materials, please call (202) 260–3027 between 9 a.m. and 3:30 p.m. Eastern Time, Monday through Friday.

FOR FURTHER INFORMATION CONTACT: For general information on radon in drinking water, contact the Safe Drinking Water Hotline, phone (800) 426–4791. The Safe Drinking Water Hotline is open Monday through Friday, excluding Federal holidays, from 9 a.m. to 5:30 p.m. Eastern Time. For technical inquiries regarding the proposed regulations, contact Sylvia Malm, Office of Ground Water and Drinking Water, U.S. Environmental Protection Agency (mailcode 4607), 401 M Street, SW, Washington DC, 20460. Phone: (202) 260–0417. E-mail: *malm.sylvia@epa.gov*. For inquiries regarding the proposed multimedia mitigation program, contact Anita Schmidt, Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, (mailcode 6609J), 401 M Street, S.W, Washington, DC, 20460. Phone: (202) 564–9452. E-mail: *schmidt.anita@epa.gov*. For general information on radon in indoor air, contact the Radon Hotline at 1–800–SOS–RADON (1–800–767–7236).

SUPPLEMENTARY INFORMATION:

Potentially Regulated Entities

Potentially regulated entities include community water systems using ground water or mixed ground and surface water.

The following table lists potentially regulated entities. This table is not intended to be exhaustive, but rather provides a guide for readers regarding entities likely to be regulated by this action. This table lists the types of entities that EPA is now aware of that could potentially be regulated by this action. Other entities not listed in the table could also be regulated. To determine whether your organization is affected by this action, you should carefully examine the proposed applicability criteria in section 40 CFR parts 141.20(b)(1) and Section IV of the preamble. If you have questions regarding the applicability of this action to a particular entity, consult Sylvia Malm who is listed in the preceding **FOR FURTHER INFORMATION CONTACT** section.

Category	Examples of potentially regulated entities
Industry	Privately owned/operated community water supply systems using ground water or mixed ground water and surface water.
State, Tribal, and Local Government.	State, Tribal, or local government-owned/operated water supply systems using ground water or mixed ground water and surface water.
Federal Government.	Federally owned/operated community water supply systems using ground water or mixed ground water and surface water.

Abbreviations Used in This Proposal

AMCL: Alternative Maximum Contaminant Level
BAT: Best Available Technology
BEIR: Committee on the Biological Effects of Ionizing Radiation. The Committee on Health Risks of Exposure on Radon that conducted the National Research Council Biological Effects of Ionizing Radiation (BEIR) VI Study (NAS 1999a). The committee is formed by the Radiation Effect Research/ Commission on Life Sciences/ National Research Council/National Academy of Sciences.
CFR: Code of Federal Regulations
CWS: Community Water System
EF: Equilibrium Factor
EPA: U.S. Environmental Protection Agency
FR: Federal Register
GAC: Granular Activated Carbon

HRRCA: Health Risk Reduction and Cost Analysis
IOC: Inorganic Contaminant
LSC: Liquid Scintillation Counting
MCL: Maximum Contaminant Level
MCLG: Maximum Contaminant Level Goal
MMM: Multimedia Mitigation
NAS: National Academy of Sciences
NAS Radon in Drinking Water Committee: The Committee on Risk Assessment of Exposure to Radon of the Drinking Water that conducted the National Research Council Risk Assessment of Radon in Drinking Water Study (NAS 1999b). The committee is formed by the Board of Radiation Effect Research of the Commission on Life Sciences of the National Research Council, National Academy of Sciences.
NELAC: National Environmental Laboratory Accreditation Conference
NIST: National Institute of Standards and Technology
NIRS: National Inorganics and Radionuclides Survey
NPDWR: National Primary Drinking Water Regulation
NPRM: Notice of Proposed Rulemaking
NTNC: Non-Transient, Non-Community
OGWDW: Office of Ground Water and Drinking Water
OMB: Office of Management and Budget
PBMS: Performance-Based Measurement System
PE: Performance Evaluation
PT: Proficiency Testing
POE: Point-of-Entry
POU: Point-of-Use
PRA: Paperwork Reduction Act
PWS: Public Water System
pCi/L: Picocuries per Liter
RFA: Regulatory Flexibility Act
SAB: Science Advisory Board
SBA: Small Business Administration
SBO: Small Business Ombudsman
SBREFA: Small Business Regulatory Enforcement and Fairness Act
SDWA: Safe Drinking Water Act
SDWIS: Safe Drinking Water Information System
SIRG: State Indoor Radon Grant
SSCT: Small Systems Compliance Technology
SSVT: Small Systems Variance Technology
SMF: Standardized Monitoring Framework
UMRA: Unfunded Mandates Reform Act
URTH: Unreasonable Risks to Health
WL: Working Level
WLM: Working Level Month

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I. Summary: What Does Today's Proposed Rulemaking Mean for My Water System?

A. Why Is EPA Proposing To Regulate Radon in Drinking Water?

The proposed National Primary Drinking Water Regulation (NPDWR) for radon in drinking water is based on a multimedia approach designed to achieve greater risk reduction by addressing radon risks in indoor air, with public water systems providing protection from the highest levels of radon in their ground water supplies. The framework for this proposal is set out in the Safe Drinking Water Act as amended in 1996 (SDWA), which provides for a multimedia approach for addressing the public health risks from radon in drinking water and radon in indoor air from soil. This statutory-based framework reflects the characteristics uniquely specific to radon among drinking water contaminants: that the relative cost-effectiveness of reducing risk from exposure to this contaminant is substantially greater for a non-drinking water source of exposure—indoor air—than it is from drinking water. Accordingly, SDWA directs the Environmental Protection Agency (EPA) to promulgate a maximum contaminant level (MCL) for radon in drinking water, but also to make available a higher alternative maximum contaminant level (AMCL) accompanied by a multimedia mitigation (MMM) program to address radon risks in indoor air. Further, in setting the MCL, EPA is to take into account the costs and benefits of programs that control radon in indoor air (SDWA 1412(b)(13)(E)).

B. What Is Radon?

Radon's Physical Properties

Throughout this preamble, ''radon'' refers to the specific isotope radon-222. Radon is a naturally occurring gas formed from the radioactive decay of uranium-238. Low concentrations of uranium and its other decay products, specifically radium-226, occur widely in the earth's crust, and thus radon is continually being generated, even in soils in which there is no man-made radioactive contamination. Radon is colorless, odorless, tasteless, chemically inert, and radioactive. A portion of the radon released through radioactive decay moves through air or water-filled pores in the soil to the soil surface and enters the air, while some remains below the surface and dissolves in ground water (water that collects and flows under the ground's surface).

Because radon is a gas, when water that contains radon is exposed to the air, the radon will tend to be released into the air. Therefore, radon is usually present in only low amounts in rivers and lakes. If ground water is supplied to a house, radon in the water will tend to be released into the air of the house via various water uses. Thus presence of radon in drinking water supplies leads to exposure via both oral route (ingesting water containing radon) and inhalation route (breathing air containing both radon and radon decay products released from water used in the house such as for cooking and washing).

Radon itself also decays, emitting ionizing radiation in the form of alpha particles, and transforms into decay products, or ''progeny'' radioisotopes. It has a half-life of about four days and decays into short-lived progeny. Unlike radon, the progeny are not gases, and can easily attach to and be transported by dust and other particles in air. The decay of progeny continues until stable, non-radioactive progeny are formed. At each step in the decay process, radiation is released.

C. What Are the Health Concerns From Radon in Air and Water?

National and international scientific organizations have concluded that radon causes lung cancer in humans. The primary risk is lung cancer from radon entering indoor air from soil under homes. Tap water is a smaller source of radon in air; however, breathing radon released to air from household water uses also increases the risk of lung cancer, and consumption of drinking water containing radon presents a smaller risk of internal organ cancers, primarily stomach cancer.

In most cases, radon in soil under homes is the biggest source of exposure and radon from tap water will be a small source of radon in indoor air.

The U.S. Surgeon General has warned that indoor radon (from soil) is the second leading cause of lung cancer (USEPA 1988b). The National Academy of Sciences (NAS 1999a) estimates that radon from soil causes about 15,000 to 22,000 (using two different approaches) lung cancer deaths each year in the U.S. If you smoke and your home has high indoor radon levels, your risk of lung cancer is especially high. EPA and the U.S. Surgeon General recommend testing all homes below the third floor.

The NAS report mandated by the 1996 SDWA identifies the same unit risk associated with radon in drinking water compared with previous EPA analyses. Based on the NAS risk assessment and an updated EPA occurrence analysis, the Agency estimates that uncontrolled levels of radon in public drinking water supplies cause 168 fatal cancers each year in the U.S. However, radon in domestic drinking water generally contributes a very small part (about 1–2 percent) of total radon exposure from indoor air. The NAS estimated that about 89 percent of the fatal cancers caused by radon in drinking water were due to lung cancer from inhalation of radon released to indoor air, and about 11 percent were due to stomach cancer from consuming water containing radon (NAS 1999b).

D. Does This Regulation Apply to My Water System?

The regulation for radon in drinking water and the multimedia approach proposed in this action would apply to all community public water systems (CWSs) that use ground water or mixed ground and surface water. The proposed regulation would not apply to non-transient non-community (NTNC) public water supplies, nor to transient public water supplies.

E. How Will This Regulation Protect Public Health?

Given the much greater potential for risk reduction in indoor air and years of experience with radon mitigation programs, EPA expects that greater overall risk reduction will result from this proposal than from an approach which solely addresses radon in public drinking water supplies. The proposed regulation for radon in drinking water is intended to promote a more cost-effective multimedia approach to reduce radon risks, particularly for small systems with limited resources, and to reduce the highest levels of radon in drinking water. This determination to have a strong and effective multimedia radon program to address radon in indoor air is consistent with the SDWA framework for multimedia radon programs and the SDWA expectation that EPA would give significant weight to the risk findings of the NAS report, which confirm the health risks of radon in drinking water, and the much greater risks from radon in indoor air arising from soil under homes.

F. How Will the Multimedia Mitigation (MMM) Program Work?

The multimedia mitigation (MMM) program is modeled on the National Indoor Radon Program implemented by EPA, States and others. That program has achieved substantial risk reduction through voluntary public action since the release of the original ‘‘A Citizen’s Guide to Radon’’ in 1986 (USEPA 1986, 1992b) and the U.S. Surgeon General’s recommendation in 1988 that all homes be tested and elevated levels be reduced. The program has been successful in achieving indoor radon risk reduction through a variety of program strategies, which form the basis for EPA’s proposed multimedia mitigation program plan criteria. Based on the estimated number of existing homes fixed and the number of new homes built radon-resistant since the national program began in 1986, EPA estimates that under existing Federal and State indoor radon programs, a total of more than 2,500 lives will be saved through indoor radon risk reduction efforts expected to take place through the year 2000. Every year the rate of lives saved increases as more existing houses with elevated radon levels are fixed and as more new houses are built radon-resistant. For the year 2000, EPA estimates that the rate of radon-related lung cancer deaths that will be avoided from mitigation of existing homes and from homes built radon-resistant (in high radon areas) will be about 350 lives saved per year (USEPA 1999i).

The MMM/AMCL approach is intended to provide a more cost-effective alternative to achieve radon risk reduction, by allowing States (or community water systems) to address radon in indoor air from the soil source, while reducing the highest levels of radon in drinking water. It is EPA’s expectation that most States will develop State-wide multimedia mitigation programs as the most cost-effective approach. Most of the States currently have indoor radon programs that are addressing radon risk from soil, and can be used as the foundation for development of MMM program plans. EPA expects that State indoor radon programs will implement MMM programs under agreements with the State drinking water programs. The regulatory expectation of community water systems serving 10,000 persons or less is that they meet the alternative maximum contaminant level (AMCL) and be associated with an approved MMM program plan—either developed by the State and approved by EPA or developed by the CWS and approved by the State. Tribal CWS MMM programs, as well as those in States and Territories that do not have drinking water primacy, will be approved by EPA. The same general criteria for State MMM program plans would apply to CWSs in developing local MMM programs in States that do not have such a program, albeit with a local perspective on such criteria and commensurate with the unique attributes of small CWSs. EPA expects that MMM program strategies for CWSs will be less comprehensive than those of State MMM programs, and will need to reflect the local character of the community served by the CWS. Strong public participation in the development of the CWS MMM program plans will help to ensure this, as well as community support for the MMM program. Figures I.1 and I.2 provide a conceptual model for the MCL, AMCL, and MMM programs for small and large systems.

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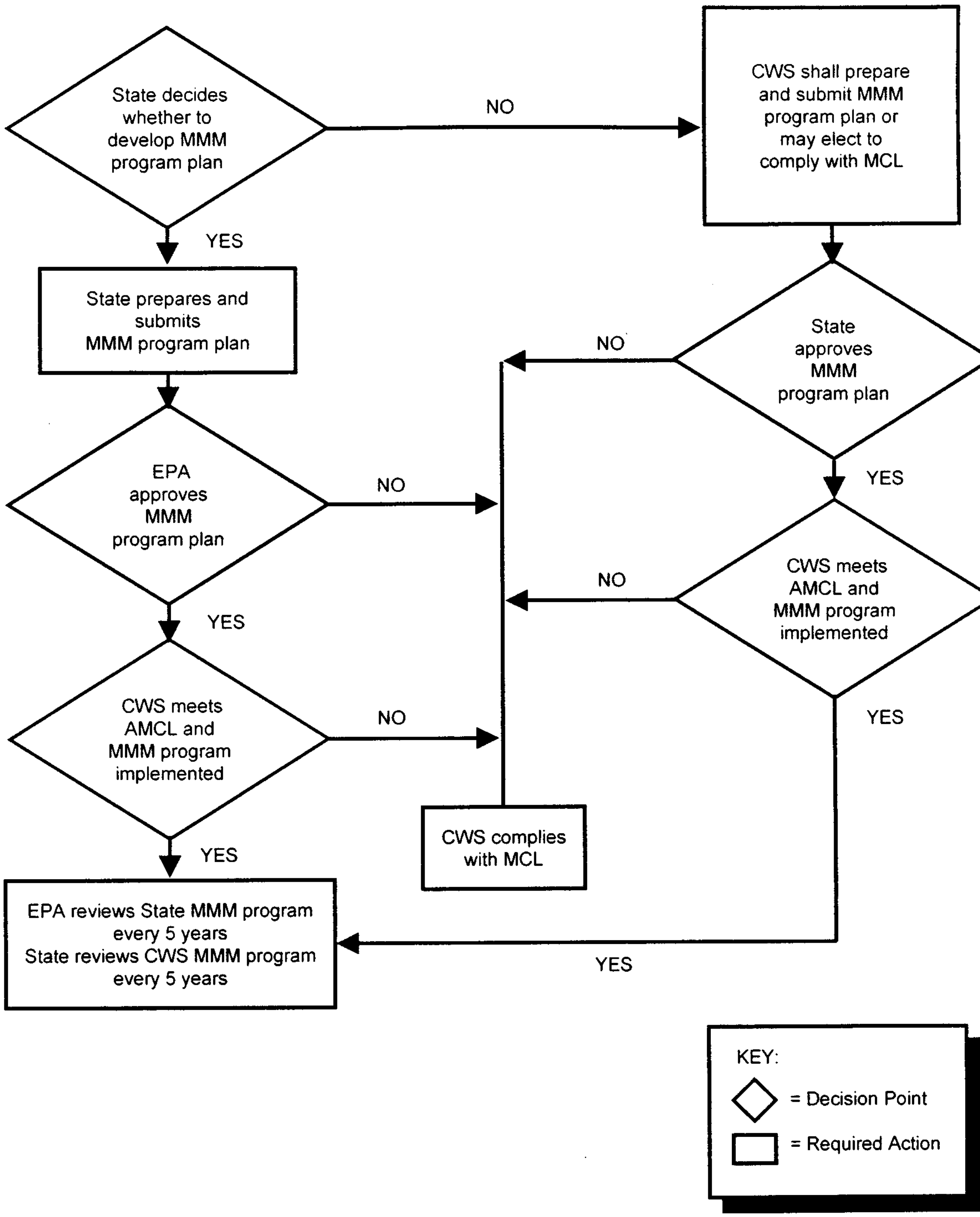
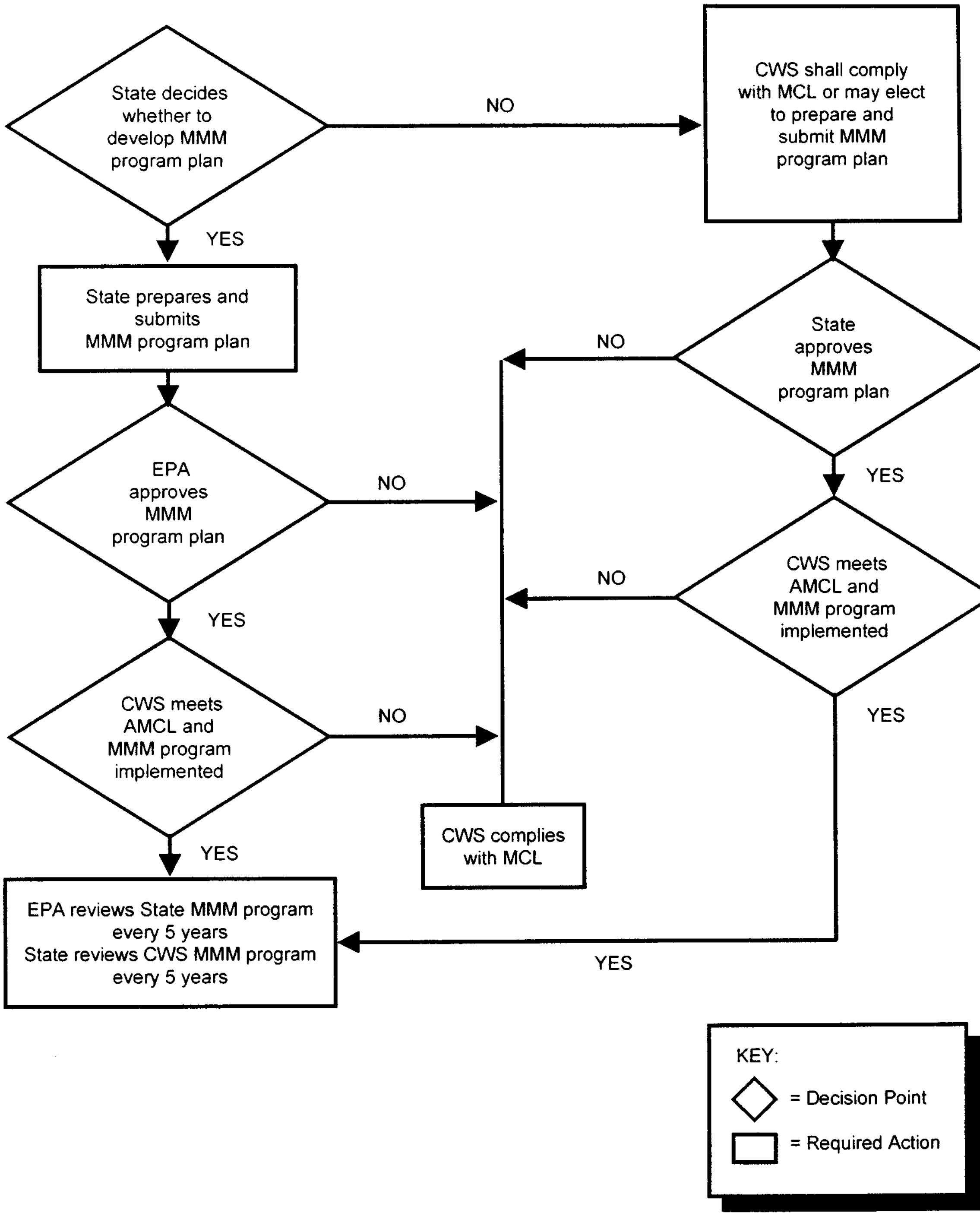
FIGURE I.1
Conceptual Model for the MCL, AMCL, and MMM Program (Small Systems)



NOTE: The regulatory expectation for small systems is compliance with the AMCL if there is an approved State MMM program, or implementation of a CWS MMM program (in the absence of a State MMM program. Small systems may elect to comply with the MCL instead of implementing an MMM program.

FIGURE I.2
Conceptual Model for the MCL, AMCL, and MMM Program
(Large Systems)



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To meet the requirements of SDWA, the risk reduction benefits expected to be achieved by MMM programs are to be equal to or greater than risk reduction benefits that would be achieved by CWSs complying with the MCL. Under SDWA, this means that if all States implemented MMM programs they would be expected to result in about 62 cancer deaths averted annually, equal to what would be achieved with universal compliance with the MCL at 300 pCi/L. Unlike health risk reduction benefits gained through water treatment, which remain constant from one year to the next, the rate of health benefits from reducing indoor radon is cumulative; that is, it steadily increases every year with every additional existing home that is mitigated and with every new home built radon-resistant. Therefore, MMM programs will use and build on the indoor radon program framework to achieve ''equal or greater'' risk reduction, rather than focusing efforts on precisely quantifying ''equivalency'' to the much more limited risk reduction expected to occur if community water systems complied with the MCL.

G. What Are the Proposed Limits for Radon in Drinking Water?

The proposed regulation provides that States may adopt State-wide MMM programs and the alternative maximum contaminant level (AMCL) of 4000 pCi/L. This is the most effective approach for radon risk reduction and the one EPA expects the majority of States to adopt. If a State has an EPA-approved MMM program plan, CWSs in that State may comply with the AMCL. In the absence of an approved State MMM program plan the regulatory expectation for small CWSs (those serving 10,000 or fewer) is that they comply with a level of 4000 pCi/L in drinking water, and develop and implement a State-approved local MMM program plan to reduce indoor radon risks arising from soil and rock under homes and buildings. Small CWSs may also choose to comply with the MCL of 300 pCi/L (and not develop a local MMM program.)

The AMCL/MMM approach is EPA's regulatory expectation for small CWSs because an MMM program and compliance with the AMCL is a much more cost-effective way to reduce radon risk than compliance with the maximum contaminant level (MCL) of 300 pCi/L. (While EPA believes that the MMM approach is preferable for small systems in a non-MMM State, small CWSs may, at their discretion, choose the option of meeting the MCL instead of developing a local MMM program). Large CWSs (serving a population of more than 10,000) must either comply with the proposed MCL or comply with the AMCL and implement a State-approved CWS MMM program plan (in the absence of an approved State MMM program plan).

If a State has an approved MMM program plan, the standard for radon in drinking water that the State would adopt in order to obtain primacy would be 4000 pCi/L.

Under the proposed requirements, an MMM program plan must address four criteria:

1. Public involvement in development of the MMM program plan
2. Quantitative goals for existing homes fixed and new homes built radon-resistant
3. Strategies for achieving goals
4. Plan to track and report results

CWSs must monitor for radon in drinking water according to the requirements described in Section VIII of this preamble, and report their results to the State. If the State determines that the radon level in a CWS is below 300 pCi/L, the system need only continue to meet monitoring requirements and is not covered by the requirements described in Section VI of this preamble, regarding MMM programs.

H. What Is the Proposed Best Available Technology (BAT) for Treating Radon in Drinking Water?

Proposed BAT for Radon Under Section 1412 of the SDWA

High-performance aeration, as described in Section VIII.A of this preamble, is the BAT for all systems. For systems serving 10,000 persons or fewer, the BAT is high-performance aeration and the Small Systems Compliance Technologies, as described in Section VIII.A.

Proposed BAT for Radon Under Section 1415 of the SDWA

BAT for purposes of variances is the same as BAT under Section 1412 of the Act.

I. What Analytical Methods Are Recommended?

EPA is proposing Liquid Scintillation Counting (Standard Method 7500–Rn) and de-emanation (''Lucas Cell'') as the approved methods. The Liquid Scintillation Counting method designated ''D 5072–92'' by the American Society for Testing and Materials (ASTM) is being proposed as an alternate method.

J. Where and How Often Must I Test My Water for Radon?

All CWSs that use ground water must monitor for radon. If your system relies on ground water or uses ground water to supplement surface water during low-flow periods, you must monitor for radon. If you are required to monitor for radon you must collect samples for analysis at each entry point to the distribution system, after treatment and storage. Initially all CWSs using ground water must monitor for radon at each entry point to the distribution system quarterly for one year. (See Section VII.E for discussion of compliance dates). If the results of analyses show that the average of all first year samples at any sample site is above the MCL/AMCL, you must continue monitoring quarterly at that sampling site until the average of four consecutive quarterly samples is below the MCL/AMCL. If the results of analyses show that the average of all first year samples at each sample site is below the MCL/AMCL, you may reduce monitoring to once a year at State discretion at each sample site. If the results indicate that the average of the four quarterly samples are close to the MCL/AMCL (as discussed next), the State may require you to continue monitoring quarterly.

The State may allow you to reduce monitoring for radon to a frequency of once every three-years, if the average from four consecutive quarterly samples is less than ½ the MCL/AMCL and the State determines that your system is reliably and consistently below the MCL/AMCL. However, if a sample collected while monitoring annually or less frequently exceeds the radon MCL/AMCL, the monitoring frequency must be increased to quarterly until the average of 4 consecutive quarterly samples is less than the MCL/AMCL. The State may require the collection of a confirmation sample(s) to verify the result of the initial sample. In the case of reduced monitoring, if the analytical results from any sampling point are found to exceed ½ the MCL/AMCL, the State may require you to collect a confirmation sample at the same sampling point. The results of the initial sample and the confirmation sample(s) will be averaged and the resulting average will be used to determine compliance. States may, at their discretion, disregard samples that have obvious sampling errors.

If, after initial monitoring, the State determines that it is highly unlikely that radon levels in your system will be above the MCL/AMCL, the State may grant a waiver reducing monitoring frequency to once every nine years. In granting the waiver, the State must take into consideration factors such as the geological area of the source water and previous analytical results which demonstrate that radon levels do not occur above the MCL/AMCL. If you are granted a waiver, it remains in effect for a nine year period.

If you monitor for radon after proposal of this rule, you may use the data, at the State's discretion, toward satisfying the initial sampling requirements for radon. Your monitoring program and the methods used to analyze for radon must satisfy the regulations set out in the proposal.

K. May I Use Point-of-Use (POU) Devices, Point-of-Entry (POE) Devices, or Bottled Water To Comply With This Regulation?

POE aeration or granular activated carbon (GAC) would be allowable for use to achieve compliance with MCLs. While these POE technologies are not considered BAT for large systems, they are considered small system compliance technologies (SSCTs), and thus may serve as BAT under Sections 1412 and 1415 of the Act for systems serving 10,000 persons or fewer. Since POU devices are used to treat water at a single tap, radon will be released at unacceptable levels from the other non-treated taps, including the shower head. For this reason, POU devices do not adequately address radon risks and will not be allowed to be used for compliance purposes. Likewise, although bottled water reduces ingestion risk from radon, it does not reduce radon-related inhalation risks from household water. For this reason, compliance determinations based on bottled water consumption cannot be used.

L. May I Get More Time or Use a Cheaper Treatment? Variances and Exemptions

Variances and Exemptions (Section 1415.a of the SDWA)

States and Tribes with primary enforcement responsibility (''primacy'') may issue a variance under Section 1415(a)(1)(A) of the Act to a CWS that cannot comply with an MCL because of source water characteristics on condition that the system install the best available technology. Under Section 1416 of the Act, primacy entities may exempt a CWS from an NPDWR due to ''compelling factors'', subject to the restrictions described in the Act. Primacy entities may require systems to implement additional interim control measures such as installation of additional centralized treatment or POE devices for each customer as measures to reduce the health risk before granting a variance or exemption. The primacy entity must find that the variance or exemption will not pose an ''unreasonable risk to health'', as determined by the State or other primacy entity. Guidance for estimating ''unreasonable risk to health'' (URTH) values for contaminants, including radon, is being developed by EPA and will result in an upcoming publication (a draft of the guidance is expected in the Fall of 1999). Preliminary information regarding URTH values may be found elsewhere (Orme-Zavaleta 1992, USEPA 1998f). States must require CWSs to provide POE devices or other means, as appropriate to the risks present (i.e., no POU or bottled water for volatile contaminants, such as radon), to reduce exposure below unreasonable risk to health values before granting a variance or exemption.

''Small Systems Variances'' (Section 1415(e) of the SDWA)

For NPDWRs proposed after the 1996 Amendments to the Act, EPA is required to evaluate the affordability and technical feasibility of treatment technologies for use as compliance technologies for small systems. Three categories of small systems will be considered: those serving: (1) 25–500, (2) 501–3,300, and (3) 3,301–10,000 persons. If EPA determines that source water conditions exist for one or more small water system size categories such that typical small systems within a given category will not be able to afford and/or implement a technology capable of achieving compliance, then EPA will designate applicable ''small systems variance technologies'' (SSVTs) capable of achieving contaminant levels that are ''protective of public health''. Primacy entities may issue small systems variances to eligible CWSs that install and properly maintain a listed SSVT. For a small system to be eligible for a small systems variance, the primacy entity must determine that the system cannot afford to comply through installing treatment, finding an alternate source of water, or restructuring/consolidating.

EPA has determined that affordable and technically feasible technologies exist for radon removal for all classes of small systems. Under the 1996 SDWA, if EPA lists at least one small systems compliance technology for a given system size category for all source water qualities, then it may not list any small systems variance technologies for that size category, *i.e.*, small systems compliance technologies and variance technologies are mutually exclusive. For this reason, no small system will be eligible for a small systems variance for radon under the SDWA (Section 1415(e)). Small systems may be eligible for general variances (under Section 1415.a of the Act) and/or exemptions on a case by case basis. It is also important to emphasize that the presumptive regulatory expectation for small systems is an MMM program (in the absence of a State MMM program) and compliance with the AMCL of 4000 pCi/L. Thus, for the vast majority of small systems (those with radon levels below 4000 pCi/L), compliance with this proposed rule will not involve any treatment of drinking water.

M. What Are State Primacy, Record Keeping, and Reporting Requirements?

The proposed Radon Rule requires States to adopt several regulatory requirements, including public notification requirements, MCL/AMCL for radon, and the requirements of Subpart R in the proposed rule. In addition, States and eligible Indian tribes will be required to adopt several special primacy requirements for the Radon Rule. The proposed rule includes additional reporting requirements for MMM program plans. The proposed rule also requires States to keep specific records in accordance with existing regulations. These requirements are discussed in more detail in Section IX of this preamble.

N. How Are Tribes Treated in This Proposal?

The proposal provides Tribes the option of seeking ''treatment in the same manner as a State'' for the purposes of assuming enforcement responsibility for a CWS program, and developing and implementing an MMM program (see Section VI.C). If a Tribe chooses not to implement an EPA-approved MMM program, any tribal CWS may develop an MMM plan for EPA approval, under the same criteria described in Section VI.A.

Statutory Requirements and Regulatory History

II. What Does the Safe Drinking Water Act Require the EPA To Do When Regulating Radon in Drinking Water?

The 1996 Amendments to the Safe Drinking Water Act (PL 104–182) establish a new charter for public water systems, States, Tribes, and EPA to protect the safety of drinking water supplies. (For an overview of the general requirements for all drinking water regulations, see Section XVI of this preamble). Among other mandates, Congress amended Section 1412 of the SDWA to direct EPA to take the following actions regarding radon in drinking water.

A. Withdraw the 1991 Proposed Regulation for Radon

Congress specified that EPA should withdraw the drinking water standards proposed for radon in 1991 (see discussion in Section III.D).

B. Arrange for a National Academy of Sciences Risk Assessment

The amendments in Section 1412(b)(13)(B) require EPA to arrange for the National Academy of Sciences (NAS) to conduct an independent risk assessment for radon in drinking water and an assessment of the health risk reduction benefits from various mitigation measures to reduce radon in indoor air.

C. Set an MCLG, MCL, and BAT for Radon-222

Congress specified in Section 1412 (b)(13) that EPA should propose a new MCLG and NPDWR for radon-222 by August, 1999. EPA is also required to finalize the regulation by August, 2000. As a preliminary step, EPA was required to publish a radon health risk reduction and cost analysis (HRRCA) for possible radon MCLs for public comment by February, 1999. As required by SDWA, this analysis addressed: (1) Health risk reduction benefits that come directly from controlling radon; (2) health risk reduction benefits likely to come from reductions in contaminants that occur with radon; (3) costs; (4) incremental costs and benefits associated with each MCL considered; (5) effects on the general population and on groups within the general population likely to be at greater risk; (6) any increased health risk that may occur as the result of compliance; and (7) other relevant factors, including the quality and extent of the information, the uncertainties in the analysis, and factors with respect to the degree and nature of the risk.

D. Set an Alternative MCL (AMCL) and Develop Multimedia Mitigation (MMM) Program Plan Criteria

The amendments in Section 1412(b)(13)(F) introduced two new elements into the radon in drinking water rule: (1) An Alternative Maximum Contaminant Level (AMCL), and (2) radon multimedia mitigation (MMM) programs. If the MCL established for radon in drinking water is more stringent than necessary to reduce the contribution to radon in indoor air from drinking water to a concentration that is equivalent to the national average concentration of radon in outdoor air, EPA is required to simultaneously establish an AMCL. The AMCL would be the standard that would result in a contribution of radon from drinking water to radon levels in indoor air equivalent to the national average concentration of radon in outdoor air. If an AMCL is established, EPA is to publish criteria for State multimedia mitigation (MMM) programs to reduce radon levels in indoor air. Section VI of this preamble describes what a State or public water system must have in their multimedia mitigation program plan.

E. Evaluate Multimedia Mitigation Programs Every Five Years

Once the MMM programs are established, EPA must re-evaluate them no less than every five years (Section 1412(b)(13)(G)). EPA may withdraw approval of programs that are not expected to continue to meet the requirement of achieving equal or greater risk reduction.

III. What Actions Has EPA Taken on Radon in Drinking Water Prior to This Proposal?

A. Regulatory Actions Prior to 1991

Section 1412 of the SDWA, as amended in 1986, required the EPA to publish Maximum Contaminant Level Goals (MCLGs) and to promulgate NPDWRs for contaminants that may cause an adverse effect on human health and that are known or anticipated to occur in public water supplies. On September 30, 1986, EPA published an advance notice of proposed rulemaking (ANPRM) (51 FR 34836) concerning radon-222 and other radionuclides. The ANPRM discussed EPA's understanding of the occurrence, health effects, and risks from these radionuclides, as well as the available analytical methods and treatment technologies, and sought additional data and public comment on EPA's planned regulation.

EPA's Science Advisory Board (SAB) reviewed the ANPRM and the four draft criteria documents that supported it prior to publication of the ANPRM in the **Federal Register**. EPA subsequently revised the criteria documents and resubmitted them to the SAB for review during the summer of 1990. EPA then revised the criteria documents based on this additional round of SAB review and presented a summary of the SAB comments and the Agency's responses in a 1991 Notice of Proposed Rulemaking (NPRM).

B. The 1991 NPRM

On July 18, 1991 (56 FR 33050), EPA proposed a NPDWR for radon and the other radionuclides addressed in the 1986 ANPRM. The 1991 notice, which built on and updated the information assembled for the 1986 ANPRM, proposed an MCLG, an MCL, BAT, and monitoring, reporting, and public notification requirements for radon in public water supplies. The proposed MCLG was zero, the proposed MCL was 300 pCi/L, and the proposed BAT was aeration. Under the proposed rule, all CWSs and NTNCWSs relying on ground water would have been required to monitor radon levels quarterly at each point of entry to the distribution system. Compliance monitoring requirements were based on the arithmetic average of four quarterly samples. The 1991 proposed rule required systems with one or more points of entry out of compliance to treat influent water to reduce radon levels below the MCL or to secure water from another source below the MCL.

The proposed rule was accompanied by an assessment of regulatory costs and economic impacts, as well as an assessment of the risk reduction associated with implementation of the MCL. EPA estimated the following potential impacts from the 1991 proposed MCL:

- An estimated lifetime cancer risk of about two cancers for every 10,000 persons exposed to radon in drinking water.
- Avoidance of about 80 cancer cases per year.
- About 27,000 public water systems affected.
- A total annual cost of about $180 million.

The Agency received substantial comments on the proposal and its supporting analyses from States, water utilities, and other stakeholder groups. EPA has included in Appendix I of this preamble a summary of major public comments on the 1991 NPRM and how EPA subsequently addressed those comments.

C. 1994 Report to Congress: Multimedia Risk and Cost Assessment of Radon

In 1992, Congress directed EPA to report on the multimedia risks from exposure to radon, the costs to control this exposure, and the risks from treating to remove radon. EPA's 1994 Report to Congress (USEPA 1994a) estimates the risk, fatal cancer cases, cancer cases avoided and costs for mitigating radon in water and in indoor air. The Report found that cancer risks from radon in both air and water are high. While radon risk in air typically far exceeds that in water, the cancer risk from radon in water is higher than the cancer risk estimated to result from any other currently regulated drinking water contaminant.

EPA conducted a quantitative uncertainty analysis of the risks associated with exposure to radon in drinking water. This analysis, reviewed by EPA's SAB at the direction of Congress, found that:

- People are exposed to waterborne radon in three ways: (1) From ingesting radon dissolved in water; (2) from inhaling radon gas released from water during household use; and (3) from inhaling radon progeny derived from radon released from water.
- The estimated total U.S. cancer fatalities per year from unregulated waterborne radon via all three routes of exposure were 192, with a range from about 51 to 620.
- The estimated annual cost was $272 million.

The 1994 Report to Congress noted that the regulated industry estimated considerably higher costs than EPA for a 300 pCi/L MCL. For example, in October 1991 the American Water Works Association (AWWA) estimated national costs at $2.5 billion/year (for discussion of this issue, see Section G of the Appendix to this preamble). The final part of the report included the SAB's comments on each analysis presented and an EPA discussion of the issues raised by the SAB.

D. 1997 Withdrawal of the 1991 NPRM for Radon-222

As required by the SDWA as amended, EPA withdrew the MCLG, MCL, and monitoring, reporting, and public notification requirements proposed in 1991 for radon-222 on August 6, 1997 (62 FR 42221). No other provision of the 1991 proposal was affected by this withdrawal.

E. 1998 SBREFA Small Business Advocacy Review Panel for Radon

In 1998, EPA convened a Small Business Advocacy Review Panel to address the radon rule, in accordance with the Regulatory Flexibility Act (RFA) as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA). The Panel of representatives from EPA, the Office of Management and Budget's Office of Information and Regulatory Affairs, and the Small Business Administration's Office of Advocacy reviewed technical background information related to this rulemaking, and reviewed comments provided by small business and government entities affected by this rule. The Panel made recommendations in a final report to the Administrator which included a discussion of how the Agency could accomplish its environmental goals while minimizing impacts to small entities. For additional details, see Section XIV.B of this proposal.

F. 1999 HRRCA for Radon in Drinking Water

EPA published the Health Risk Reduction and Cost Analysis required by the SDWA on February 26, 1999 (64 FR 9559), and took public comment for 45 days. EPA held a one-day public meeting in Washington, D.C. on March 16, 1999, to present the HRRCA and the latest MMM framework, and discuss stakeholder questions and issues. For details of the contents of the HRRCA and EPA's response to significant public comment, see Section XIII of this preamble.

Requirements

IV. To Which Water Systems Does This Regulation Apply?

The SDWA directs EPA to develop national primary drinking water regulations (NPDWRs) that apply to public water systems (PWSs). The statute defines a PWS as a system that provides water to the public for human consumption if such system has at least 15 service connections or regularly serves at least 25 individuals (Section 1401(4)(A)). EPA's regulations at 40 CFR 141.2 define different types of PWSs. A community water system (CWS) serves at least 15 service connections used by year round residents or regularly serves at least 25 year-round residents. A non-community system does not serve year-round residents; rather, it (1) regularly serves at least 25 of the same persons over 6 months of the year (a ''non-transient'' system such as a restaurant or church) or (2) does not serve at least 25 of the same persons over 6 months of the year (a ''transient'' system such as a campground or service station).

The regulation for radon in drinking water and the multimedia approach for reduction of radon in indoor air (MMM program) proposed in this notice applies only to CWSs that use ground water or mixed ground and surface water (see following discussion regarding ''mixed'' supplies). The proposed regulation does not apply to transient water systems because most people who use such facilities do so only occasionally (*e.g.*, travelers). There is no evidence that such short-term exposure to radon would cause acute illness. The data on which health risks from radon were determined for this rulemaking reflect long-term exposure (see chapter 3 of the RIA (USEPA 1999f) HRRCA section that discusses calculation of risk). And, as discussed next in the context of non-transient non-community systems, even workers at transient facilities who regularly drink the water would be expected to have much less exposure than persons served by community water systems. For these reasons, the proposed rule does not cover transient systems.

The proposed regulation also does not apply to non-transient non-community (NTNC) water systems. EPA has determined that the risks posed to persons served by NTNC systems (such as factories, hospitals, and schools with their own drinking water wells) are substantially less than the risks to persons served by community water systems.

The Agency recently completed a preliminary analysis of radon occurrence (using data provided by six States), exposure and risk at NTNC public water systems. Results from this preliminary analysis indicate that even though radon concentrations are likely to be about 60 percent higher at NTNC locations than at locations served by a community water system, the lifetime average risk to individuals who work or attend school in buildings served by a groundwater-based NTNC system is probably about 17 percent of the average risk to a worker (and 6.7 percent of the average risk to a student) exposed in a home served by a community ground water system. The reason that risks are lower in the NTNC setting than the residential setting is that people who are exposed at NTNC locations spend a smaller fraction of their lifetime there than in the home. Further, in the particular case of students most do not spend their entire school years in the same school. EPA also notes that there is limited data in this area, and more information is needed on how water is used in NTNC facilities and on the contribution NTNC water use makes to radon inhalation risk. In addition, the overall population served by NTNC PWSs is relatively small (5.2 million vs. 89.7 million in homes served by CWSs using ground water (USEPA 1999b)).

EPA acknowledges that the SDWA applies to all public water systems. However, EPA believes that limiting the applicability of the radon rule to community water systems where the risk from radon exposure is the greatest meets a major goal of Congress in enacting the 1996 amendments to the Act-to focus regulations on the most significant problems. In the Conference Report adopting the 1996 amendments, Congress finds that ''more effective protection of public health requires—a Federal commitment to set priorities that will allow scarce Federal, State, and local resources to be targeted toward the drinking water problems of greatest public health concerns. '' H. Rep. 104–182, Sec. 3. Moreover, Congress specifically directed EPA in setting the NPDWRs for radon to take into consideration the costs and benefits of control programs for radon from other sources. EPA has used this authority in this proposal to set the MCL at 300 pCi/L and to encourage small systems to implement the MMM program and comply with the AMCL. In both circumstances, EPA took into account the fact that programs to control radon in indoor air promise greater benefits at considerably less cost. EPA believes this cost-effectiveness factor is also relevant in determining the applicability of the radon rule. EPA's preliminary analysis of the risk associated with exposure to radon from NTNC systems is that it is much less than the risk from exposure from CWSs. For this reason, EPA has determined that it is not cost-effective to regulate these systems.

However, it is important to note that this analysis is based on limited occurrence and exposure data. In particular, relatively little is known about the transfer factor for release of radon from water into indoor air at NTNC locations, or about the equilibrium factor affecting the amount of radon in indoor air at such locations. The calculations done by EPA to date have assumed that certain values for these parameters at NTNC locations are similar to those in homes, although the data are limited.

The EPA is soliciting comment on the proposal to exclude NTNC PWSs from the radon regulation. EPA is soliciting comments on the Agency's preliminary analysis of radon exposure in NTNC PWSs, as well as any additional data on key parameters, including data on the release of radon from drinking water in the types of buildings (*e.g.*, restaurants, factories, churches, etc.) supplied by NTNC PWSs, and occurrence of radon in NTNC PWSs. If information by commenters shows a greater opportunity for risk reduction than identified in its initial analysis, EPA may make the final radon rule applicable to NTNC PWSs without further public comment.

With regard to systems using mixed ground and surface water, current regulations require that all systems that use any amount of surface water as a source be categorized as surface water systems. This classification applies even if the majority of water in a system is from a ground water source. Data currently in SDWIS does not identify how many of these mixed systems exist although this information would help the Agency to better understand regulatory impacts. To the extent that systems correctly classified by SDWIS as surface water systems also use ground water that may exceed the MCL/AMCL for radon, the costs and benefits of the current proposal will be underestimated.

EPA is investigating ways to identify how many mixed systems exist and how many mix their ground and surface water at the same entry point or at separate entry points within the same distribution systems. For example, a system may have several plants/entry points that feed the same distribution system. One of these entry points may mix and treat surface water with ground water prior to its entry into the distribution system. Another entry point might use ground water exclusively for its source while a different entry point would exclusively use surface water. However, all three entry points would supply the same system classified in SDWIS as surface water.

One method EPA could use to address this issue would be to analyze Community Water System Survey (CWSS) data then extrapolate this information to SDWIS to obtain a national estimate of mixed systems. CWSS data, from approximately 1,900 systems, breaks down sources of supply at the level of the entry point to the distribution system and further subdivides flow by source type. The Agency could use the national estimate of mixed systems to regroup surface water systems for certain impact analyses when regulations only impact one type of source. The Agency requests comment on this methodology and its applicability for use in regulatory impact analyses.

V. What Is the Proposed Maximum Contaminant Level Goal for Radon?

A. Approach To Setting the Maximum Contaminant Level Goal (MCLG)

Under Section 1412(b)(4) of the SDWA, the EPA must establish maximum contaminant level goals (MCLG) at the level at which no known or anticipated adverse effects on the health of persons occur, and which allow an adequate safety margin. Section 1412(b)(13) requires the Administrator to set an MCLG for radon in drinking water.

B. MCLG for Radon in Drinking Water

As described in Section XII of this preamble, radon is a documented human carcinogen, classified by EPA as a Group A carcinogen (*i.e.*, there is sufficient evidence of a causal relationship between exposure to radon and lung cancer in humans). Radon is classified as a known human carcinogen based on data from epidemiological studies of underground miners. This finding is supported by a consensus of opinion among national and international health organizations. The carcinogenicity of radon has been well established by the scientific community, including the Biological Effects of Ionizing Radiation (BEIR VI) Committee of the National Academy of Sciences (NAS 1999a), the National Institute of Environmental Health Sciences, U.S. Department of Health and Human Services, the World Health Organization's International Agency for Research on Cancer (IARC 1988), the International Commission on Radiological Protection (ICRP 1987), and the National Council on Radiation Protection and Measurement (NCRP 1984). In addition, the Centers for Disease Control, the American Lung Association, the American Medical Association, the American Public Health Association and others have recognized radon as a significant public health problem.

Based on the well-established human carcinogenicity of radon, and of ionizing radiation in general, the Agency is proposing an MCLG of zero for radon in drinking water. This decision is also supported by the NAS' current recommendation for a linear non-threshold relationship between exposure to radon and cancer in humans. In the BEIR VI report (NAS 1999a), the NAS concluded that there is good evidence that a single alpha particle (high-linear energy transfer radiation) can cause major genomic changes in a cell, including mutation and transformation that potentially could lead to cancer. They noted that even if substantial repair of the genomic damage were to occur, ''the passage of a single alpha particle has the potential to cause irreparable damage in cells that are not killed.'' Given the convincing evidence that most cancers originate from damage to a single cell, the committee went on to conclude that ''On the basis of these [molecular and cellular] mechanistic considerations, and in the absence of credible evidence to the contrary, the committee adopted a linear non-threshold model for the relationship between radon exposure and lung-cancer risk. However, the BEIR VI committee recognized that it could not exclude the possibility of a threshold relationship between exposure and lung cancer risk at very low levels of radon exposure.'' The NAS committee on radon in drinking water (NAS 1999b) reiterated the finding of the BEIR VI committee's comprehensive review of the issue, that a ''mechanistic interpretation is consistent with linear non-threshold relationship between radon exposure and cancer risk''. The committee noted that the ''quantitative estimation of cancer risk requires assumptions about the probability of an exposed cell becoming transformed and the latent period before malignant transformation is complete. When these values are known for singly hit cells, the results might lead to reconsideration of the linear no-threshold assumption used at present.'' EPA recognizes that research in this area is on-going but is basing its regulatory decisions on the best currently available science and recommendations of the NAS that support use of a linear non-threshold relationship. For additional information on this issue see Section XII.C.3. ''Biologic Basis of Risk Estimation'' of this preamble.

VI. What Must a State or Community Water System Have in Its Multimedia Mitigation Program Plan?

Today's proposed rule provides States (as defined in Section 1401 of the SDWA) with alternatives for controlling radon exposure. States can develop a MMM program for the reduction of the higher risk of radon in indoor air together with an alternative MCL (AMCL) of 4000 pCi/L to address the highest levels of exposure from radon in drinking water. If a State does not choose this option, the community water systems (CWS) in that State must develop and implement local MMM program plans or comply with an MCL of 300 pCi/L. See Section VII for information on the regulatory expectations for CWSs.

A. What Are the Criteria?

1. Overview

EPA has identified four criteria that State MMM program plans are required to meet to be approved by EPA. MMM program plans developed by Indian tribes will be reviewed by EPA, according to these same criteria. CWSs developing local MMM programs are also subject to these criteria. These four criteria are: public participation, setting quantitative goals, strategies for achieving goals, and a plan to track and report results.

The criteria are based on a number of factors. Foremost, the criteria reflect the elements found in successful voluntary action programs for radon in indoor air that have been underway for more than a decade. It is estimated that at the end of the year 2000, voluntary programs to test homes and mitigate elevated radon levels in indoor air and to encourage the construction of ''radon-resistant'' new homes will have saved some 2500 lives; and, there is much more that can be done. In the 1999 BEIR VI report (NAS 1999a), NAS concluded that 5,000 to 7,000 cancer cases (using two different methods) could be avoided annually if all homes were below EPA's voluntary radon action level of 4 pCi/L of air. Incorporating these program elements into the criteria required for the MMM programs builds on successful efforts and can be expected to result in an even greater number of lives saved as more States adopt programs and existing programs are strengthened and expanded.

EPA has developed criteria that allow considerable flexibility for those developing and expanding programs. EPA was urged by States and other stakeholders to avoid prescribing the specific elements of the MMM program in a ''one size fits all'' approach. States and CWSs adopting MMM programs will be required to set quantitative goals for mitigating elevated levels of radon in indoor air of existing homes and building radon-resistant new homes, and to initiate strategies to promote and increase these activities. However, there are requirements that will be new to many of the State indoor radon programs. Those adopting MMM programs will be required to involve the public in a number of important (and on-going) ways, and to track and report results from the implementation of the programs. With these additional elements, both the affected public and EPA will be able to assess the success of the MMM programs. Stakeholder input and EPA's experience with the national voluntary program and the State indoor radon programs led EPA to conclude that these criteria will provide the basis for a program that meets the statutory directive for equal or greater risk reduction benefits.

The Agency also considered equity-related issues concerning the potential impacts of MMM program implementation. There is no factual basis to indicate that minority and low income or other communities are more or less exposed to radon in drinking water than the general public. However, some stakeholders expressed more general concerns about equity in radon risk reduction that could arise from the MMM/AMCL framework outlined in SDWA. One concern is the potential for an uneven distribution of risk reduction benefits across water systems and society. Under the proposed framework for the rule, customers of CWSs complying with the AMCL could be exposed to a higher level of radon in drinking water than if the MCL were implemented, though this level would not be higher than the background concentration of radon in ambient air. However, these CWS customers could also save the cost, through lower water rates, of installing treatment technology to comply with the MCL. Under the proposed regulation, CWSs and their customers have the option of complying with either the AMCL (associated with a State or local MMM program) or the MCL. EPA believes it is important that these issues and choices be considered in an open public process as part of the development of MMM program plans. Therefore, EPA has incorporated requirements into the proposed rule that provide a framework for consideration of equity concerns with the MMM/AMCL. First, the proposed rule includes requirements for public participation in the development of MMM program plans, as well as for notice and opportunity for public comment. EPA believes that the requirement for public participation will result in State and CWS program plans that reflect and meet their different constituents' needs and concerns and that equity issues can be most effectively dealt with at the State and local levels with the participation of the public. In developing their MMM program plans, States and CWSs are required to document and consider all significant issues and concerns raised by the public. EPA expects and strongly recommends that States and CWSs pay particular attention to addressing any equity concerns that may be raised during the public participation process. In addition, EPA believes that providing CWS customers with information about the health risks of radon and on the AMCL and MMM program option will help to promote understanding of the health risks of radon in indoor air, as well as in drinking water, and help the public to make informed choices. To this end, EPA is requiring CWSs to alert consumers to the MMM approach in their State in consumer confidence reports issued between publication of the final radon rule and the compliance dates for implementation of MMM programs. This will include information about radon in indoor air and drinking water and where consumers can get additional information.

EPA is encouraging the States to elect to develop and implement State-wide MMM program plans. Since almost all States currently have State indoor radon programs, EPA considers the States to be best positioned to develop strong MMM program plans that, when implemented, will be expected to achieve equal or greater radon risk reduction when compared to compliance with the MCL. For example, a State-wide plan can take into account the within-State variations in indoor radon potential, the differences in radon levels in drinking water, the experienced coalitions and cooperative partners that have been working to promote public action on indoor radon, the technical expertise of State drinking water and indoor radon programs, and many other factors. EPA expects that the States will be best positioned to develop MMM program plans that are robust and credible in terms of the level of public participation in the development and review process, the goals that are to be achieved from implementation of MMM, and the program strategies to be used.

In the development of State MMM program plans meeting EPA's criteria and in the implementation of the State's MMM program plan, EPA expects and strongly recommends that the State's programs responsible for drinking water and for indoor radon coordinate and collaborate on their efforts. This is particularly important because of the uniqueness of the MMM/AMCL approach which addresses radon risk reduction in drinking water and in indoor air in a multimedia manner that is outside the normal regulatory structure for drinking water. Both programs have important responsibilities and roles in making the AMCL and MMM program approach successful in achieving optimal radon risk reduction. To this end, EPA has included as a special primacy requirement (see Section 142.16 of the proposed rule) that States include in their primacy revision application for the AMCL a description of the extent and nature of coordination between the State's interagency programs (*i.e.*, indoor radon and drinking water programs) on development and implementation of the MMM program plan, including the level of resources that will be made available for implementation and coordination between these agencies.

CWSs developing local MMM program plans are also subject to these criteria. CWS MMM program plans developed in the absence of a State program are deemed to be approved by EPA if they meet the same criteria and are approved by the State. States without a MMM program, as a special condition of primacy (see Section 142.16 of the proposed rule), will be required to review and approve local CWS MMM program plans and to submit their process for approving such plans to EPA. The Agency considered an approach under which it would directly review and approve CWS MMM program plans. However, for several reasons, EPA is proposing that States review local MMM program plans. EPA believes that responsibility for such reviews is an appropriate and natural extension of the States' primacy responsibilities for oversight and enforcement of drinking water regulations. State review and approval of local MMM program plans will ensure that all elements of the radon rulemaking—both the MMM program as well as implementation of the AMCL/MCL—are enforced through the State, rather than separating elements of the rule between the Federal and State governments. Dividing responsibility in such a way may complicate implementation of both elements of the radon rule and be confusing to both CWSs and the public. EPA also believes that the States are best positioned to assist CWSs, especially small systems, in the development of local MMM programs plans to review and approve local plans that meet the four criteria. States have a direct and ongoing regulatory relationship with CWSs as a part of their primacy authorities, as well as a major responsibility for public health related policy and programs in the State. In addition, States are aware of and sensitive to local public health needs and concerns, as well as other issues, that may need to be considered in the development and implementation of local MMM programs. For all these reasons, EPA is proposing an approach today that would require the States to review and approve local MMM program plans in accordance with the same criteria used in EPA's review of State MMM program plans. However, EPA solicits comments on other approaches, such as EPA review and approval of local MMM program plans or other options intermediate between sole State or sole Federal responsibility.

EPA anticipates, and recommends, that States would assist CWSs in developing their local MMM program plans and would approve program plans that meet the criteria and that reflect local radon implementation issues as discussed in Section VI.F. In non-MMM States, EPA is also including as a special primacy requirement that States include in their primacy revision application for the MCL a description of the extent and nature of coordination between interagency programs (*i.e.*, indoor radon and drinking water programs) on development and implementation of the State's review and approval process for CWS MMM program plans, including the level of resources will be made available for implementation and coordination between these agencies.

2. Criteria for MMM Program Plans

The following four criteria are required for approval of State MMM program plans by EPA. Local MMM program plans developed by community water systems are deemed to be approved by EPA if they meet these criteria (as appropriate for the local level) and are approved by the State. The term "State", as referenced next, includes States, Indian tribes and community water systems. EPA is requesting comment on each of the criteria for approval of State, and CWS, MMM program plans. In particular, EPA is requesting comment on whether the criteria need to be more or less stringent, and the supporting rationale for EPA's consideration of other potentially credible approaches.

(a) Description of Process for Involving the Public. (1) States are required to involve community water system customers, and other sectors of the public with an interest in radon, both in drinking water and in indoor air, in developing their MMM program plan. The MMM program plan must include:

- A description of processes the State used to provide for public participation in the development of its MMM program plan, including the components identified in the following paragraphs b, c, and d;
- A description of the nature and extent of public participation that occurred, including a list of groups and organizations that participated;
- A summary describing the recommendations, issues, and concerns arising from the public participation process and how these were considered in developing the State's MMM program plan; and,
- A description of how the State made information available to the public to support informed public participation, including information on the State's existing indoor radon program activities and radon risk reductions achieved, and on options considered for the MMM program plan along with any analyses supporting the development of such options.

(2) Once the draft program plan has been developed, the State must provide notice and opportunity for public comment on the draft plan prior to submitting it to EPA.

(b) Quantitative Goals. (1) States are required to establish and include in their plans quantitative goals, to measure the effectiveness of their MMM program, for the following:

(i) Existing houses with elevated indoor radon levels that will be mitigated by the public; and,

(ii) New houses that will be built radon-resistant by home builders.

EPA is proposing to require establishing quantitative goals in these two areas because they represent the most direct link to the risk reduction benefits that are the ultimate objective of the MMM programs. In addition, EPA analyses indicate that it is very cost-effective to test and mitigate existing homes with elevated indoor radon levels. It is also very cost-effective to build new homes radon-resistant, especially in higher radon potential areas. In the existing indoor radon program, EPA has been encouraging the States to promote testing and mitigation in all areas of a State. EPA has also encouraged the States to focus on their activities to promote radon-resistant new construction on the highest radon potential areas (Zone 1) where building homes radon-resistant is most cost-effective. However, it is also cost-effective to build homes in medium potential areas (Zone 2), as well as in ''hot'' spots found in most lower radon potential areas (Zone 3).

EPA recognizes the States' (and CWSs') need for flexibility in designing MMM programs reflecting their needs and circumstances, in particular the extent to which opportunities are available for risk reduction in mitigation of existing homes with elevated indoor radon levels or in construction of new homes built radon-resistant. Some States, in particular those with a preponderance of lower radon potential areas (and for CWSs in lower radon potential areas), may find it preferable to focus more heavily on testing and mitigation of existing housing than on radon-resistant new construction.

EPA is requesting comment on whether there are alternative goals that achieve radon risk reduction and the rationale for those goals. EPA is also soliciting comments on the goals outlined in paragraph (b), in particular on the appropriateness of the goals and whether the goals need to be more or less stringent.

(2) These goals must be defined quantitatively either as absolute numbers or as rates. If goals are defined as rates, a detailed explanation of the basis for determining the rates must be included.

EPA is proposing to provide this option, in part, because opportunities available for risk reduction in mitigation of existing homes with elevated indoor radon levels or in construction of new homes built radon-resistant may vary between States and within States. In addition, the level of new home construction may vary from year to year in different parts of a State or in a local jurisdiction. In this situation, it may be more appropriate to set goals for radon-resistant new construction as a rate, rather than absolute numbers, to account for this variability. This may be especially true for CWS developing local MMM program plans where no new home construction is currently taking place but may in the future.

(3) States are required to establish goals for promoting public awareness of radon health risks, for testing of existing homes by the public, for testing and mitigation of existing schools, and for construction of new public schools to be radon-resistant, or to include an explanation of why goals were not established in these program areas.

EPA is proposing that States have this option of defining goals as absolute numbers or as rates because, while awareness of radon health risks is a necessary element and a first step in getting the public to take action on indoor radon, public awareness, in and of itself, does not constitute radon exposure reduction. It does, however, help to facilitate informed choice by the public regarding radon testing and mitigation. Since the level of awareness on the health effects of radon is already high in many States, EPA is proposing to give flexibility to the States on this goal. In the case of radon in schools, many States have undertaken a range of activities to address radon in schools and some have done extensive testing, in some cases passing State legislation requiring the State to test public schools. Therefore, EPA is proposing to give States the option of setting these goals for schools. Although this approach provides flexibility in goal setting, EPA strongly encourages those States which do not have high levels of public awareness on radon and where there has been limited testing of public schools across the State to set goals in these areas. EPA is soliciting comment on whether States should be required to set quantitative goals in all or some of these areas in paragraph (b)(3).

(c) Implementation Plans. (1) States are required to include in their MMM program plan implementation plans outlining the strategic approaches and specific activities the State will undertake to achieve the quantitative goals identified in paragraphs (b)(1) and (b)(2). This must include implementation plans in the following two key areas:

(i) Promoting increased testing and mitigation of existing housing by the public through public outreach and education and during residential real estate transactions.

(ii) Promoting increased use of radon-resistant techniques in the construction of new homes.

(2) If a State has included goals for promoting public awareness of radon health risks; promoting testing of existing homes by the public; promoting testing and mitigation of existing schools; and promoting construction of new public schools to be radon resistant, then the State is required to submit a description of the strategic approach that will be used to achieve the goals.

(3) States are required to provide the overall rationale and support for why their proposed quantitative goals identified in paragraphs (b)(1) and (b)(2), in conjunction with their program implementation plans, will satisfy the statutory requirement that an MMM program be expected to achieve equal or greater risk reduction benefits to what would have been expected if all public water systems in the State complied with the MCL.

(d) Plans for Measuring and Reporting Results. (1) States are required to include in the MMM plan submitted to EPA a description of the approach that will be used to assess the results from implementation of the State MMM program, and to assess progress towards the quantitative goals in paragraphs (b)(1) and (b)(2). This specifically includes a description of the methodologies the State will use to determine or track the number of existing homes with elevated levels of radon in indoor air that are mitigated and the number or the rate of new homes built radon-resistant. This must also include a description of the approaches, methods, or processes the State will use to make the results of these assessment available to the public.

(2) If a State includes goals in paragraph (b)(3) for promoting public awareness of radon health risks; testing of existing homes by the public; testing and mitigation of existing schools; and, construction of new public schools to be radon-resistant; the State is required to submit a description of how the State will determine or track progress in achieving each of these goals. This must also include a description of the approaches, methods, or processes the State will use to make these results available to the public.

B. Why Will MMM Programs Get Risk Reduction Equal or Greater Than Compliance With the MCL?

The National Indoor Radon Program implemented by EPA, States and others, has achieved substantial risk reduction through voluntary public action since the release of the original ''A Citizen's Guide to Radon'' in 1986 (USEPA 1986) (updated: USEPA 1992b) and the U.S. Surgeon General's recommendation in 1988 (US EPA, 1988b) that all homes be tested and elevated radon levels be reduced. The program has been successful in achieving voluntary risk reduction on indoor radon through a variety of program strategies. It is important to keep in perspective the comparatively large potential for risk reduction that can be achieved if all existing homes with indoor radon levels at or above EPA's voluntary action level for indoor radon of 4 pCi/L in the U.S. were mitigated (approximately 6 million homes). In addition there is the potential for significant risk reduction potential if the approximately 1 million new homes built annually in the U.S. were built radon-resistant. Based on the estimated number of existing homes fixed and the number of new homes built radon-resistant since the national program began in 1986, EPA estimates that a total of more than 2,500 lives will be saved through voluntary indoor radon risk reduction efforts expected to take place up through the year 2000. Every year the rate of lives saved increases as more existing houses with elevated radon levels are fixed and as more new houses are built radon-resistant. On average this rate of lives that will be saved from these risk reduction actions increases by about 30 additional lives per year. EPA estimates that for the year 2000, the rate of radon-related lung cancer deaths that will be avoided from mitigation of existing homes and from homes built radon-resistant in high radon areas will be about 350 lives saved per year (USEPA 1999i).

Under the radon provision of SDWA, if all States adopted the AMCL, all State MMM programs together must be expected to result in at minimum about 62 cancer deaths averted annually; equal to what would be achieved with universal compliance with the MCL. Unlike these health risk reduction benefits which remain constant from one year to the next, the rate of health benefits from reducing radon in indoor air, as noted previously, steadily increases every year with every additional existing home that is mitigated and with every new home built radon-resistant. This steady incremental risk reduction offered by mitigation of existing homes with elevated indoor radon and building homes radon-resistant, especially during real estate transactions and through builder and consumer education and State and local adoption of radon-resistant building codes, holds the potential for substantial long-term risk reduction. NAS in their 1999 BEIR VI Report, concluded that up to one third (*i.e.*, 5,000 to 7,000) of their estimated 15,000 to 22,000 annual radon-related lung cancer deaths in the U.S. could be avoided if all homes were below EPA's voluntary radon action level of 4 pCi/L of air (NAS 1999a). This does not include the risk reduction that is achieved from new homes built radon-resistant. The one million new homes on average being built every year represent a significant radon risk reduction opportunity. Therefore, a critical element for MMM is to utilize and build on the indoor radon program framework to achieve ''equal or greater'' risk reduction rather than focusing efforts on precisely quantifying the much more limited risk reduction that will not occur in community water systems complying with the AMCL (*i.e.*, the difference in the risk reduction between the MCL and the AMCL).

C. Implementation of an MMM Program in Non-Primacy States

A State that does not have primary enforcement responsibility for the Public Water System Program under Section 1413 of the SDWA (''primacy'') and where EPA administers the CWS program may still develop a State-wide MMM program plan. EPA would not expect to develop an MMM program plan where the State elects not to develop a State-wide MMM program plan. Accordingly, CWSs in such jurisdictions would be required to comply with the more stringent MCL or develop local MMM program plans for approval by EPA.

The SDWA authorizes all States to develop and submit a MMM program plan to mitigate radon levels in indoor air for approval by the Administrator under Section 1412(b)(13)(G). EPA is proposing that States that do not have primacy may submit a plan to EPA that meets the criteria of 40 CFR 141.302. If the State's plan is approved, the State would be subject to all reporting and compliance requirements of 40 CFR 141.303. Community water systems in States with approved MMM programs would comply with the AMCL of 4000 pCi/L, and would be subject to the requirements for monitoring and analytical methods in 40 CFR 141.20. EPA would continue to administer compliance with the MCL/AMCL, and with monitoring and methods requirements.

D. Implementation of the MMM Program in Indian Country

Under this proposal, States can develop State-wide MMM programs for the reduction of radon in indoor air, and community water systems in such States can then comply with an AMCL of 4000 pCi/L (rather than an MCL of 300 pCi/L). Under Section 1451 of the SDWA, the Administrator of EPA is authorized to treat Indian Tribes in the same manner as States. The proposal provides tribes the option of seeking ''treatment in the same manner as a State'' for the purposes of assuming enforcement responsibility for a community water system program, and developing and implementing an MMM program. If a tribe does not choose to implement an MMM program, any tribal CWS may develop an MMM program plan for EPA approval, under the same criteria described previously.

EPA is proposing to amend the ''treatment as a State'' regulations to allow tribes to be treated in the same manner as States for purposes of carrying out the MMM program. Under this proposal, a tribe would not need to demonstrate that it qualified for treatment in the same manner as a State for any other purpose other than the MMM provisions. Tribes may want to seek treatment in the same manner as a State for this limited purpose to the extent that radon is a significant problem on tribal lands because the MMM program provides an opportunity to focus resources on reducing the higher risk exposure—indoor air—and addressing radon in drinking water at the highest levels of exposure. EPA is proposing to amend the treatment in the same manner as State regulations (40 CFR 142.72 and 40 CFR 142.78) to obtain treatment as a State status solely for the purpose of implementing the MMM authorities. Tribes can, of course, always apply to be treated in the same manner as a State for primacy over the Public Water Supply Program under 40 CFR 142.72.

A tribe applying for authority to develop and implement an MMM program plan that has met the criteria under 40 CFR 142. 72 to be treated in the same manner as a State for any purpose will not need to reestablish that it meets the first two criteria (40 CFR 142.72 (a) and (b)) and needs to provide only information in 40 CFR 142.76 that is necessary to demonstrate that the criteria in 40 CFR 142.72 (c) and (d) are met for the MMM program plan. A tribe whose application for authority to carry out the MMM program is approved must develop and implement a MMM program plan in accordance with 40 CFR 141.302 and 141.303.

E. CWS Role in State MMM Programs

EPA anticipates that CWSs, especially small systems, would have a limited role in State-wide MMM programs. For example, States may develop information brochures on radon that could be distributed locally by CWSs. EPA expects that States will want to consult with CWSs, small and large, in making a determination about the nature and scope of the role, if any, of CWSs in implementing a State-wide MMM program. During EPA's stakeholder process, many States and CWSs agreed that States were best positioned to design and implement effective State-wide MMM programs and that it was not apparent what role CWSs might take in such a program. However, CWSs do have important responsibilities for communicating information on radon to their customers (see Section VI.G).

F. Local CWS MMM Programs in Non-MMM States and State Role in Approval of CWS MMM Program Plans

The regulatory expectation of small community public water systems (CWSs) is that they meet the AMCL and be associated with a MMM program-either developed by the State and approved by EPA or developed by the CWS and approved by the State. EPA strongly recommends that States choose to develop and implement State-wide MMM programs as the most cost-effective approach to manage the health risks from radon. In those cases where States do not elect to do a State-wide MMM program, CWSs would need to notify the State of its intention to develop and submit a local MMM program plan to the State (4 years after publication of the final rule in the **Federal Register**). EPA believes that, in all cases, the regulatory burden of complying with AMCL and implementing a MMM program will be considerably less than complying with the more stringent regulatory level for radon in drinking water. EPA believes that the MMM/AMCL is the appropriate standard for CWSs, especially for small systems, because it results in greater radon risk reduction and makes better use of limited resources. EPA believes that the four criteria for plan approval can be applied to CWS local MMM program plans (as appropriate for the local level), commensurate with the unique attributes of these CWSs and their service areas. As previously discussed in more detail, these four criteria are: public participation, setting quantitative goals, strategies for achieving goals, and a plan to track and report results.

In general, EPA expects that CWSs would be able to meet the four criteria by carrying out a wide range of diverse activities, many of which are well within the expertise of CWSs. However, small CWSs would not necessarily be expected to perform some of the activities entirely on their own. In carrying out certain activities, small CWSs would be expected to seek help from others in order to build upon and take advantage of existing CWS and State networks. The existing State indoor radon programs, for example, operate in large measure through a network of State and local partners such as the American Lung Association, the National Association of Counties, the National Environmental Health Association, the National Safety Council, consumer advocacy groups, non-government organizations, and other local and county governmental organizations. CWSs should be able to use the same networks and their capabilities, and State radon in indoor air programs should help facilitate these contacts. The following provides some additional perspective on the four criteria relative to CWS MMM programs.

Public Participation: Thorough public participation is certainly within the capability of CWSs. Systems are often required in the course of CWS activities, such as operation, maintenance, water bill collection, violation notification, and planning for new facilities, to involve, communicate with, inform, and in other ways interact with the public. Thus, these systems already engage, to a significant degree, in public outreach and communication. EPA expects that such expertise can readily be directed toward the particular public participation requirements associated with MMM programs. Public participating during development of local MMM plans will help ensure greater local support for and implementation of the CWS MMM programs.

Quantitative Goals: EPA notes that the quantitative goals that CWSs, especially small CWSs, typically will need to establish may be rather modest compared to those that would be expected for State-wide programs. The level of risk reduction needed to ensure ''equal or greater'' risk reduction be achieved (as if the MCL were being met) from a local MMM program plan is a function of and takes into account factors such as the size of the population served, level of radon in drinking water, and most importantly, the needs and goals of the community.

Strategies for Achieving Goals: EPA recognizes that promoting public action in the areas of new homes built radon-resistant and mitigation of existing homes with elevated levels of radon in indoor air will be entirely new ventures for CWSs. However, EPA believes CWSs, including small CWSs, will be capable of conducting various activities designed to promote testing and mitigation of existing homes with elevated levels of radon in indoor air and building of new homes to be radon-resistant. Such activities include public education programs, provision of radon test kits, establishing networks with local health and government officials to gain their support and involvement in MMM implementation, meeting with community leaders, customers, local real estate and home building officials and organization, utilizing existing information distribution network employed by CWSs, and other types of activities to promote public action on indoor radon. EPA expects that MMM program strategies for CWSs will be less comprehensive and far reaching than those of State MMM programs, and will need to reflect the local character of the community served by the CWS.

Tracking and Reporting of Results: EPA recognizes that assessing or tracking progress towards meeting these goals also represents a new responsibility for CWSs. However, CWSs may be able to build upon their experience and networks for communicating with customers and identifying their needs or concerns and find ways to collect information about actions taking place in the community. To track homes built or modified to be radon resistant, CWSs may be able to obtain needed information from various local and State programs and offices and other organizations in its network. CWS may also choose to employ contractor support or consultant services to obtain this information or to help track other MMM related activities. EPA also expects the States to provide assistance to CWSs in developing their tracking and assessment approach based on State experience in determining the results of their State indoor radon programs. EPA recognizes that CWSs' options for tracking results may be more limited than those available to the States, and that States should consider such limitations in their five-year review of local programs.

CWSs may find it useful to combine efforts with adjacent CWSs for purpose of developing and implementing joint MMM programs, thereby broadening their combined expertise, local infrastructure and institutional bases, and network of partners. EPA also expects that privately-owned, as well as publicly owned, CWSs can avail themselves of these same kinds of networks, partnership, and consultant services. Private systems will generally also be well connected to the municipal entities in the jurisdictions in which they operate.

The report of the Small Business Advocacy Review Panel included a discussion of the concept of a ''model MMM program'' for small systems which would not be required but could provide a workable option for small systems. It might address potential concerns of the smallest systems that anticipate they may lack the resources and expertise to develop an MMM program. As discussed subsequently in Section VI. H., EPA has concerns in general about the appropriateness and applicability of a ''one-size-fits-all'' approach for MMM programs. A model approach, even for small CWSs, would not address the unique, site-specific needs of different CWSs and their associated communities. EPA is requesting public comment on the concept of a model MMM program for CWSs.

As noted previously, EPA is strongly recommending that States choose to develop and implement State-wide MMM programs as the most cost-effective approach to manage the health risks from radon which would preclude the need for water systems to develop such programs on their own. EPA also believes the States which choose not to do an MMM program have an important role, and are the best positioned, to assist CWSs in development of local MMM program plans. EPA will also be providing guidance to assist CWSs, including small CWSs, in the development of local MMM programs. This section has discussed the manner in which the four criteria could be applied to CWSs in non-MMM States. EPA is requesting comment on approaches to applying these criteria to CWSs, especially the smallest CWSs, in view of the capabilities of these systems and their ability to get assistance from others. EPA is also requesting comment on options that may be available to CWSs, particularly, small systems, to develop and implement an MMM program plan.

In summary, EPA recognizes that CWSs do not have the same institutional base and infrastructure, legislative authority, proportionate resource base, or indoor radon program experience as States on which to base development of a local MMM program plan. However, EPA believes that the four criteria for approval are equally applicable to both States and CWSs, and can be applied to CWSs (particularly small CWSs) in a manner that recognizes and accounts for these differences. As discussed previously, the manner in which these criteria are addressed by CWSs in local MMM program plans, and the level and scope of effort, will necessarily differ from that embodied in State plans. States should consider these differences in evaluating CWS MMM program plans and in their five-year review of CWS MMM program implementation. EPA believes that States, in particular, are best positioned to assist CWSs, especially small systems, in the development of local MMM programs that satisfy the four criteria, and expects them to provide such assistance. In evaluating CWS plans, States should exercise flexibility in their review and approval process, especially for small CWSs, recognizing that they will not have the same institutional and resource base or experience and may need to obtain assistance from others.

The Agency expects that most systems in non-MMM States with radon levels between 4,000 pCi/L and 300 pCi/L will develop and submit MMM program plans. However, the Agency recognizes that some CWSs in non-MMM States may elect not to develop a MMM program plan for a variety of reasons. In these cases, certain options are available to small CWSs. They may consider working with one or more other systems for the purposes of developing and implementing an MMM program plan, in order to take advantage of greater institutional capabilities. If a system does not develop an MMM program plan on its own or together with other systems, the system must comply with the MCL of 300 pCi/L through any available means (*e.g.*, blending, use of alternate sources, and treatment).

From a risk communication standpoint, EPA wishes to convey to customers of small CWSs that its regulatory expectation for these systems is that they meet the AMCL and implement an MMM program. However, CWSs can choose to meet the MCL rather than take the MMM approach. If a CWS opts for the MMM/AMCL approach but is unable to develop and successfully implement a State-approved MMM program plan, it may be required as part of an enforcement order, to meet the MCL rather than comply with the MMM/AMCL. The Agency requests comment on this approach for small system MMM programs.

The SDWA provides that EPA will approve local water system MMM program plans and EPA has developed the criteria to be used for approving MMM program plans, as discussed in (A). EPA will review and approve State MMM program plans. CWS MMM program plans that address the criteria and are approved by the State are deemed approved by EPA. The proposed rule requires States that do not have a State-wide MMM program, as a condition of primacy for the radon regulation, to review MMM program plans submitted by CWSs and to approve plans meeting the four criteria for MMM program plans discussed in Section VI.A. of this, including providing notice and opportunity for public comment on CWS MMM program plans. EPA solicits comment on this approach to reviewing and approving local MMM plans. Under SDWA, MMM program plans submitted by CWSs are to be subject to the same criteria and conditions as State MMM program plans. EPA believes that the States are best positioned to assist CWSs, especially small systems, in the development and review of local MMM program plans that meet the four criteria, and to have public health oversight of the progress of the implementation of these local radon risk reduction programs. EPA encourages those States not choosing to develop a State-wide MMM program plan to exercise flexibility in their review and approval of local MMM program plans, especially for small CWSs, recognizing that CWSs will not have the same institutional base, nor the State's program experience on indoor radon, on which to base to local development of a MMM program plan. EPA expects that the State drinking water programs and indoor radon programs will work collaboratively in assisting CWSs that elect to develop and implement local CWS MMM program plans and comply with the AMCL. In non-primacy states, EPA will review and approve local CWS MMM program plans and oversee compliance with the AMCL if the state chooses not to do a state-wide MMM program plan. MMM program plans developed by Indian Tribes or tribal community water systems will be reviewed by EPA. The specific requirements of a CWS in a State with a State-wide MMM program are addressed in Section VI.E. CWSs may choose to meet the MCL.

For those CWSs (both large and small) in non-MMM States that develop local MMM program plans, the State would review the MMM program at least once every 5 years and provide progress reports to the EPA in keeping with the statutory requirements of the SDWA and this Section. (States may also establish interim reporting requirements for the CWS under a MMM program to help ensure adequate progress toward the goals set forth in the local MMM program plan.) Failure of a CWS to develop its MMM program plan by the required regulatory deadline or failure of a CWS to implement its approved MMM program plan (5 years and 5½ years, respectively after the final rule is published) would be a violation of this regulation unless the CWS is complying with the MCL. It is expected that a CWS would be given time to correct any violations relating to its MMM program through an appropriate enforcement action.

G. CWS Role in Communicating to Customers

At a minimum, CWSs have important responsibilities for communicating information on radon to their customers. Under the requirements of the Consumer Confidence Rule (CCR), CWSs will be required to provide key information on the health effects of radon should the level of radon in drinking water exceed the MCL (or AMCL in States with MMM programs). Today's action also updates the standard CCR rule requirements and adds special requirements that reflect the multimedia approach of this rule. The intent of these provisions is to assist in clearer communication of the relative risks of radon in indoor air from soil and from drinking water, and to encourage public participation in the development of the State or CWS MMM program plans. Today's action also proposes to require CWSs to add information to the mandatory yearly report which would inform their customers on how to get involved in developing their State or local CWS MMM program plan. This information would include a brief educational statement on radon risks, explaining that the principal radon risk comes from radon in indoor air, rather than drinking water, and for that reason, radon risk reduction efforts may be focused on indoor air rather than drinking water. This information will also note that many States and systems are in the process of creating programs to reduce exposure to radon, and encourage readers to call for more information. This information would be provided every year until the compliance date for implementation of State MMM programs (or CWS local MMM programs in States without a State-wide MMM program. (See Section X of this preamble for more information on CCR and public notice requirements for radon). EPA is also planning to develop public information materials on radon in drinking water and indoor air as ''tools'' to assist CWSs, as well as the States, Indian tribes, and others, with the risk communication issues associated with the MCL, AMCL, and MMM.

H. How Did EPA Develop These Criteria?

EPA obtained extensive stakeholder input in developing the regulatory criteria for State MMM program plans. Stakeholders participating in this process represented many diverse groups and organizations with an interest in radon, both from the perspective of radon in drinking water and of radon in indoor air. This included State drinking water and State radon program representatives, municipal and privately owned public water system suppliers, local government officials, environmental groups, and organizations representing State health officials, county governments, public interest groups, and others.

As part of the process of getting stakeholder input on development of MMM guidelines and criteria, EPA presented several conceptual framework options for MMM for discussion and consideration. Three preliminary approaches were discussed: (1) To set specific numerical targets in mitigations of existing houses and houses built radon-resistant (as surrogates for lives saved) for each State to meet; (2) to set a level of effort that States must demonstrate would be achieved under their MMM plan; and (3) to set minimum core indoor radon program elements required for all plans.

Under the first approach, specific targets to achieve ''equal'' risk reduction could be set using a variety of approaches and tools and based on a number of factors, such as the level of radon in the drinking water, the number of people served by that system, and other factors. It would also require allocating among the States the total number of lives saved nationally by universal compliance with the MCL (estimated to be about 62 lives saved yearly). The allocation of lives saved by States would likely lead to some State targets being fractions of a life saved yearly, depending on the number of systems, radon levels, and people served. Many stakeholders thought that significant attention would need to be paid to the risk communication challenges of communicating this approach to the public. Although some stakeholders thought this approach might be workable, others did not consider it universally applicable or workable and that it might preclude flexibility and innovation.

The second approach, ''level of effort'', would focus more on a plan for implementation of risk reduction strategies using a point system where different risk reduction strategies (such as public education, radon-resistant new construction code adoption, *etc.*) would be assigned a specific number of points based on potential to achieve health risk reduction. The number of State-specific points that a MMM program plan would have to meet to be approved would require determining the number of systems complying with the AMCL rather than the MCL, the radon levels in their drinking water, and population served. This approach would give States flexibility in choosing the combination of indoor radon risk reduction strategies that best meets the needs of that State by giving them a menu of approaches from different categories of strategies with different assigned points. There are two difficulties in implementing this approach that would need to be addressed. First, it may be difficult to assign in advance a specific quantified value for different strategies in terms of a numerical outcome in risk reduction (*i.e.*, in lives saved or in existing homes mitigated or houses built radon-resistant). EPA requested the National Academy of Sciences (NAS), as part of its assessment of radon in drinking water, to ''prepare an assessment of the health risk reduction benefits associated with various mitigation measures [described in SDWA] to reduce radon levels in indoor air.'' Although the NAS included some review of the States' experience with public education and risk communication, they did not include a quantitative assessment of the ''health risk reduction benefits'' associated with specific ''mitigation measures'' referred to by SDWA. Second, risk communication research has shown, and many stakeholders agreed, that a variety of strategies must be employed simultaneously when trying to get voluntary public actions on preventive health and safety measures. It is often difficult to single out or characterize, for example, the number of people who take voluntary health risk reduction actions because of viewing a particular televised public service announcement separate from other messages, activities, communications, and efforts being implemented by society to reduce that particular public health risk.

Setting specific State risk reduction targets or a level of effort point system were considered in part to address language in the SDWA radon provision that State plans approved by EPA are expected to achieve health risk reduction benefits ''equal to or greater than the health risk reduction benefits that would be achieved if each public water system in the State complied with the maximum contaminant level [MCL]* * *.'' As some stakeholders noted, there are complexities associated with determining risk reduction targets (*e.g.*, in pCi/L) for indoor radon needed to substitute or ''make-up'' for some very small level of risk reduction that would not occur if systems comply with the AMCL. Careful attention would need to be paid to ensuring that this approach did not produce the unintended effect of narrowly focusing or limiting the risk reduction goals of MMM program plans. Some States and other stakeholders were concerned that a complex approach, that may be difficult to communicate to the public, could hamper voluntary public action currently taking place on indoor radon. Some States thought that they may have the data and/or tools that would permit such an approach.

The third conceptual approach was to require MMM program plans to include a set of core program elements, without targets or points, to be determined by EPA. This would require a set of basic program elements that each State MMM program plan would have to incorporate to be approved by EPA. In addition, the States could choose to add additional program elements from a menu of strategies to be provided by EPA. An example of implementation of a core program element might be that each State would have to adopt radon-resistant new construction standards into their State and local building codes, or require testing and mitigation firms to register with the State and report numbers of radon tests and mitigations conducted. Many stakeholders were concerned that this approach might not provide sufficient flexibility needed by the States to reflect their particular needs, including the scope of the radon in drinking water and indoor radon problem, and the varying extent to which the States have been addressing their indoor radon problem through their existing State radon programs.

EPA is soliciting public comment on these three alternative conceptual frameworks for MMM program plans that were examined through the stakeholder process and is also requesting public comment on other potential frameworks and rationale for why and how these would achieve increased radon risk reduction.

While stakeholders had differing views of the three conceptual approaches presented by EPA for discussion purposes, a number of mutual concerns and issues integral to formulation of a conceptual framework for MMM were identified. The following set of broad issues and concerns raised by stakeholders were considered in the development of the required criteria that EPA is proposing.

A uniform approach, that is, a ''one size fits all'' approach to MMM might not provide States with the flexibility they need to custom tailor their plans to their needs. Every State is different in terms of the extent and magnitude of the indoor radon problem, the nature of the existing State indoor radon program, the levels of radon in public water supplies, and many other factors.

Because the SDWA framework for radon permits States to choose to adopt either the MCL or AMCL/MMM option, some stakeholders believed that States might be less inclined to adopt the MMM/AMCL approach if it were considered too complex and difficult to implement and communicate to the public. The approach needs to be simple and straightforward, provide flexibility to accommodate the variety of needs in different States, and encourage innovation at the State and local level.

MMM will be most effective if it is built on and consistent with the foundation and infrastructure of the existing State indoor radon programs. States are better positioned than public water suppliers to achieve radon risk reduction under MMM programs. Most States currently have a voluntary radon program. Some States noted the need for some consistency between the criteria and objectives for MMM program plans and the goals, priorities, and EPA's existing State Indoor Radon Grant (SIRG) program guidance.

States and other stakeholders raised concerns about the potential relationship between MMM and the current State indoor radon programs. Stakeholders strongly encouraged EPA to carefully identify and consider the potential for negative impacts of MMM requirements on current State efforts on indoor radon. In particular there were concerns that attention and resources might be diverted to the MMM program. States might choose not to do a MMM program if the effectiveness or infrastructure of their current indoor radon program might be reduced, or if it does not help States meet the goals of their voluntary programs. This would be counter-productive if it resulted in reduced efforts and diminished infrastructure of a State's voluntary program already achieving indoor radon risk reduction.

Some States felt it was important to have extensive public debate and examination of any program proposed by the State in order to get public support for the AMCL and MMM approach.

A number of stakeholders noted the need for MMM programs to have definable endpoints or goals, show how these endpoints will be attained, and describe how results will be determined. Some States indicated the importance of demonstrating to the public that the program is achieves radon risk reduction.

Stakeholders noted that the level of risk reduction that can be achieved by focusing resources and effort on radon in indoor air is significantly greater than what can be achieved by universal compliance with the MCL. MCL-based risk reduction targets would also be significantly smaller than the risk reduction already being achieved. Therefore it is important to focus on the greater risk reduction potential for radon in indoor air, and on enhancement of indoor radon programs, rather than focus on the smaller risk reduction potential from radon in water.

In developing and deciding on proposed criteria, EPA took into account these stakeholder views and concerns, as well as EPA's goals for MMM and the current approach used by EPA and the States to get indoor radon risk reduction. This information and experience taken together led to the proposed MMM criteria that are based upon three elements: (1) Involve the public in development of MMM; (2) track the level of indoor radon risk reduction that occurs; and, (3) build on the existing framework of State indoor radon programs.

First, stakeholders suggested that extensive public participation in the development of a State MMM program plan is important. One important approach is to involve various segments of the public, from community water system customers to key public health and other organizations, the business community, local officials, and many others. The public needs to be informed about and participate in the MMM development process to ensure that the goals and other elements of the plan will be publicly supported, responsive to the needs of the various stakeholders, and meet public and State goals for reducing indoor radon. Such a process may also result in increased public awareness and voluntary action to reduce the levels of indoor radon. Stakeholder involvement can help States clearly define goals and design the process and strategies for meeting these goals. EPA recognizes that there are a variety of non-quantitative and quantitative approaches, tools, and types of information that can be used to develop goals, but public input is very important to this process. The public involvement in development and examination of plans will help to get support and buy-in from all stakeholders to a set of goals, program strategies, and results measurement, and thus, helps to ensure program success.

Second, a successful MMM program plan needs to include a provision for determining progress on reducing the public's exposure to indoor radon, and for reporting back to the public. In the case of indoor radon, risk reduction results can be evaluated by tracking or in some way determining the level of existing home mitigation and new homes built radon-resistant. A few States already track this information closely. Many do not. EPA believes that there are a variety of approaches currently being used, such as statistically-based surveys; State requirements for tracking testing and mitigation by radon testing and mitigation companies; voluntary agreement by builders to provide information on construction of radon-resistant homes; and other approaches. EPA also recognizes the importance of providing States the flexibility to craft new and innovative approaches for tracking and assessing progress. Through implementation of a State-wide MMM/AMCL approach, States may be able to provide new incentives and opportunities for gathering the information the State will need to demonstrate to the public, and EPA, that progress is being made in getting public action to reduce radon risks.

Third, building MMM on the framework of existing State indoor radon programs takes advantage of the existing programs already working to get public action on indoor radon. Nearly every State currently has a program with existing policies, public outreach and education programs, partner networks and coalitions, and other infrastructure. States have used the State Indoor Radon Grant (SIRG) funds available under Title III of the Toxics Substances Control Act (TSCA) to develop a variety of radon strategies, including distributing information materials to educate the public, maintaining radon hotlines, conducting training programs, providing technical assistance, operating certification programs for the radon industry, setting up regulatory requirements for industry reporting of testing and mitigation, conducting surveys (testing) of homes and schools, working with local governments in high-risk areas to establish incentive programs for radon-resistant new construction, and many other activities. Many of these activities are consistent with the findings of the National Academy of Sciences. They found three factors were most important for motivating the public to test and fix their home: (1) A radon awareness campaign; (2) promoting the widespread voluntary testing by the public of indoor radon levels; and (3) educating the public about mitigation and ensuring the availability of qualified contractors. The reinforcement and augmentation of these types of efforts through MMM programs is expected to result in increased levels of testing and mitigation of existing homes by the public and of homes being built to be radon-resistant.

The ''mitigation measures'' set forth in the 1996 SDWA are similar to those being used in the existing national and State radon programs. Section 1412 (b)(13)(G)(ii) provides that State MMM programs may rely on a variety of ''mitigation measures'' including ''public education, testing, training, technical assistance, remediation grants and loans and incentive programs, or other regulatory or non-regulatory measures''. These represent many of the same strategies that are integral to the indoor radon program strategy, as well as those outlined in the 1988 Indoor Radon Abatement Act.

The risk reduction achieved to date through the national and State radon programs has been achieved primarily through a non-regulatory approach. The SIRG guidance for implementing a program also outlines and recommends indoor radon program priorities, encourages States to develop narrative descriptions of how they intend to address the priority areas, and encourages the establishment of goals for awareness, testing and mitigation of homes and schools, and radon-resistant new construction. Under SIRG, the States are required to submit a list of their activities and workplans for each project that will be done under the grant. While EPA's SIRG guidance requires a list of program activities, it is not currently a Federal requirement under the Indoor Radon Abatement Act of 1988 or under SIRG that State indoor radon programs to: (a) publicly set goals for awareness, testing, mitigation and new construction; (b) develop and implement a strategic plan for action through real estate transactions, new home construction, testing and fixing schools, and getting the public to test and fix their homes; (c) develop and implement approaches to track and measure the results of their strategic plans and activities and report those results to the public; and (d) directly involve the public in the development of the States' program goals and strategic plans. EPA is proposing that, in order to have an approved MMM program plan, States now be required to take these steps.

EPA believes this augmentation of State programs required under the criteria will result in an increased level of risk reduction. States will develop their plans with direct public participation in setting goals, develop strategic plans in key areas, and develop approaches for tracking and measuring results against goals. EPA also expects that substantial and constructive public participation in the development process of the State's MMM program plan is likely to result in a program that meets the public's needs and concerns on an important public health issue, as well as in greater public awareness of the health effects of radon and in increased voluntary action by the public to address their risks from indoor radon. Given EPA's estimate of the expected increase in the yearly rate of lung cancer deaths avoided from the current voluntary program, EPA expects that State MMM program plans meeting these four criteria will achieve equal, or much more likely, greater health risk reduction benefits.

I. Background on the Existing EPA and State Indoor Radon Programs

Implementation of EPA's current national strategy to reduce public health risks from radon in indoor air has focused on using a decentralized management and risk communication approach in partnership with States, local governments and a network of national organizations; a continuum of risk reduction strategies; and, a strong focus on key priorities. Reduction of indoor radon levels has the potential to yield very large risk reduction benefits through pursuit of a wide range of approaches including the availability of relatively inexpensive testing, mitigation, and new construction techniques to reduce the risk from indoor radon. National, State, and local efforts continue to proactively encourage the public to test and fix their homes, promote action on radon in association with real estate transactions, and promote the construction of new homes with radon-resistant techniques through institutional changes such as local adoption of new construction standards and codes.

Prior to 1985 the federal government and only a few States had initiated activities to address indoor radon problems. The initial foundation and scope of State programs was determined by the different needs of the States. For example, some Western States developed programs to assist citizens living on or near uranium mines or mill tailings sites. When very high levels of radon in homes in the area known as the Reading Prong in the Northeastern U.S. were discovered in late 1984, the Agency began to develop and to implement a coordinated national radon program. Some Eastern States situated over the Reading Prong began to develop strong programs in response to homes being found with radon levels in the hundreds and thousands of pCi/L of air. However, there was no coordinated government program, or testing and mitigation industry, to address the risks posed by radon and only a very small fraction of the public was even aware of the problem.

Since then, there has been significant progress in the nation's program to promote voluntary public action to reduce the health risks from radon in indoor air. EPA's non-regulatory Radon Program has established a partnership between federal, State, local and private organizations, as well as private industry, working together on numerous fronts to promote voluntary radon risk reduction. This partnership initially focused programs on increasing public awareness of the problem and providing the public with the necessary resources, including a range of technical guidance and information, to enable them to reduce their health risks through voluntary actions across the nation. Congress endorsed this strategy and strengthened the indoor radon program through the Superfund Amendments and Reauthorization Act of 1986, and again in 1988 through passage of the Indoor Radon Abatement Act. The Superfund Amendments and Reauthorization Act of 1986 (SARA) authorized EPA to conduct a national assessment of radon in residences, schools, and workplaces. The 1988 Indoor Radon Abatement Act (IRAA), an amendment to the Toxic Substances Control Act. established the overall long-term goal of reducing indoor radon levels to ambient outdoor levels, required the development and promotion of model standards and techniques for radon-resistant construction, and established the State Indoor Radon Grant program (SIRG). IRAA also directed EPA to study radon levels in the U.S., evaluate mitigation methods to reduce indoor radon, establish proficiency programs for radon detection devices and services, develop training centers, provide the public with information about radon, and assist States to develop and implement programs to address indoor radon.

Recognizing the importance of working in partnership with the States and leading national organizations, EPA developed a decentralized system for informing the public about the health risks from radon, consisting primarily of State and local governments and key national organizations, with their state and local affiliates, who serve as sources of radon information and support activities to the public. EPA has worked with the States to help establish and enhance effective State indoor radon programs and develop basic State capabilities needed for assisting the public in reducing their risk from indoor radon. EPA developed and transferred technical guidance on radon measurement and mitigation to the States, the private sector, and the public.

A key initiative in this effort to build State Radon Programs has been the State Indoor Radon Grant (SIRG) Program, which provides funding to help States develop and operate effective and self-sustaining radon programs. As of August 1999, forty-five States are currently participating in the SIRG program. These grants have been instrumental in establishing State radon programs or in helping States expand their radon programs more quickly than they otherwise could have.

EPA, the States and national and local partners are using a mixture of diverse strategies that range from the more flexible, such as providing information to the public to encourage the public to act, to more prescriptive, such as providing incentives that give some advantage for taking action, or to adopting policies and requirements that mandate certain actions. As a result, many initiatives are underway today both to actively encourage and motivate homeowners to test and fix their homes as well as to institutionalize risk reduction through testing and mitigation during real estate transactions and through construction of new homes to be radon-resistant.

EPA and the States, working with key national and local organizations, have developed a wide range of channels for delivering information to their members, affiliates and other target audiences. Many organizations have their own ''hotlines,'' journals, brochures, newsletters, press releases, radio and television programs, national conferences, and offer training and continuing education programs. These partners collaborate to urge public action on radon though a wide variety of strategies including information, motivation, incentives, and state and local mandates. The public receives a consistent message on radon from EPA, the States, and a number of other key, respected, and credible sources. Each target audience, like physicians or school nurses or local government officials, becomes in turn a source of information for new target audiences like their patients and local constituents. This approach is comparable to that used to encourage people to take various other voluntary preventive measures to reduce their risk of various health and safety risks. Some of the national organizations that EPA and the States work with include the American Lung Association, the National Association of City and County Health Officials, the National Parent Teacher Association, the Asian American and Pacific County Health Officials, the Association of State and Territorial Health Officials, the National Environmental Health Association, the National Association of County Officials, the Consumer Research Council of Consumer Federation of America, the National Safety Council, and many others.

Many of the publicly available information materials are specialized and designed to encourage specific actions by certain groups, e.g., physicians, homebuilders, real estate agents, home inspectors, home buyers and sellers, and many others. As a result, for example, many home builders are voluntarily using radon resistant new construction techniques and some real estate associations are voluntarily incorporating the use of radon disclosure forms into their regular business practices. Medical and health care professionals are being educated about the health risks of radon and are encouraging their patients to test their homes for radon as a preventive health care measure. Public service announcements by local radio and TV stations encourage the public to act. Other public information materials provide consumers with information on how to test their homes and what options they have for mitigating their radon problem.

Incentive programs and initiatives, such as free radon test kits, and builder rebates when builders build homes radon-resistant, are being implemented. States and local jurisdictions are also pursuing a variety of regulatory radon initiatives, such as requiring schools to be tested for indoor radon, requiring disclosure of elevated radon levels in residential real estate transactions, and requiring new homes to be built with radon-resistant new construction features through building codes. These strategies and many others are being used to successfully achieve public action to reduce the health risks from indoor radon.

EPA has consulted with scientists, federal, state and local government officials, public health organizations, risk communication experts, and others to design this program and focus on radon program strategies which have the greatest potential for reducing radon risks through long-term institutional change. In developing strategies for reducing radon risks, EPA and the States have learned from the experience of other successful national public health campaigns, such as the campaigns to promote the use of seat belts. These campaigns have shown that significant public action to voluntarily reduce health risks can be achieved from concerted efforts through a variety of diverse strategies and through the combined efforts of State and local governments, public health organizations, and other public interest groups, grass roots organizations, and the private sector.

Program priorities have been identified to help concentrate and focus efforts of EPA, the States, and local organizations, and others on those activities that are most effective in achieving the overall mission of indoor radon risk reduction. Working with a broad group of stakeholders, EPA established several key priority areas for indoor radon. States and cooperative national organizations have been focusing many of their efforts and activities in these areas.

1. Targeting Efforts on the Greatest Risks First

EPA, the States, and many other public health organizations recommend that all homes be tested and all homes at or above 4 pCi/L be fixed. However, resources have been more heavily focused initially in areas where action produces the most substantial risk reduction, such as on homes and schools in the high radon potential areas and on the increased risk of lung cancer from indoor radon to current and former smokers.

2. Promote Radon-Resistant New Construction

EPA and others encourage programs to promote voluntary adoption of radon-resistant building techniques by builders and the adoption of radon construction standards into national, State and local building codes. Methods (model standards) that establish construction techniques for reducing radon entry in new construction have been developed and published by EPA in collaboration with the National Association of Home Builders. There are currently over 30 major building contractors (some are national firms) who design and construct radon resistant new homes. It is very cost-effective to build new homes radon-resistant, especially in higher radon potential areas. In the existing indoor radon program, EPA has been encouraging the States to promote testing and mitigation in all areas of a State. EPA has also encouraged the States to focus on their activities to promote radon-resistant new construction on the highest radon potential areas (Zone 1) where building homes radon-resistant is most cost-effective. However, it is also cost-effective to build homes in medium potential areas (Zone 2), as well as in ''hot'' spots found in most lower radon potential areas (Zone 3).

3. Promote Testing and Mitigation During Real Estate Transactions

Based on the efforts of EPA, the States, and others, there has been a steady increase in the number of radon tests and mitigations voluntarily done through real estate actions. It is very cost-effective to test and mitigate existing homes with elevated indoor radon levels. Real estate transactions offer a significant opportunity to achieve radon risk reduction. In 1993, EPA published the ''Home Buyer's and Seller's Guide to Radon'' (USEPA 1993f). Hundreds of thousands of copies of the ''Home Buyer's Guide'' have been distributed to consumers. The companion to the ''Home Buyer's Guide'' is the ''Consumer's Guide to Radon Reduction'' (USEPA 1992d) which provides information on how to go about reducing elevated radon levels in a home.

A significant amount of radon testing and mitigation of existing homes takes place during real estate transactions through the combination of home inspections, real estate transfers, and relocation services. Many different groups are in a position to influence buyers and sellers to test and mitigate elevated radon levels. This includes sales agents and brokers, buyers agents, home inspectors, mortgage lenders, secondary mortgage lenders, appraisers, insurance companies, State real estate licensing commissions, real estate educators, relocation companies, real estate press, and others. There are currently no requirements at the federal, State, or local level that a house be tested for indoor radon as part of a real estate transaction. Many State and local governments, however, have passed laws requiring some form of radon disclosure, although the extent and detail of these mandatory disclosure laws varies.

4. Promote Individual and Institutional Change through Public Information and Outreach Programs

Because the health risk associated with indoor radon is controlled primarily by individual citizens, EPA, the States and others have developed a nationwide public information effort to inform the public about the health risks from indoor radon and encourage them to take action. EPA recommends that the public use EPA-listed or State-listed radon test devices and hire a trained and qualified radon contractor to fix elevated radon levels. Early on, EPA established voluntary programs to evaluate the proficiency of these testing and mitigation service companies to provide a mechanism for providing the public with information by publishing updated lists of firms that pass all relevant criteria. Many States have established their own proficiency programs. To help support these efforts, EPA established four self-sustaining Regional Radon Training Centers across the country to train testing and mitigation contractors, State personnel, and others in radon measurement, mitigation, and prevention techniques. In 1998, the Conference of Radiation Control Program Directors (CRCPD), representing State radiation officials, initiated a pilot program through the National Environmental Health Association to establish a privatized national proficiency program to replace EPA's proficiency program which is terminating.

VII. What Are the Requirements for Addressing Radon in Water and Radon in Air? MCL, AMCL and MMM

A CWS must monitor for radon in drinking water in accordance with the regulations, as described in Section VIII of this preamble, and report their results to the State. If the State determines that the system is in compliance with the MCL of 300 pCi/L, the CWS does not need to implement a MMM program (in the absence of a State program), but must continue to monitor as required.

As discussed in Section VI, EPA anticipates that most States will choose to develop a State-wide MMM program as the most cost-effective approach to radon risk reduction. In this case, all CWSs within the State may comply with the AMCL of 4000 pCi/L. Thus, EPA expects the vast majority of CWSs will be subject only to the AMCL. In those instances where the State does not adopt this approach, the proposed regulation provides the following requirements:

A. Requirements for Small Systems Serving 10,000 People or Less

The EPA is proposing that small CWS serving 10,000 people or less must comply with the AMCL, and implement a MMM program (if there is no state MMM program). This is the cut-off level specified by Congress in the 1996 Amendments to the Safe Drinking Water Act for small system flexibility provisions. Because this definition does not correspond to the definitions of ''small'' for small businesses, governments, and non-profit organizations previously established under the RFA, EPA requested comment on an alternative definition of ''small entity'' in the preamble to the proposed

Consumer Confidence Report (CCR) regulation (63 FR 7620, February 13, 1998). Comments showed that stakeholders support the proposed alternative definition. EPA also consulted with the SBA Office of Advocacy on the definition as it relates to small business analysis. In the preamble to the final CCR regulation (63 FR 4511, August 19, 1998), EPA stated its intent to establish this alternative definition for regulatory flexibility assessments under the RFA for all drinking water regulations and has thus used it for this radon in drinking water rulemaking. Further information supporting this certification is available in the public docket for this rule.

EPA's regulation expectation for small CWSs is the MMM and AMCL because this approach is a much more cost-effective way to reduce radon risk than compliance with the MCL. (While EPA believes that the MMM approach is preferable for small systems in a non-MMM State, they may, at their discretion, choose the option of meeting the MCL of 300 pCi/L instead of developing a local MMM program). The CWSs will be required to submit MMM program plans to their State for approval. (See Sections VI.A and F for further discussion of this approach).

SDWA Section 1412(b)(13)(E) directs EPA to take into account the costs and benefits of programs to reduce radon in indoor air when setting the MCL. In this regard, the Agency expects that implementation of a MMM program and CWS compliance with 4000 pCi/L will provide greater risk reduction for indoor radon at costs more proportionate to the benefits and commensurate with the resources of small CWSs. It is EPA's intent to minimize economic impacts on a significant number of small CWSs, while providing increased public health protection by emphasizing the more cost-effective multimedia approach for radon risk reduction.

B. Requirements for Large Systems Serving More Than 10,000 People

The proposal requires large community water systems, those serving populations greater than 10,000, to comply with the MCL of 300 pCi/L unless the State develops a State-wide MMM program, or the CWSs develops and implements a MMM program meeting the four regulatory requirements, in which case large systems may comply with the AMCL of 4,000 pCi/L. CWSs developing their own MMM plans will be required to submit these plans to their State for approval.

C. State Role in Approval of CWS MMM Program Plans

The SDWA provides that EPA will approve CWS MMM program plans. EPA has developed criteria to be used for approving MMM programs. EPA will review and approve State MMM program plans. CWS MMM program plans that address the criteria and are approved by the State are deemed approved by EPA. The proposed rule requires States that do not have a State-wide MMM program, as a condition of primacy for the radon regulation, to review MMM program plans submitted by CWSs and to approve plans meeting the four criteria for MMM programs discussed in Section VI of this preamble, including providing notice and opportunity for public comment on CWS MMM program plans. Under Section 1412(b)(13)(G)(vi) of SDWA, MMM program plans submitted by CWSs are to be subject to the same criteria and conditions as State MMM program plans. EPA will review CWS MMM program plans in non-primacy States, Tribes and Territories that do not have a state-wide MMM program, and approve them if they meet the four required criteria.

D. Background on Selection of MCL and AMCL

The SDWA directs that if the MCL for radon is set at a level more stringent than the level in drinking water that would correspond to the average concentration of radon in outdoor air, EPA must also set an alternative MCL at the level corresponding to the average concentration in outdoor air. Consistent with this requirement, EPA is proposing to set the AMCL at 4000 pCi/L. This level is based on technical and scientific guidance contained in the NAS Report (NAS 1999b) on the water-to-air transfer factor of 10,000 pCi/L in water to 1 pCi/L in indoor air and the average outdoor radon level of 0.4 pCi/L.

The SDWA generally requires that EPA set the MCL for each contaminant as close as feasible to the MCLG, based on available technology and taking costs to large systems into account. The 1996 amendments to the SDWA added the requirement that the Administrator determine whether or not the benefits of a proposed maximum contaminant level justify the costs based on the HRRCA required under Section 1412(b)(3)(C). They also provide new discretionary authority to the Administrator to set an MCL less stringent than the feasible level if the benefits of an MCL set at the feasible level would not justify the costs (SDWA section 1412(b)(6)(A)).

EPA is proposing to set the MCL at 300 pCi/L, in consideration of several factors. First, the Agency considered the general statutory requirement that the MCL be set as close as feasible to the MCLG of zero (SDWA section 1412(b)(4)), and its responsibility to protect public health. In addition, the radon-specific provisions of the amendments provide that, in promulgating a radon standard, the Agency take into account the costs and benefits of programs to control indoor radon (SDWA 1412(b)(13)(E). Although EPA believes that an MCL of 100 pCi/L would be feasible, EPA believes that consideration of the costs and benefits of indoor radon control programs allows the level of the MCL to be adjusted to a less stringent level than the Agency would set using the SDWA feasibility test. The proposed MCL of 300 pCi/L takes into account and relies on the unique conditions of this provision and the reality it reflects that the great preponderance of radon risk is in air, not water, and the much more cost-effective alternative to water treatment is to address radon in indoor air through the MMM program. The Agency recognizes that controlling radon in air will substantially reduce human health risk in more cost-effective ways than spending resources to control radon in drinking water. If most states adopted the MMM/AMCL option, EPA estimates the combined costs for treatment of water at systems exceeding the AMCL, developing a MMM program, and implementing measures to get risk reduction equivalent to national compliance with the MCL (62 avoided fatal cancer cases and 4 avoided non-fatal cancer cases per year) at $80 million, which is substantially less than the $407.6 million cost of achieving the MCL. EPA expects that most states will adopt the AMCL/MMM program option

While EPA believes it is appropriate to acknowledge the more cost-effective control program to a certain extent in setting the MCL, the Agency does not believe the cost-effectiveness is the sole determining factor. Rather, EPA believes the absolute level of risk to which members of the public may be exposed is also a key consideration in determining a standard that is protective of public health.

The Agency proposed an MCL of 300 pCi/L in 1991 based, in part, on its assessment of the health risk posed by radon in drinking water. It should be noted that the overall magnitude of risk estimated by the Agency at that time is in agreement with the overall risk of radon in drinking water currently estimated by the National Academy of Sciences (NAS 1999b). The Agency has a long-standing policy that drinking water standards should limit risk to within a range of approximately 10^{-4} to 10^{-6} and is thus proposing to use the flexibility provided by the authority in 1412(b)(13)(E) to propose an MCL of 300 pCi/L, which is approximately at the upper bound of the Agency's traditional risk range used for the drinking water program (representing an estimated 2 fatal cancers per 10,000 persons).

As noted earlier, the Administrator must publish a determination as to whether the benefits of the proposed MCL justify the costs, based on the Health Risk Reduction and Cost Analysis prepared in accordance with SDWA § 1412(b)(3)(C). Accordingly, the Administrator has determined that the benefits of the proposed MCL of 300 pCi/L justify the costs. The benefits of the proposed MCL, include about 62 avoided fatal lung cancer cases and 4 avoided non-fatal lung cancer cases annually. EPA has used a valuation of $5.8 million ($1997) to value the avoided fatal cancers and a valuation of $536,000 ($1997) to value the avoided non-fatal cancers. Multiplying these valuations by the estimated cancer cases avoided (62 fatal, 3.6 non-fatal) yields a benefits estimate of $362 million per year. The cost to achieve national compliance with an MCL of 300 pCi/L is estimated at $407.6 million per year. EPA expects the actual cost of the proposed rule to be significantly lower, since the expectation is that most systems will not need to comply with the MCL of 300 pCi/L. Costs would be about $80 million per year if the AMCL/MMM option is widely adopted by States.

There are also some potential non-quantified benefits, including customer peace of mind from knowing drinking water has been treated for radon and reduced treatment costs for arsenic for some water systems that have problems with both contaminants, and non-quantified costs, including increased risks from exposure to disinfection byproducts, permitting and treatment of radon off-gassing, anxiety on the part of residents near treatment plants and customers who may not have previously been aware of radon in their water, and safety measures necessary to protect treatment plant personnel from exposure to radiation. However, in this case it is not likely that accounting for these non-quantifiable benefits and costs quantitatively would significantly alter the overall assessment. Taking both quantified and non-quantified benefits into account, EPA has determined that the costs are justified by the benefits. Accordingly, the new authority to set a less stringent MCL if benefits do not justify costs is not applicable and has not been used in this proposal.

Although the central tendency estimate of monetized costs exceeds the central tendency estimate of monetized benefits, the determination that benefits justify costs is consistent with the legislative history of this provision, which makes clear that this determination whether benefits ''justify'' costs is more than a simple arithmetic analysis of whether benefits ''exceed'' or ''outweigh'' costs. The determination must also ''reflect the non-quantifiable nature of some of the benefits and costs that may be considered. The Administrator is not required to demonstrate that the dollar value of the benefits are greater (or lesser) than the dollar value of the costs.'' [Senate Report 104–169 on S. 1316, p. 33] The determination is based on the analysis conducted under SDWA § 1412(b)(3)(C), in the Health Risk Reduction and Cost Analysis (HRRCA) published for public comment on February 26, 1999 (64 FR 9559), revised in response to public comment, and available as part of the Regulatory Impact Analysis (1999n) in the public docket to support this rulemaking. The costs and benefits of the proposed rule, and the methodologies used to calculate them, are discussed in detail in section XII of this preamble and in the Regulatory Impact Analysis (1999n).

In making this determination, EPA also considered the special nature of the radon standard, which provides an alternate MCL of 4000 pCi/L for states or water systems that adopt a MMM program designed to produce equal or greater risk reduction benefits to compliance with the MCL by promoting voluntary public action to mitigate radon in indoor air. As noted previously, mitigation of radon in indoor air is much more cost-effective than mitigation of radon in drinking water. If most states adopted the MMM/AMCL option, EPA estimates the combined costs for treatment of water at systems exceeding the AMCL, developing a MMM program, and implementing measures to get risk reduction equivalent to national compliance with the MCL (62 avoided fatal cancer cases and 4 avoided non-fatal cancer cases per year) at $80 million, which is substantially less than the $407.6 million cost of achieving the MCL.

In its valuation of costs and benefits for the MMM program, EPA has assumed that adopting the MMM approach will achieve only benefits equivalent to those for meeting the MCL and has calculated the costs and benefits of the proposed rule on this basis. However, EPA expects that adoption of MMM programs will be widespread as a result of this rule and that the actual benefits realized will be far greater than those associated with meeting the MCL. In addition, EPA fully expects most States to follow the MMM approach, therefore CWSs below the AMCL will incur minimal costs and a much smaller subset of CWSs will incur costs to meet the AMCL. Thus, costs for meeting the MCL are a theoretical worst case scenario which the Agency believes will not occur, particularly since the regulatory expectation for water systems serving 10,000 people or fewer would be that they meet the 4000 pCi/L AMCL, along with implementation of a local MMM program. Although in some cases small CWSs may choose to meet the MCL of 300 pCi/L through water treatment, this is voluntary and not a requirement of the proposed regulation.

The Agency also considered the costs, benefits, and risk reduction potential of radon levels at 100 pCi/l, 500 pCi/L, 1000 pCi/L, 2000 pCi/L and 4000 pCi/L. As table VII.1 illustrates, the costs and benefits increase as the radon level increases. The quantified costs somewhat exceed the quantified benefits at each level, but the benefit-cost ratios are similar. However, the difference between costs and benefits becomes somewhat larger as the various MCL options become more stringent, with the largest difference at 100 pCi/L. When the uncertainty of the estimates is factored in, there is overlap in the benefit and cost estimates at all evaluated options. For more information on this analysis, please refer to the Regulatory Impact Analysis (RIA) for this proposal (USEPA, 1999n).

TABLE VII.1.—EVALUATION OF RADON LEVELS

Radon level (pCi/L)	Fatal cancer cases avoided	Individual fatal lifetime cancer risk	Cost per fatal cancer case avoided ($M)	Total national costs [1] $M	Monetized benefits [1] $M	Benefit-cost ratio
4000	2.9	26.8 in 10,000	14.9	43.1	17.0	0.4
2000	7.3	13.4 in 10,000	9.5	69.7	42.7	0.6
1000	17.8	6.7 in 10,000	7.3	130.5	103	0.8
500	37.6	3.35 in 10,000	6.8	257.4	219	0.9
300	62.0	2.0 in 10,000	6.6	407.6	362	0.9
100	120.0	0.67 in 10,000	6.8	816.2	702	0.9

[1] Water Mitigation only; assuming 100% compliance with MCL. Source: revised HRRCA.

Some commenters recommended that EPA give serious consideration to setting an MCL at the AMCL level (4000 pCi/L), or at least at a level substantially above 300 pCi/L, in order to control radon levels in drinking water at a level more comparable to outdoor background levels. This approach was also discussed by the Small Business Advocacy Review Panel convened for this rule under the RFA as amended by SBREFA. (A copy of the Panel's final report is available in the docket for this rule making, (USEPA, 1998c).)

As noted earlier, EPA's interpretation of the standard-setting requirements of the SDWA for radon are that they rely primarily upon the general standard-setting provisions for National Primary Drinking Water Regulations, with some additional radon-specific provisions. The general provisions require that the MCL be set as close as feasible to the MCLG. The radon-specific provisions direct the Administrator to take into account the costs and benefits of control programs for radon from other sources. As discussed, EPA is interpreting these general and radon-specific authorities to propose an MCL above the feasible level, near the upper end of the risk range traditionally used by the Agency in setting drinking water standards. In addition, EPA believes that the extensive statutory detail enacted on multimedia mitigation illustrates a congressional preference for cost-effective compliance through the AMCL/MMM program approach. EPA notes that the equal or greater risk reduction required to be achieved through the AMCL/MMM option would be diminished as the MCL approaches the AMCL of 4,000 pCi/L and that fewer States and CWSs would select this option. Further, the AMCL/MMM approach would be eliminated entirely if the MCL were set at the AMCL.

As noted previously, EPA believes the proposed MCL of 300 pCi/L, in combination with the proposed AMCL and MMM approach, accurately and fully reflects the SDWA provisions. The Agency recognizes , however, that some stakeholders may have strong views about the appropriateness of setting an MCL at a higher level. Accordingly, EPA requests comment on the option of setting the MCL closer to or at the AMCL level of 4000 pCi/L. In this connection, the Agency also requests comments on and the rationale for how such alternative options could be legally supported under the SDWA and in the record for this rulemaking, in light of the considerations EPA has applied for the MCL it proposes.

EPA solicits comment on the proposed MCL and AMCL and the Agency's rationale, and on other appropriate MCLs given these considerations, and the rationale for alternative levels. In the final rule, the Agency may select a higher or lower option from those analyzed in the HRRCA for the final radon rule without further public comment.

E. Compliance Dates

The proposed time line for compliance with the radon rule is described next and illustrated in Figure VII.1.

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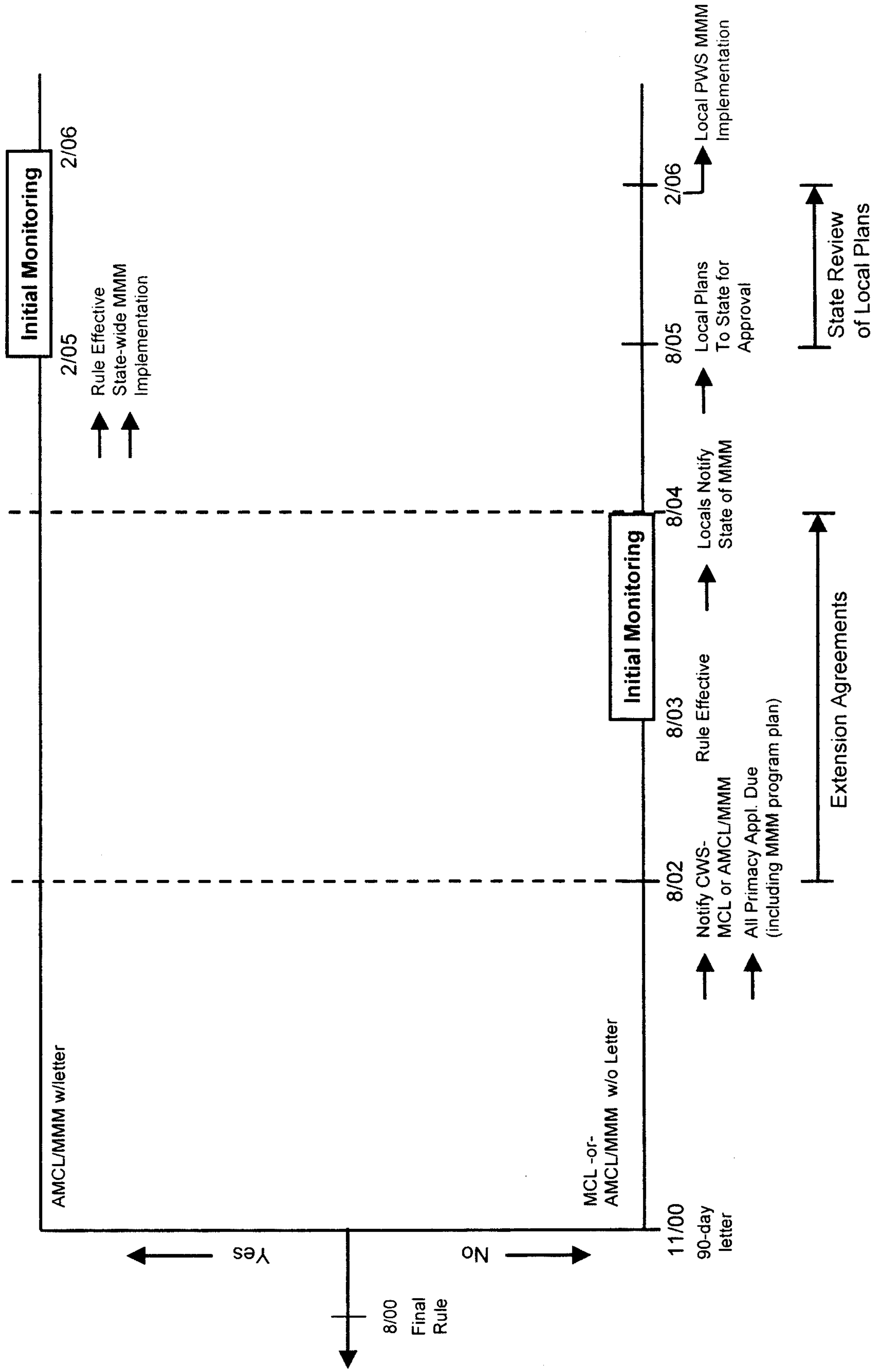
FIGURE VII.1

Timeline for Compliance (Radon)



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States are required to submit their primacy revision application packages by two years from the date of publication of the final rule in the **Federal Register**. For States adopting the AMCL, EPA approval of a State's primacy revision application is contingent on submission of and EPA approval of the State's MMM program plan. Therefore, EPA is proposing to require submission of State-wide MMM program plans as part of the complete and final primacy revision application. This will enable EPA to review and approve the complete primacy application in a timely and efficient manner in order to provide States with as much time as possible to begin to implement MMM programs. In accordance with Section 1413(b)(1) of SDWA and 40 CFR 142.12(d)(3), EPA is to review primacy applications within 90 days. Therefore, although the SDWA allows 180 days for EPA review and approval of MMM program plans, EPA expects to review and approve State primacy revision applications for the AMCL, including the State-wide MMM program plan, within 90 days of submission to EPA.

EPA is proposing that CWSs begin their initial monitoring requirements (one year of quarterly monitoring) for radon by 3 years after publication of the final rule in the **Federal Register**, except for CWSs in States that submit a letter to the Administrator committing to develop an MMM program plan in accordance with Section 1412 (b)(13)(G)(v). For CWSs in these States, one year of quarterly monitoring is proposed to begin 4.5 years after publication of the final rule. The proposed rule allows systems to use grandfathered data collected after the proposal date to satisfy the initial monitoring requirements provided the monitoring and analytical methods employed satisfy the regulations set forth in the rule and the State approves. Systems opting to conduct early monitoring will not be considered in violation of the MCL/AMCL until after the initial monitoring period applicable to their State (*i.e.,* 4 years after publication of the final rule, 5.5 years after publication of the final rule).

The routine and reduced monitoring requirements were developed to be consistent with the Standardized Monitoring Framework (SMF) and the Phase II/V monitoring schedule. EPA believes this is valuable for States and systems by providing sampling efficiency and organization, therefore, EPA has tried to adapt the compliance dates so that States and systems can make a smooth transition into the SMF following the initial monitoring requirements. The necessity to complete the initial monitoring in a timely manner is driven by the need for systems in non-MMM States to evaluate their compliance options, including development of a local MMM program and compliance with the AMCL), and for systems in MMM States to ensure compliance with the AMCL.

EPA feels it is important to set time constraints on implementation of the MMM plans to ensure the equal or greater risk reduction resulting from multimedia mitigation. Therefore, the rule must allow the systems in non-MMM States enough time to develop their MMM program plan with technical assistance from the State and submit the plan for State approval. In addition, the State must have sufficient time to review and approve the local plans. If the compliance determination for a system in a non-MMM State exceeds the MCL during the initial monitoring period, the proposed rule requires these systems to notify the State of their intention to develop a local MMM program at the completion of initial monitoring, 4 years after publication of the final rule. The local MMM program plans must be submitted to the State for approval by 5 years after of publication of the final rule (*i.e.,* 12 months after the completion of initial monitoring) and the States have 6 months from the submittal date to review and approve or disapprove the plan. The system will begin implementation of their MMM program 5.5 years after publication of the final rule (*i.e.,* 1.5 years after the completion of initial monitoring). If the State fails to review and disapprove the local MMM program in the time allowed, the system will begin implementation of the submitted plan. If the system fails to comply with these compliance dates, a MCL violation will apply from the date of exceedence. If the compliance determination for a system choosing to comply with the MCL exceeds the MCL following the completion of the initial monitoring period, the system will have the option to submit a local MMM plan to the State within 1 year from the date of the exceedence and begin implementation 1.5 years from the date of the exceedence or incur a MCL violation.

Implementation of State-wide MMM programs must begin 3 years after publication of the final rule, unless the State submits a letter to the Administrator committing to develop an MMM program plan in accordance with Section 1412 (b)(13)(G)(v) of the SDWA. States submitting this letter must implement their State-wide MMM program plan by 4.5 years after publication of the final rule. EPA feels it is extremely important that the MMM program plans be completed on a schedule that allows States sufficient time to begin implementation by the compliance date to ensure that equal or greater risk reduction benefits are provided.

EPA recognizes potential issues may arise as a result of the proposed initial monitoring schedule. The potential issues include lab capacity and a temporary deviation from the SMF schedule. EPA is requesting comment on alternatives to avoid or lessen the impact of these issues and other issues not listed here.

EPA considers the proposed monitoring schedule to be acceptable since the proposed rule affects one contaminant and applies to a smaller universe of water systems (NTNCWSs, transient systems, and CWSs relying solely on surface water are not covered by the rule) which decreases the number of systems effected, and therefore lessens the impacts of the potential issues. An alternative initial monitoring scenario which was considered would specify early monitoring requirements for systems serving more than 10,000 people. This scenario would put additional burden on the States and systems to monitor early and it would not substantially ease the workload since the number of systems serving greater than 10,000 that use groundwater or groundwater under the direct influence of surface water is relatively small.

Initial monitoring could be phased in over a period of two or three years, but EPA does not feel it is appropriate to extend the initial monitoring period due to the necessity to evaluate the need to develop and implement local MMM program plans. In MMM States, systems must be in compliance with the AMCL in a timely manner to ensure the maximum risk reduction.

In consideration of all these factors, EPA is proposing to require the initial monitoring over a one-year period as specified earlier. However, systems opting to conduct early monitoring will not be considered in violation of the MCL/AMCL until after the initial monitoring period applicable to their State (*i.e.,* 4 years after publication of the final rule, 5.5 years after publication of the final rule). However, CWSs opting to conduct early monitoring will not be considered in violation of the MCL/AMCL until after the initial monitoring period applicable to their State (*i.e.,* 4 years after publication of the final rule, 5.5 years after publication of the final rule. It is EPA's strong recommendation that all States choose to adopt the AMCL and implement an MMM program. But some States may elect to adopt the MCL or may decide later to adopt the AMCL/MMM approach. In these states, the initial monitoring will be required to begin by 3 years after publication of the final rule, whereas in States submitting the 90-day letter committing to develop an MMM program plan will begin initial monitoring 4.5 years after publication of the final rule.

VIII. What Are the Requirements for Testing for and Treating Radon in Drinking Water?

A. Best Available Technologies (BATs), Small Systems Compliance Technologies (SSCTs), and Associated Costs

1. Background

Section 1412(b)(4)(E) of the Act states that each national primary drinking water regulation which establishes an MCL shall list the technology, treatment techniques, and other means which the Administrator finds to be feasible for purposes of meeting the MCL. In addition, the Act states that EPA shall list, if possible, affordable small systems compliance technologies (SSCTs) that are feasible for the purposes of meeting the MCL. In order to fulfill these requirements, EPA has identified best available technologies (BAT) and SSCTs for radon.

(a) Proposed BAT. Technologies are judged to be BAT when they are able to satisfactorily meet the criteria of being capable of high removal efficiency; having general geographic applicability, reasonable cost, and a reasonable service life; being compatible with other water treatment processes; and demonstrating the ability to bring all of the water in a system into compliance. The Agency proposes that, of the technologies capable of removing radon from source water, only aeration fulfills these requirements of the SDWA for BAT determinations for this contaminant. The full range of technical capabilities for this proposed BAT is discussed in the EPA Technologies and Costs document for radon (USEPA 1999h). Table VIII.A.1 summarizes the BAT findings by EPA for the removal of the subject drinking water contaminants, including a summary of removal capabilities.

TABLE VIII.A.1—PROPOSED BAT AND ASSOCIATED CONTAMINANT REMOVAL EFFICIENCIES

High Performance Aeration[1].	Up to 99.9% Removal.

Note: (1) High Performance Aeration is defined as the group of aeration technologies that are capable of being designed for high radon removal efficiencies, *i.e.,* Packed Tower Aeration, Multi-Stage Bubble Aeration and other suitable diffused bubble aeration technologies, Shallow Tray and other suitable Tray Aeration technologies, and any other aeration technologies that are capable of similar high performance.

Granular activated carbon (GAC) can also remove radon from water, and was evaluated as a potential BAT and a potential small systems compliance technology for radon. Since GAC removes radon less efficiently than it does organic contaminants, it generally requires designs that use larger quantities of carbon per volume of water treated to remove radon compared to contaminants for which GAC is BAT. This requirement for larger carbon amounts translates to much higher treatment costs for GAC radon removal. In fact, full-scale application of GAC for radon removal has been limited to installations at the household point-of-entry and for centralized treatment for very small communities (AWWARF 1998a). EPA has determined that the requirements for radon removal render it infeasible for large municipal treatment systems, and it is therefore not considered a BAT for radon. However, GAC and point-of-entry (POE) GAC may be appropriate for very small systems under some circumstances, as described next (USEPA 1999h, AWWARF 1998a, AWWARF 1998b).

(b) Proposed Small Systems Compliance Technologies. The 1996 Amendments to SDWA recognize that BAT determinations may not address many of the problems faced by small systems. In response to this concern, the Act specifically requires EPA to make technology assessments relevant to the three categories of small systems respectively for both existing and future regulations. These requirements are in addition to EPA's obligation, unchanged by the SDWA as amended in 1996, to designate BAT. The three population-served size categories of small systems defined by the 1996 SDWA are: 10,000—3,301 persons, 3,300—501 persons, and 500—25 persons. These evaluations include assessments of affordability and technical feasibility of treatment technologies for each class of small system. Table VIII.A.2, ''Proposed Small Systems Compliance Technologies (SSCTs) and Associated Contaminant Removal Efficiencies'', lists the proposed small systems compliance technologies for radon and summarizes EPA's findings regarding affordability and technical feasibility for the evaluated technologies. EPA has interpreted the SSCTs as equivalent to BATs under Section 1415 of the Act, for the purposes of small systems (those serving 10,000 persons or fewer) applying to primacy agencies for Section 1415(a) variances.

TABLE VIII.A.2.— PROPOSED SMALL SYSTEMS COMPLIANCE TECHNOLOGIES (SSCTS)[1] AND ASSOCIATED CONTAMINANT REMOVAL EFFICIENCIES

Small systems compliance technology	Affordable listed small systems categories[2]	Removal efficiency	Operator level required[3]	Limitations (see footnotes)
Packed Tower Aeration (PTA)	All Size Categories	90– > 99.9% Removal	Intermediate	(a)
High Performance Package Plant Aeration (*e.g.*, Multi-Stage Bubble Aeration, Shallow Tray Aeration).	All Size Categories	90– > 99.9% Removal	Basic to Intermediate.	(a)
Diffused Bubble Aeration	All Size Categories	70 to > 99% removal	Basic	(a, b)
Tray Aeration	All Size Categories	80 to > 90%	Basic	(a, c)
Spray Aeration	All Size Categories	80 to > 90%	Basic	(a, d)
Mechanical Surface Aeration	All Size Categories	> 90%	Basic	(a, e)
Centralized granular activated carbon	May not be affordable, except for very small flows.	50 to > 99% Removal	Basic	(f)

TABLE VIII.A.2.— PROPOSED SMALL SYSTEMS COMPLIANCE TECHNOLOGIES (SSCTS) [1] AND ASSOCIATED CONTAMINANT REMOVAL EFFICIENCIES—Continued

Small systems compliance technology	Affordable listed small systems categories [2]	Removal efficiency	Operator level required [3]	Limitations (see footnotes)
Point-of-Entry (POE) granular activated carbon.	May be affordable for systems serving fewer than 500 persons..	50 to > 99% Removal	Basic	(f, g)

Notes: [1] The Act (Section 1412(b)(4)(E)(ii)) specifies that SSCTs must be affordable and technically feasible for small systems.

[2] This section specifies three categories of small systems: (i) those serving 25 or more, but fewer than 501, (ii) those serving more than 500, but fewer than 3,301, and (iii) those serving more than 3,300, but fewer than 10,001.

[3] From National Research Council. Safe Water from Every Tap: Improving Water Service to Small Communities. National Academy Press. Washington, DC. 1997.

Limitations: (a) Pre-treatment to inhibit fouling may be needed. Post-treatment disinfection and/or corrosion control may be needed.

(b) May not be as efficient as other aeration technologies because it does not provide for convective movement of the water, which reduces the air:water contact. It is generally used in adaptation to existing basins.

(c) Costs may increase if a forced draft is used. Slime and algae growth can be a problem, but may be controlled with chemicals, e.g., copper sulfate or chlorine.

(d) In single pass mode, may be limited to uses where low removals are required. In multiple pass mode (or with multiple compartments), higher removals may be achieved.

(e) May be most applicable for low removals, since long detention times, high energy consumption, and large basins may be required for larger removal efficiencies.

(f) Applicability may be restricted to radon influent levels below around 5000 pCi/L to reduce risk of the build-up of radioactive radon progeny. Carbon bed disposal frequency should be designed to allow for standard disposal practices. If disposal frequency is too long, radon progeny, radium, and/or uranium build-up may make disposal costs prohibitive. Proper shielding may be required to reduce gamma emissions from the GAC unit. GAC may be cost-prohibitive except for very small flows.

(g) When POE devices are used for compliance, programs to ensure proper long-term operation, maintenance, and monitoring must be provided by the water system to ensure adequate performance.

(c) Approaches for Listing Small Systems Compliance Technologies (SSCTs). EPA has considered several options for the listing of SSCTs in the proposed rule for radon. The issue is how to list SSCTs with BAT in the rule, while at the same time allowing for flexible and timely updates to the list of SSCTs in the future.

EPA would like to establish a procedure that allows SSCT lists to be updated by guidance, rather than through the more resource intensive and time-consuming process of rule-making. For example, under today's proposal, EPA is including SSCT lists in the rule. This approach fully satisfies the requirements in Section 1412(b)(4)E(ii) of the Act, which states that EPA shall include SSCTs in lists of BAT for meeting the MCL. Since BATs are explicitly listed in rules, it is consistent to explicitly list SSCTs. Also, Section 1415(a) of the Act requires that BAT be proposed and promulgated with NPDWRs to satisfy the provisions for ''general variances'' (variances under Section 1415(a)); therefore, SSCTs must be listed in the rule if small systems are to be allowed to use them as BAT in satisfying the provisions for general variances.

Regarding updates to the list of SSCTs, Section 1412(b)(9) of the Act states that EPA shall review and revise, as appropriate, all promulgated NPDWRs every six years. However, since revisions of NPDWRs follow the normal rule-making process of proposing, taking public comment, and finalizing the rule, the process can be very time-consuming. While EPA believes that this six year review cycle is sufficient for updates to lists of BAT, it is unlikely to be sufficient for updates to lists of SSCTs, since recent improvements in package plant technologies, POE/POU devices, and remote monitoring/control technologies have been fairly rapid and future improvements seem imminent. For this reason, EPA seeks comment on this approach or alternate approaches that would allow for more timely updates to the list of SSCTs.

In support of an approach to SSCT list updates that is less formal and more expeditious than rulemaking, EPA notes that new Section 1412(b)(4)(E)(iv) allows the Administrator, after promulgating an NPDWR, to ''supplement the list of technologies describing additional or new or innovative treatment technologies that meet the requirements of this paragraph for categories of small public water systems.'' This provision does not contain any reference to or require rulemaking to update the SSCT list, in contrast with the earlier 1994 House version (in H.R. 3392) of this provision that specifically required revisions of the list to be made ''by rule.''

Under one alternative, EPA would publish only an initial list of SSCTs with the BAT list in 40 CFR 141.66. EPA would also state in the rule that updates to the list of SSCTs would be done through guidance published in the **Federal Register** or through updates to the SSCT guidance manual. This process would be consistent with the process already used for listing SSCTs for the currently regulated drinking water contaminants (USEPA 1998g). A similar alternative approach would simply ''list'' SSCTs in Section 141.66 by referencing EPA guidance, which would be published separately and which could be updated periodically as needed outside of the normal rule-making process. Finally, EPA could publish both the initial list and the updates solely in a **Federal Register** notice or as guidance; however, under this last approach, only the promulgated BAT listed in the rule (which would not include SSCTs) would be available for small systems seeking a general variance under Section 1415(a) of the Act. EPA solicits comments on the suggested approaches for the listing of SSCTs and on the equivalency of SSCTs with BAT for the purposes of small systems applying for variances under Section 1415 of the Act.

(d) Small Systems Affordability Determinations. The affordability determinations that are used for listing SSCTs are discussed in detail in recent EPA publications (USEPA 1998i, USEPA 1998e). It should be noted that aeration is one of the least expensive treatment technologies for drinking water (USEPA 1993d, NRC 1997) and has been determined to be affordable for all three small systems size categories. For the smallest size category (serving 25 to 500 persons), EPA cost estimates indicate that typical annual household

costs for aeration (80% removal efficiency, with disinfection and scaling inhibitor) are $190 per household per year ($/HH/yr). For systems installing aeration only, household costs for the smallest system size category are $114 per household per year. Case studies (n=9, USEPA 1999h) for systems with aeration serving between 25 and 500 persons showed annual household costs ranging from $5 to $97 per household per year, with an average of $45 per household per year. Costs reported in these case studies included all pre- and post-treatments added with aeration. The ''national average per household cost'' estimated in the Regulatory Impact Analysis is $260 per household per year for 25–500 persons. This average per household cost is higher than the estimated per household costs for systems using aeration since these average costs include not only aeration, but also the more expensive compliance alternatives (GAC, regionalization, and ''high side'' PTA). Note that the cost for the 25–500 category is a weighted average of the per household costs for the 25–100 and 101–500 categories reported in Table 7–2 of the Regulatory Impact Analysis. Also note that monitoring costs of approximately $4.00 per household per year ($270 per system) are included in the national average per household costs, but not in the aeration treatment per household costs reported.

Granular activated carbon (GAC) may be affordable only for very small flows. EPA's GAC-COST model estimates indicate that GAC may not be affordable for the smallest size category (25–500 persons served) in whole. Annual household costs are estimated to be approximately $800 to > $1000 per household per year. However, case studies of small systems using GAC to remove radon for very small flows (populations served < 100 persons) show annual household costs ranging from $46 to $77 per household per year. The large discrepancy between modeled costs and full-scale case study costs is probably due to the fact that the model design assumptions are more typical of larger systems, whereas the designs used in the case studies are much simpler. The American Water Works Association Research Foundation (AWWARF 1998a) similarly concludes that EPA's cost estimates for radon removal by GAC are over-estimates (ibid., p. 190) and that GAC can be cost competitive with aeration for very small systems (*ibid*., Chapter 8). Examples of estimates of POE-GAC capital costs are shown in the next section, ''Treatment Costs''.

2. Treatment Costs: BAT, Small Systems Compliance Technologies, and Other Treatment

(a) Modeled Treatment Unit Costs. Total production costs associated with the various technological options for radon reduction, such as packed tower aeration and diffused bubble aeration installations, have been examined (USEPA 1999h). For systems that are currently disinfecting, ninety-nine percent reduction of radon by PTA is estimated to cost from $2.48/kgal (dollars per 1,000 gallons treated) for the smallest systems, defined as those serving 100 persons or fewer, to $ 0.12/kgal for large systems, defined as those serving up to 1,000,000 persons. Eighty percent reduction of radon by PTA without disinfection is estimated to range from $2.10/kgal to $0.08/kgal for the same system sizes. For those systems adding disinfection because of the addition of aeration treatment, disinfection treatment costs for very small systems are estimated at an additional $1.40/kgal and costs for large systems are estimated at an additional $0.07/kgal. Aeration production costs have been adjusted to include costs that account for the addition of a chemical stabilizer (orthophosphate) by 25 percent of small systems (those serving 10,000 persons or fewer) and by 15 percent of large systems. In other words, the production costs shown are weighted averages that simulate the installation of aeration without chemical stabilizers by a fraction of the systems and with chemical stabilizers by the remaining fraction. Chemical stabilizers are used to minimize fouling from iron and manganese and/or to reduce corrosivity to the distribution system. Chemical addition cost estimates include capital costs for feed systems and operations and maintenance costs for the processes involved. Table VII.A.3 summarizes total production costs for system size categorizes for 80 percent radon removal. Further details on costing assumptions and breakdown of the unit treatment costs can be found in the RIA (USEPA 1999h).

TABLE VIII.A.3.—TOTAL PRODUCTION COST[1] OF CONTAMINANT REMOVAL BY BAT FOR 80 PERCENT RADON REMOVAL (DOLLARS/1,000 GALLONS, LATE 1997 DOLLARS)

	Population Served					
	25–100	100–500	500–1,000	1,000–3,300	3,300–10,000	>10,000
Aeration[2]	2.06	0.71	0.39	0.22	0.15	0.08–0.10
Aeration + disinfection	3.44	1.09	0.69	0.40	0.22	0.09–0.12
Granular Activated Carbon (GAC)	0.34	2.16	2.16	NA	NA	NA
GAC + disinfection	1.71	2.54	2.46	NA	NA	NA
POE GAC + UV disinfection	16.99	14.03	NA	NA	NA	NA

Notes:
[1] Cost ranges are estimated from cost equations found in the radon Technologies and Costs document (EPA 1999h), as used in the radon HRCCA (64 FR 9559).
[2] Aeration costs are weighted to include chemical inhibitor costs (Fe/Mn and corrosion control) for 25 percent of small systems and 15 percent of large systems.

(b) Case Studies of Treatment Unit Costs. Case studies for aeration and GAC are reported in detail in the radon Technologies and Costs document (USEPA 1999h). Total production costs for aeration case studies ranged from an average of $0.82/kgal for systems serving 25—100 persons (n = 4, standard deviation = $0.32/kgal, average population = 58) to $0.19/kgal for systems serving 100—3,300 persons (n = 11, standard deviation = $0.22/kgal, average population = 873). Total production costs for GAC ranged from $1.50/kgal for systems serving fewer than 100 persons (n = 2, standard deviation = $0.48/kgal, average population = 55) to $0.40/kgal for a system serving approximately 23,000 persons. Production costs for two POE GAC installations ranged from $0.21/

kgal to $0.75/kgal. It should be noted that these POE GAC costs do not include the additional monitoring costs that would apply in a compliance situation. Annual monitoring costs are generally negligible compared to annual treatment costs for centralized treatment (<2.5 percent for very small systems to <1 percent for large systems), and may be significant in the case of POE treatment (USEPA 1998g). For this reason, the POE GAC case study production costs may under-estimate true POE GAC costs. In general, the case studies suggest that EPA's modeled unit costs may be conservative for small systems. Since it is true that the radon case studies are not necessarily a random sample of all systems that will be impacted by the future radon rule, it may be argued that the typical reported costs may differ significantly from the typical costs of compliance. However, the costs of aeration from the radon case studies overlap nicely with the costs reported in the VOCs case studies, which should represent typical costs of compliance. Given this fact and the large number of case studies used, EPA has confidence that the case studies represent a best estimate of costs of treatment for compliance purposes. It should be noted that these reported case study costs are total costs and include all pre- and post-treatments added with the radon treatment process.

(c) Treatment Cost Assumptions and Methodology. The general assumptions used to develop the treatment costs include costs for: chemicals and general maintenance, labor, capital amortized over 20 years at a 7 percent interest rate, equipment housing, associated engineering and construction, land for small systems (design flow < 1 mgd per well), and power and fuel (USEPA 1998h, USEPA 1998g, USEPA 1999h). Costs were updated to December 1997 dollars using a standard construction cost index (Engineering News-Record Construction Cost Index). Process capital costs for aeration technologies were calculated using updated cost equations from the Packed Tower Column Air Stripping Cost Model (USEPA 1993e). Process capital costs for granular activated carbon and total capital costs for iron and manganese sequestration/corrosion control, and disinfection were calculated using standard EPA models (as described in USEPA 1998e and USEPA 1999a). Construction, engineering, land, permitting, and labor costs were estimated based upon recommendations from an expert panel comprised of practicing water design and costing engineers from professional consulting companies, utilities, State and Federal agencies, and public utility regulatory commissions (USEPA 1998i). GAC disposal costs are included in the GAC-COST O&M model. All cost estimates include capital costs for equipment housing and land for small systems (design flows < 1.0 MGD). It was assumed that all treatment installations would include disinfection. Capital and operating & maintenance costs for iron and manganese (Fe/Mn) sequestration by the addition of zinc orthophosphate were included for 25 percent of small systems and 15 percent of large systems. Pre- and post-treatment assumptions are explained in more detail later.

(d) ''Decision Tree''. Compliance costs were estimated assuming that non-compliant water systems would choose from a variety of compliance options, including installing a suitable treatment train, finding an alternate source of water, purchasing water from a near-by water utility, and using best management practices, like blending or ventilated storage. The modeled proportions of systems choosing a compliance pathway (the ''decision tree'') is based on the assumption that systems will choose the most cost-effective alternative, given the fact that site-specific factors (*e.g.*, a well located in a suburban residential area) may force some systems to choose an option that is more expensive than the least cost alternative. The modeled proportions were assumed to vary by system size and water quality. More details on these assumptions are found in the Health Risk Reduction and Cost Analysis supporting this proposal (64 FR 9559).

(e) Iron and Manganese Assumptions. Treatment costs assume that 25 percent of small systems and 15 percent of large systems installing aeration will need to add an additional chemical inhibitor (*e.g.*, orthophosphate, polyphosphates, silicates, *etc.*) to minimize the formation of iron/manganese (Fe/Mn) precipitates and carbonate scale; to reduce bio-fouling from the growth of Fe/Mn oxidizing bacteria (See, *e.g.*, Faust and Aly 1998); and to reduce water corrosivity. Although zinc orthophosphate was assumed to be universally used, this was done as a simplifying costing assumption, and should not interpreted as suggesting that zinc orthophosphate is the appropriate inhibitor choice for all circumstances. Uncertainty analyses were performed in national cost estimates to simulate a range of choices of chemical inhibitors by systems and to simulate a range in the percentages of systems requiring the addition of an inhibitor. It is reiterated that, for the purposes of iron/manganese control and corrosion control, other chemical inhibitors may be more appropriate than zinc orthophosphate on a case by case basis.

(f) Iron and Manganese Occurrence. Tables VIII.A.4 and VIII.A.5 show the estimated co-occurrence of radon with dissolved iron and manganese in raw ground water for various radon and Fe/Mn levels. It can be seen from these tables (based on the U.S. Geological Survey's National Water Information System database, ''NWIS'') that the majority of ground water systems will be expected to have Fe/Mn source water levels below the secondary MCLs (SMCLs) for iron (greater than 85 percent of GW samples have less than the SMCL of 0.3 mg/L) and manganese (greater than 75 percent of GW systems have less than the SMCL of 0.05 mg/L). Since Fe/Mn precipitation inhibitors are appropriate for treating combined Fe/Mn levels up to around 1–2 mg/L (Faust and Aly 1998, USEPA 1999h), this data indicates that the vast majority of ground water systems (greater than 95 percent) will be expected to be in situations where inhibitors are sufficient for handling iron and manganese problems. The cost estimates conservatively assume that inhibitors will also be used by systems with source water below the SMCLs for iron and manganese. Systems with Fe/Mn levels above 1–2 mg/L may require oxidation/filtration or a similar removal technology. However, it should be noted that Fe/Mn levels this high may cause very noticeable nuisance problems, including ''red water'', noticeable turbidity, laundry and sink staining, and interference with the brewing of tea and coffee. It is likely that many systems with source water Fe/Mn levels this high will have already addressed this problem.

TABLE VIII.A.4.— CO-OCCURRENCE OF RADON WITH DISSOLVED IRON IN RAW GROUND WATER[1, 2] (4188 SAMPLES)

Radon (pCi/L)	Dissolved Fe (mg/L) (percent)					
	ND	<0.3	0.3–1.5	1.5–2.5	>2.5	Totals
ND	0.67	0.36	0.21	0.02	0.31	1.57
<100	2.17	1.72	0.53	0.12	0.48	5.02
100–300	7.55	10.20	2.67	1.34	1.74	23.50
300–1,000	18.89	22.61	[3] 3.08	0.57	1.31	46.46
1,000–3,000	6.42	9.05	0.74	0.10	0.62	16.93
>3,000	2.10	3.82	0.31	0.02	0.26	6.51
Totals	37.80	47.76	7.54	2.17	4.72	100.00

Notes:
[1] Based on analyses as described in USEPA 1999c.
[2] The USGS National Water Information System (NWIS) database was used for this analysis.
[3] Shaded area denotes region where radon level is above MCL and dissolved iron is above 0.3 mg/L, the secondary MCL for iron.

TABLE VIII.A.5.—CO-OCCURRENCE OF RADON WITH DISSOLVED MANGANESE IN RAW GROUND WATER [1, 2] (4189 SAMPLES)

Radon (pCi/L)	Dissolved Mn (mg/L) (percent)				
	ND	<0.02	0.02–0.05	>.050	Totals
ND	0.69	0.26	0.05	0.57	1.57
<100	2.67	0.84	0.36	1.15	5.02
100–300	8.00	5.97	2.20	7.33	23.50
300–1,000	21.99	11.84	3.17	[3] 9.48	46.48
1,000–3,000	6.45	5.90	1.24	3.34	16.93
>3,000	1.43	3.39	0.53	1.17	6.52
Totals	41.23	28.20	7.55	23.04	100.00

Notes: [1] and [2]: See Table VIII.A.4.
[3] Shaded area denotes region where radon level is above MCL and dissolved manganese is above 0.05 mg/L, the secondary MCL for manganese.

A similar analysis of the National Inorganic and Radionuclides Survey (NIRS) database, which sampled finished ground water, suggests that greater than 81 percent of GW systems sampled have dissolved Fe/Mn levels less than 0.3 mg/L and greater than 97 percent of systems sampled have levels less than 1.5 mg/L (USEPA 1999h). Table VIII.A.6 compares combined Fe/Mn levels predicted by the NIRS database to occur in finished ground water with levels predicted by NWIS to occur in raw ground water. This table is consistent with expectations that the vast majority of ground water systems will have combined Fe/Mn levels below 1–2 mg/L and that a significant fraction of ground water systems with Fe/Mn levels above the SMCL are already taking measures to reduce Fe/Mn levels.

TABLE VIII.A.6.—CO-OCCURRENCE OF RADON WITH DISSOLVED COMBINED IRON AND MANGANESE IN RAW AND FINISHED GROUND WATER

Ground water type	Percent of samples with dissolved combined Fe and Mn (mg/L) (percent)		Data sources
	<0.3	<1.5	
Finished Ground Water	>81, >93	>97 >99	NIRS,[1] AWWA Water:/Stats [2]
Raw Ground Water	>85, >71	>95 >88	NWIS,[3] AWWA Water:/Stats

Notes:
[1] ''National Inorganics and Radionuclides Survey'': See USEPA 1999c for references.
[2] American Water Works Association, ''Water:/Stats, 1996 Survey: Water Quality''.
[3] USGS, National Water Information System.

An analysis of the American Water Works Association (AWWA) ''Water:/Stats'' database corroborates these conclusions: average Fe/Mn levels in finished water from 442 ground water systems showed that greater than 93 percent of the systems had combined Fe/Mn levels less than 0.3 mg/L and greater than 99 percent of systems had combined Fe/Mn levels less than 1.5 mg/L (AWWA 1997); average Fe/Mn levels in raw ground water from 433 systems showed that greater than 71 percent of systems had combined Fe/Mn levels less than 0.3 mg/L and greater than 88 percent of systems had Fe/Mn levels less than 1.5 mg/L. While this analysis does support the conclusions from NIRS and NWIS, it should be noted that the AWWA ''Water:/Stats Survey'' is skewed towards large ground water systems: only 3.4 percent of the systems surveyed serve fewer than 10,000 persons, whereas at the national level, greater than 95 percent of ground water systems serve fewer than 10,000 persons. In comparison, NIRS was designed to be nationally representative of contaminant occurrence in CWSs, while NWIS is a ''data bank'' in which the U.S. Geological Survey stores water contaminant data from its various studies. While the data in NWIS was not collected as part of a designed national survey (and hence can not be claimed to be necessarily nationally representative), it is arguably nationally representative based on its large sample size and its wide distribution of sample collection locations (USEPA 1999c).

(g) Disinfection Assumptions. It was assumed that all systems adding treatment would include disinfection. Since a significant fraction of ground water systems already disinfect, the percentage of systems that would have to add disinfection was estimated from a ''disinfection-in-place baseline'', as described in the Radon Health Risk Reduction and Cost Analysis published on February 26, 1999 (64 FR 9559). It should be noted that this baseline is nationally representative. Some States will, of course, have higher proportions of ground water systems with disinfection-in-place (*e.g.*, those States that require that ground water systems disinfect) and some will have lower proportions. Since the cost estimates being calculated are at the national level, EPA believes that this assumption is valid since this will over-estimate costs for systems in some States and under-estimate costs for systems in other States, with the respective cost errors tending to cancel at the national level. As a simplifying cost assumption, chlorination was assumed for all systems adding disinfection. The actual choice of disinfection technology should, of course, be made on a case by case basis. The fact that many systems will choose disinfection systems other than chlorination and that some systems will not add disinfection at all is captured in the uncertainty analysis, described later in this section.

(h) Comparison of Modeled Costs with Real Costs from Case Studies. Figure VIII.A.1 compares modeled total capital costs against case studies of actual aeration treatment installations for radon and VOCs found in the literature and gathered by EPA. It should be noted that these case studies include all pre- and post-treatments capital costs and costs for land, housing structures, permits, and all other capital added with the aeration process. If EPA's assumptions regarding pre- and post-treatments were seriously flawed, this comparison would demonstrate the fact. As can be seen, EPA's models fit the data fairly well and, in fact, Figure VIII.A.2 shows that the ''typical cost model'' rather closely approximates a power fit through the capital cost data for the larger systems and significantly over-estimates capital costs for small systems.

The ''PTA Cost Model'' represents EPA's best estimate of the costs of constructing and operating a PTA system under the associated design assumptions (steel shell, below-ground concrete clearwell, structure, etc.). This design was intended to be fairly typical of those systems serving more than 500 persons and up to 1,000,000 persons. The ''High Side PTA Cost Model'' represents EPA's best estimate of the costs of constructing and operating a PTA system under the same basic treatment design, but including significantly higher land, structure, and permitting costs. This model was intended to be fairly typical of systems that are ''land-locked'' in suburban or urban areas where land costs, building codes, and permitting demands may be much higher than for typical situations. The ''Low Side PTA Cost Model'' represents EPA's best estimate of the costs of constructing and operating a PTA system using designs more typical of very small systems, including package plant installations. This model is described in the Radon Technologies and Costs Document (USEPA 1999h). As can be seen in Figure VIII.A.1, the PTA Cost and High Side PTA Cost models are representative of the systems with design flows greater than 0.1 MGD. All of these models tend to over-estimate costs for those systems with smaller design flows.

The relative percentages of non-compliant systems modeled by the low-, typical-, and high-side costs are shown in the ''decision tree'' in Table 7–3 of the Regulatory Impact Assessment supporting this proposal. As part of the uncertainty analysis (described later in this section), these decision tree percentages were varied significantly. The results and assumptions are presented in detail in Section 10.8.3 of the Regulatory Impact Assessment. Based on a sensitivity analysis of the relative impacts of all the cost elements studied, the variance in the decision tree percentage values had much less of an impact on national costs compared to the variance in the treatment unit costs ($/kgal).

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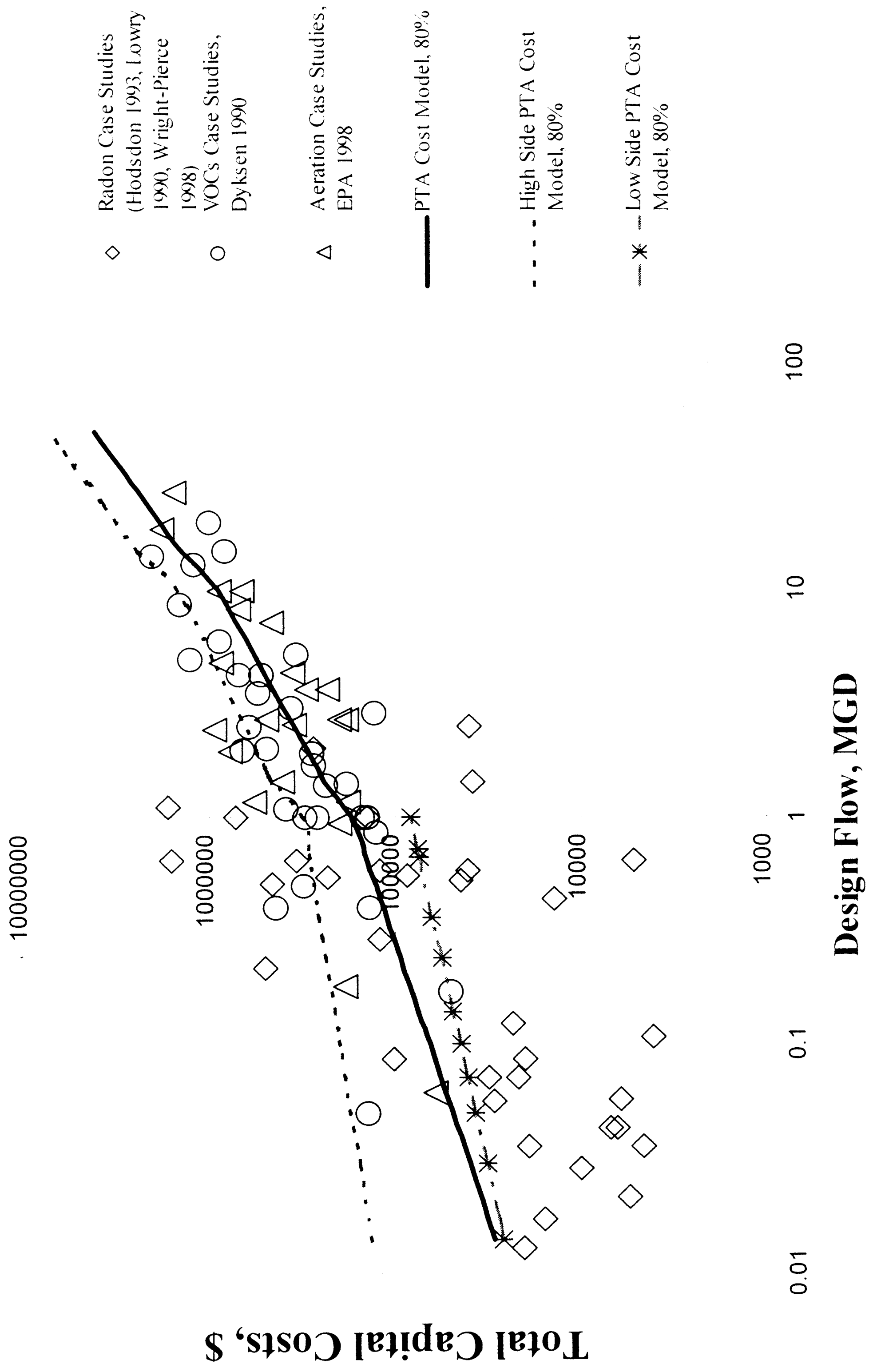
Figure VIII.A.1 Total Capital Costs: Aeration Cost Case Studies. (Late 1997 Dollars)



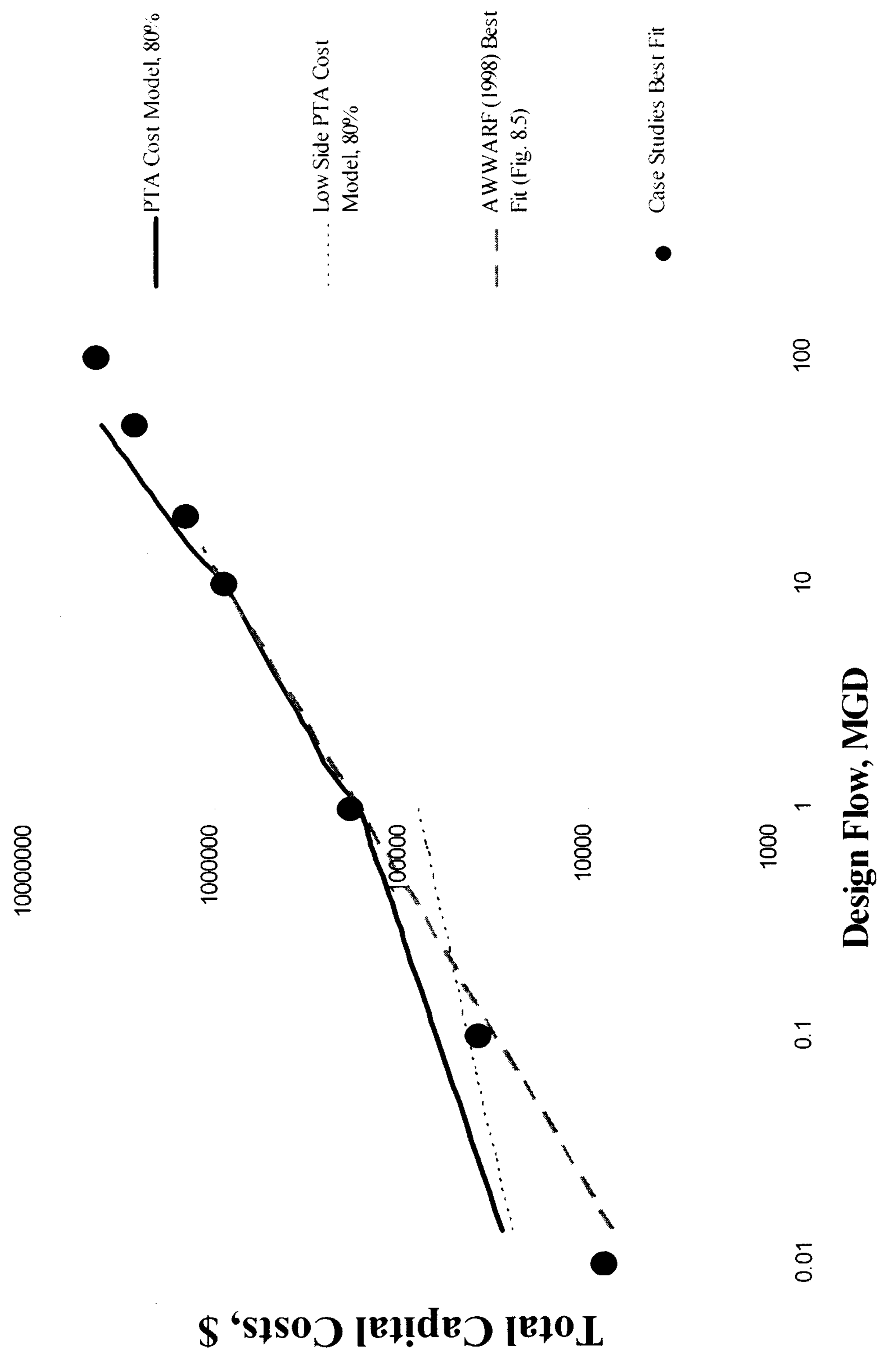


Figure VIII.A.2. Total Capital Costs: Comparison of EPA's Capital Costs Estimates to Literature Estimates. (Late 1997 Dollars)

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Figure VIII.A.2 compares the EPA aeration capital cost models against best fits to aeration capital cost case studies from the Radon Technologies and Costs Document (which includes aeration installations for VOCs) and to capital costs for radon case studies as reported by American Water Works Association Research Foundation (AWWARF 1998b). In general, EPA's unit cost estimates are supported by the case studies cited previously and by the findings reported by the AWWARF (AWWARF 1998b).

Figure VIII.A.3 shows that EPA's modeled operations and maintenance (O&M) costs are representative of the case study cost data. It should be noted that EPA is modeling incremental O&M aeration costs (additional O&M costs due to the addition of radon treatment) and that many of the radon case studies and all of the VOCs case studies report total O&M costs, which include O&M costs not related to the removal of radon. For this reason, the case study O&M costs would be expected to be considerably higher than the modeled costs, especially for the larger systems (which tend to have other processes in place that require substantial O&M costs). For example, most of the case studies using disinfection already had disinfection in place before adding aeration for radon. Since it is very difficult to separate the individual components of O&M costs without detailed site-specific information, these disinfection O&M costs are included in the O&M costs shown even though they are not related to treatment added for radon. As described previously, EPA did model O&M costs for disinfection and sequestration for iron and manganese and did include these in its national cost estimates. Figure VIII.A.3 compares modeled O&M costs for aeration with and without disinfection. Modeled O&M costs for iron/manganese stabilization and corrosion control are included through a weighting procedure that simulates 25 percent of small systems and 15 percent of large systems adding a chemical inhibitor. EPA solicits public comment and data on treatment costs and performance for the removal of radon from drinking water.

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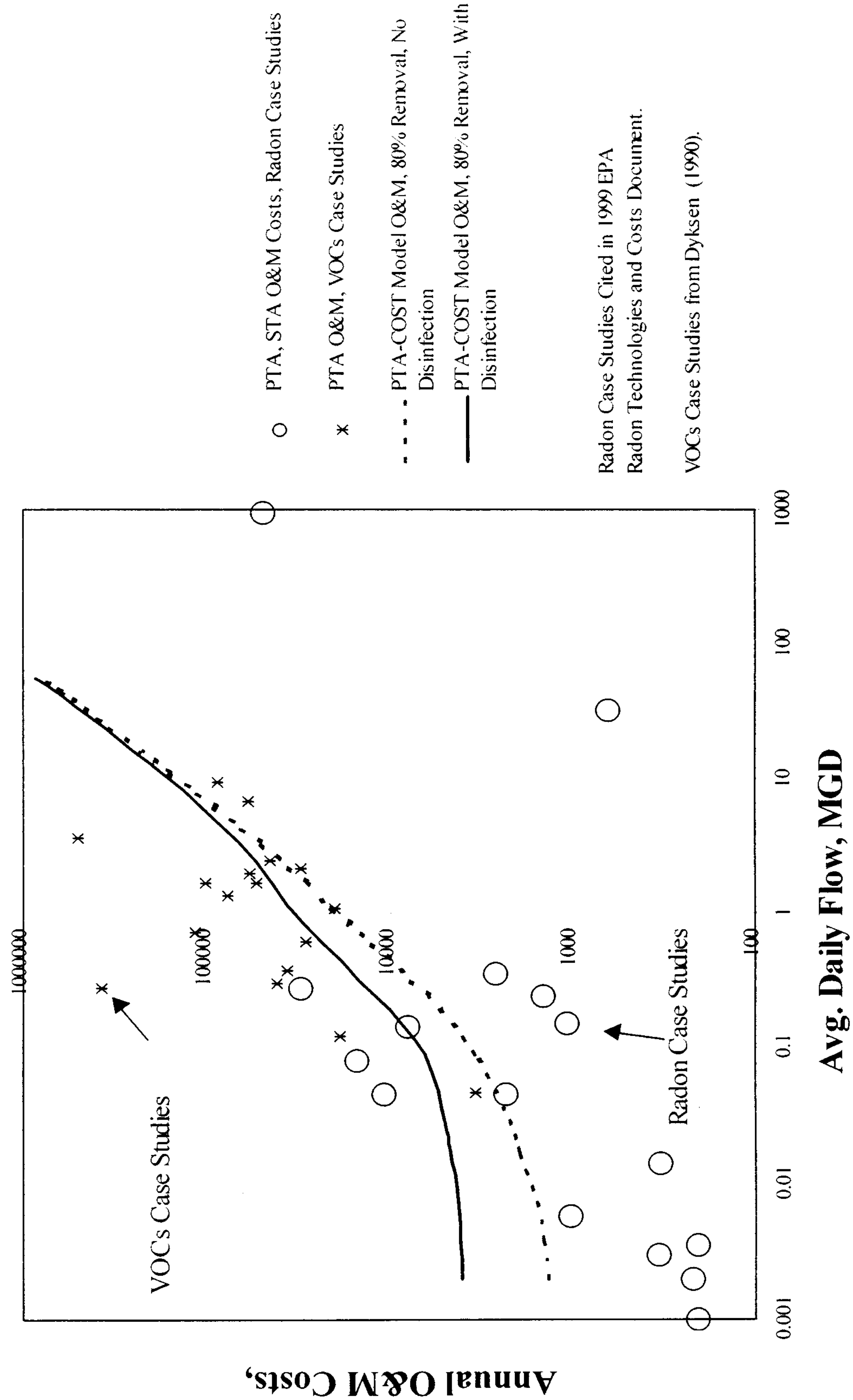
Figure VIII.A.3 Annual O&M Costs: Aeration Cost Case Studies.
(Late 1997 Dollars per Annum)



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Figures VIII.A.4 and VIII.A.5 compare the modeled capital costs and O&M costs for GAC against actual costs reported in case studies (USEPA 1999a, AWWARF 1998b). As can be readily seen, EPA's modeled costs are significantly higher than the actual costs, especially so for very small flows. To account for this discrepancy, EPA used the best fit through the case study data to generate a calibrated GAC model for capital and O&M costs. EPA calculated GAC treatment costs based on this model and did an uncertainty analysis on GAC costs assuming that while the modeled costs were typical, they could be as high as the GAC–COST predictions. This procedure is described in more detail in the radon HRRCA.

EPA also estimated point-of-entry GAC (POE–GAC) costs for very small systems. While capital and standard maintenance costs may be affordable ($100–$350 per household per year), monitoring costs can make POE–GAC much more expensive. EPA estimates (USEPA 1998g) that monitoring costs alone can be as much as $140 per household per year. A ''high end'' estimate for POE–GAC is $1,000 per household per year. If more cost-effective monitoring and maintenance program schemes are devised, these costs may be considerably lower.

In general, treatment costs may vary significantly depending on local circumstances. For example, costs of treatment will be less than shown if contaminant concentration levels encountered in the raw water are lower than those used for the calculations or if an existing clearwell can be retrofitted for aeration. However, costs of treatment will be higher if oxidation/filtration pre-treatment is required for iron and manganese removal or if water must be piped from the well-head to an off-site area for treatment.

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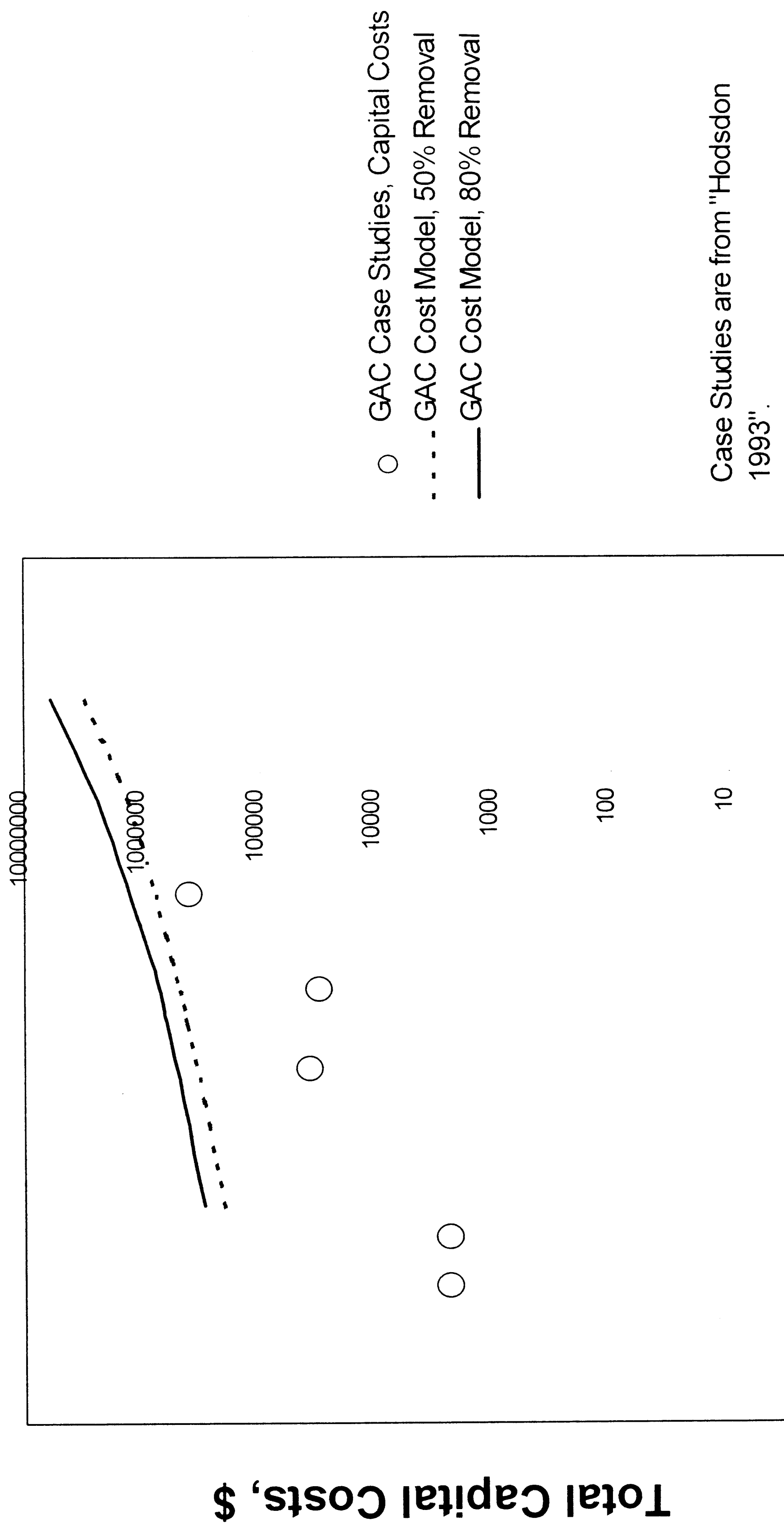
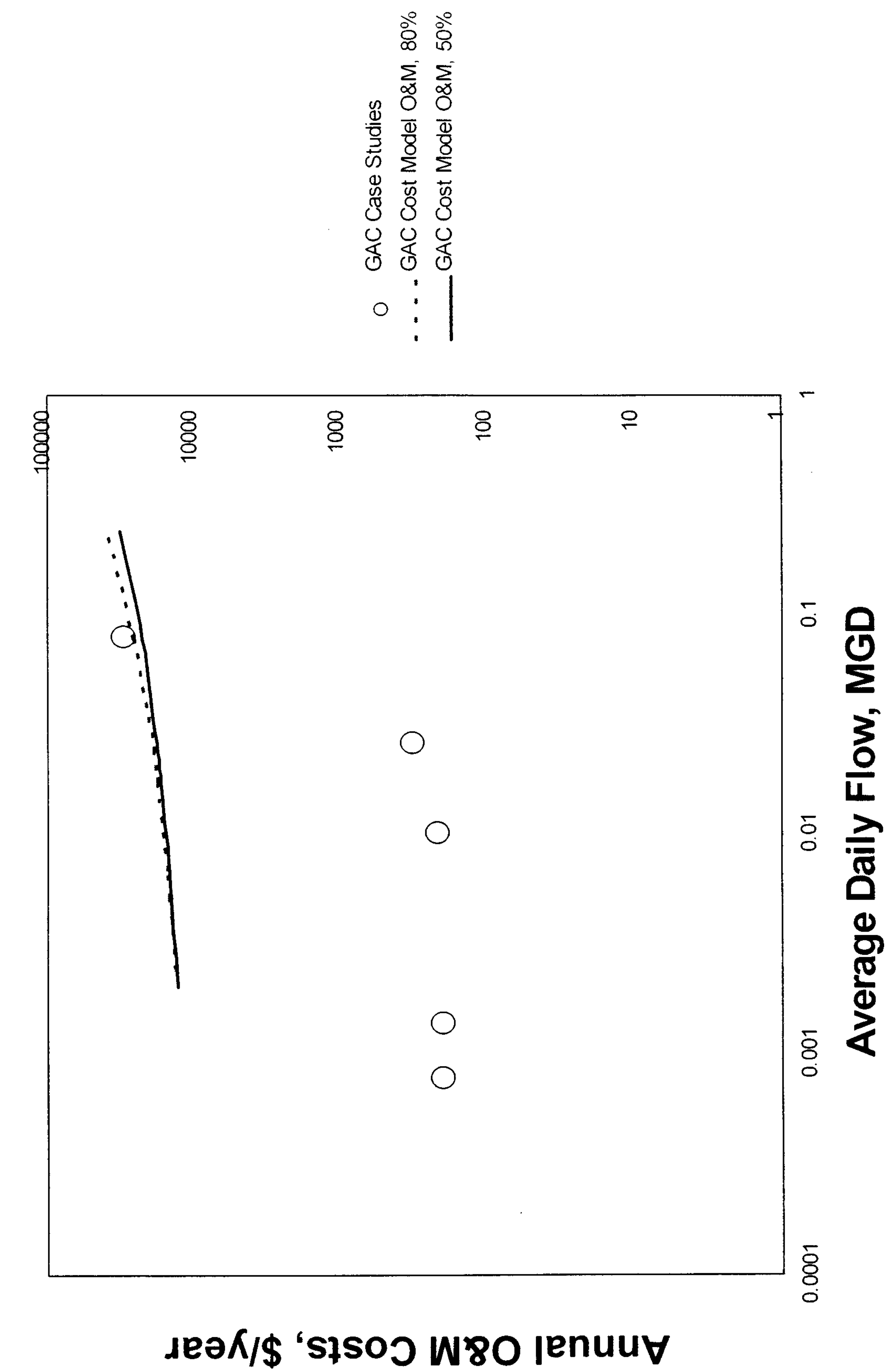


Figure VIII.A.4 Total Capital Costs: GAC Case Studies

Figure VIII.A.5 Annual O&M Costs: GAC Case Studies



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(i) Uncertainty Analysis for Treatment Costs. To estimate the uncertainty in national treatment costs, EPA estimated credible ranges and distributions of values for the most important factors (inputs) affecting costs. Distributions of selected inputs were then used in a Monte Carlo analysis to explore the uncertainty in national costs. The cost factors that were analyzed include:

- Numbers of systems in the various size categories;
- The distribution of the numbers of sources (wells) per system in each size category;
- Distributions of populations served in each size category;
- Annual household water consumption;
- Proportions of systems and wells exceeding radon limits; and
- Unit costs of radon treatment technologies (aeration and GAC).

Each of these inputs was modeled using probability distributions that reflect the spread in the available data. In some cases, (distributions of populations served, daily household water consumption, unit costs) variability was estimable from SDWIS, the CWSS, or other sources. In the case of the numbers of systems of different sizes, the estimated variability was greatest for the smallest systems, less for the moderate size systems, and the numbers of the largest systems (serving greater than 100,000 customers) was assumed to be known with certainty. The variation in the proportions of systems and sources above radon limits was estimated based on EPA's recent analysis (USEPA 1999l) of inter- and intra-system radon variability in radon levels.

In addition to these inputs, the estimated percentages of systems choosing particular treatment technologies (the ''decision tree'') were allowed to vary as well. Three decision tree matrices were used, corresponding to a central tendency estimate of the proportions of systems choosing specific mitigation technologies, and to lower- and higher-cost distributions of technology selection. When the simulation was run, the central tendency matrix was selected in 80 percent of the iterations, and the low- and high-cost decision matrices were selected in ten percent of the iterations each.

The variability in the estimated mitigation costs was examined using a conservative test case in which all systems above an MCL of 300 pCi/L were assumed to mitigate to comply with the MCL. The results of the analysis are described in detail in the radon Health Risk Reduction and Cost Analysis. In general, the distribution of cost estimates, even with all the variables included in the Monte Carlo analysis, is much narrower than the corresponding distribution of risk and benefit results. For this hypothetical scenario, the fifth percentile cost estimate is $455 million per year, while the 95th percentile estimate is $599 million per year (only 32 percent higher). The compactness in spread in national costs relative to the spread in national benefits is primarily due to the fact that the variability in the individual cost model inputs is low relative to the variability in some of the inputs (*e.g.*, individual risk) to the benefits model.

(j) Potential Interactions Between the Radon Rule and Upcoming and Existing Rules Affecting Ground Water Systems: Aeration and GAC are BAT for more than 25 and 50 currently regulated contaminants, respectively. Both technologies have been well-demonstrated and the secondary effects of each technology are well understood (See, e.g., Cornwell 1990, Umphres and Van Wagner 1986, AWWA 1990). These technologies are also used to remove other contaminants from drinking water, including taste and odor causing compounds. The Community Water System Survey (USEPA 1997a) indicates that 2 to 5 percent of ground water systems serving fewer than 500 persons currently have aeration treatment in place. Of systems serving more than 500 persons, 10–25 percent of these systems have aeration treatment at one or more entry points.

In the case of aeration, these secondary effects include carbon dioxide release (pH increase), oxygen uptake, and potential bacterial density increases, all of which potentially impact other existing and future drinking water regulations that pertain to ground water. In the case of GAC treatment, potential bacterial density increases are of concern. These potential interactions are described in a following section. (Concerns that are specific to radon removal and secondary effects due to other contaminants, *e.g.*, radium and uranium, are discussed in part 3 of this Section.)

(k) Ground Water Rule: Since the treatment techniques applicable to the removal of radon, *i.e.*, aeration, GAC, and/or ventilated storage, may result in increases in microbial activity (NAS 1999b, Spencer et al. 1999), it is important that water systems determine whether post-treatment disinfection is necessary. The ''Ten States Standards'' (GLUMRB 1997) suggest that disinfection should follow ground water exposure to the atmosphere (*e.g.*, aeration or atmospheric storage). The Ten State Standards also suggest that systems using GAC treatment implement ''provisions for a free chlorine residual and adequate contact time in the water following the [GAC] filters and prior to distribution.'' While EPA is not requiring that disinfection be used in conjunction with any treatment for radon, it is including costs for disinfection with treatment in accordance with good engineering practice. Cost assumptions for disinfection, including clearwell sizing for 5–10 minutes of contact time, are consistent with 4-log viral inactivation for ground water, which is expected to be consistent with requirements in the upcoming Ground Water Rule.

It should be noted that air is not a significant pathogen vector and thus aeration does not necessarily increase pathogenic risk for ground water users. However, bacterial activity can increase upon aeration and/or treatment with GAC. In the case of aeration treatment, bacteria that oxidize iron and/or sulfide may proliferate because of the oxygen increase; in the case of GAC treatment, bacteria may proliferate since the GAC surface tends to accumulate organic matter and nutrients that support the bacteria. In either case, heterotrophic plate count limits may become high enough to be of concern and for this reason disinfection may be necessary (USEPA 1999h, NAS 1999b).

(l) Disinfectants and Disinfection Byproducts (D/DBP) Rule: Commonly used disinfection practices for ground water systems include chlorination and, especially for small systems with limited distribution systems, ultraviolet (UV) radiation. Disinfection is used by many ground water systems because it decreases microbial risks from microbial contamination of ground water (NAS 1999b). However, there is a trade-off between a reduction in microbial risks and the risks introduced from disinfection by-products. Various disinfectant by-products (DBPs) can be formed depending on the disinfectant used, the disinfectant concentration and contact time, water temperature, the levels of DBP pre-cursors like natural organic materials and bromide, *etc.* For example, chlorination by-products like trihalomethanes can result from the interaction between chlorine chemical species and naturally occurring organic materials (NOM) and bromate can result from the ozonation of waters with sufficiently high levels of naturally occurring bromide ion.

Ground water systems tend to have significantly lower trihalomethane (THM) organic precursors than surface waters, although this is not always the case. Total organic carbon (TOC) is often used as a surrogate for formation of one important class of DBPs, total trihalomethanes (THM), since the THM formation potential of chlorinated waters correlates with TOC. As reported in the proposed Disinfectants and Disinfection Byproducts Rule (July 29, 1994: 59 FR 38668), a survey of surface waters showed TOC levels at the 25th, 50th, and 75th percentiles of 2.6, 4.0, and 6.0 mg/L, respectively; ground waters showed TOC levels at the same percentiles of ''non-detect'', 0.8, and 1.9 mg/L, respectively. Nationally, typical ground waters have low TOC levels. However, some areas of the U.S., e.g., the Southeastern U.S. (EPA Region 4), have some aquifers with high TOC levels.

One approach for the minimization of DBP formation in drinking water is to employ a disinfectant other than chlorine. Primary disinfection with chloramination, ozonation, or UV radiation are examples. However, other considerations may apply. For example, ozonation of ground water with sufficiently high bromide levels may result in significant levels of the DBP bromate. If a residual is required, it may be necessary to add secondary chlorination to maintain a residual in the distribution system. Other strategies include reducing the precursor concentration prior to chlorination, removal of THMs after their formation, and the installation of a second chlorination point in the distribution system. This last approach allows much lower chlorination levels to be used for primary chlorination, which greatly reduces THM formation.

While these strategies may be employed to minimize the formation of DBPs and, thereby reducing potential DBP risks and avoiding MCL violations for the DBP rule, there are other reasons to expect minimal interactions between the radon rule and the D/DBP rule. Namely, EPA expects that the radon rule will not result in a large percentage of systems adding disinfection because of the need to treat for radon. Since the primary regulatory option for small ground water systems is the MCL/MMM option (MCL = 4000 pCi/L) and less than one percent (1%) of small systems have radon levels that high, EPA does not expect many small systems to add treatment for radon in response to the radon rule, resulting in a very small percentage of small systems adding disinfection. Roughly half of all small systems already half disinfection in place already, further suggesting minimal small system impact from the radon rule. While EPA also expects that many large systems will also adopt the MCL/MMM option, EPA estimates that 95–97 percent of large ground water systems are already disinfecting, and thus would not have to add disinfection if treating for radon. For the expected small minority of systems that do add chlorination disinfection with radon treatment, the trade-off between a reduction in risks from radon exposure to an increase in risk from disinfection by-products will need to be carefully considered by the system installing treatment and strategies to minimize DBP formation should be implemented (NRC 1997, NAS 1999b, Spencer *et al.* 1999).

(m) Lead and Copper Rule: For several reasons, it is expected that few systems already in compliance with the Lead and Copper Rule will experience direct cost impacts because of the Radon Rule. Systems serving fewer than 50,000 persons do not have to modify corrosion control practices if the lead and/or copper contaminant trigger levels are not exceeded. For the reasons explained next, aeration is not expected to result in increased lead and copper levels in the vast majority of cases. While larger systems will have to include radon treatment into their over-all ''optimal corrosion control'' plans as they are updated, aeration tends to reduce or maintain corrosivity levels and should not result in measures beyond those included in the national costs for the proposed radon rule.

Aeration of ground water for radon treatment tends to raise the pH of water (Kinner *et al.* 1990, as cited by NAS 1999b, Spencer *et al.* 1999), since it tends to remove dissolved carbon dioxide, which forms carbonic acid when dissolved in water. In a study of VOCs removal by aeration, the American Water Works Association (AWWA 1990) reported that the net effect of aeration was ''no increase in corrosivity'': The reduction in carbon dioxide levels resulted in higher pH and in increased stability of carbonate minerals that serve to protect distribution systems, negating the corrosive effects of increased oxygen levels. The NAS concludes (NAS 1999b and references cited within Spencer *et al.* 1999) that studies suggest that corrosivity tends to decrease with aeration, but that a minority of systems that aerate may have to add a corrosion inhibitor to stabilize the impacts of the increased oxygen levels. As described previously, EPA has assumed in its national costs that, of the systems that install aeration, 25 percent of small systems and 15 percent of large systems will add chemical inhibitors for the dual purposes of corrosion control and the control of iron and manganese.

(n) Arsenic Rule: It is expected that there will be no significant negative relationships between compliance measures for the Arsenic and Radon Rules. In fact, one of the few expected impacts is beneficial: aeration plus disinfection may serve to pre-oxidize As(III) to the more readily removable As(V) form. However, the benefits estimated in this notice do not reflect this potential benefit.

3. Descriptions of Technologies and Issues

(a) Aeration. Aeration techniques for removal of radon from drinking water include active processes such as diffused bubble aeration (DBA), packed tower aeration (PTA), simple spray aeration, slat tray aeration, and free fall aeration, with or without spray aerators. Passive aeration processes such as free-standing, open air storage of water for reduction of radon may be effective for systems requiring lower removal efficiencies. Additional removal of radon via radioactive decay (into the daughter products of radon) may also occur in storage tanks and in pipelines which distribute drinking water, reducing radon by approximately 10 to 30 percent, within 8 to 30 hour detention periods. Although all of these aeration processes may be effective, depending on site specific conditions, only active aeration processes are considered BAT. Site specific considerations that may influence an individual water system's choice of treatment include source water quality (including concentrations of radon and other contaminants removed or otherwise affected by aeration), institutional or labor constraints, wellhead location, seasonal climate (*e.g.*, temperature), site-specific design factors, and local preferences. Identical treatment designs may achieve different radon removal efficiencies at individual water systems, depending upon these factors. A design for a technology may be altered to increase the radon removal efficiency, *e.g.*, an increase in the technology's air:water ratio (the respective flows of air and water being mixed) may increase the radon removal efficiency to account for local conditions that depress the radon removal efficiency. In some cases, the removal efficiency requirement may be high enough that only high performance aeration technologies (*e.g.*, packed tower aeration) will achieve the desired removals.

High performance aeration technologies, *e.g.*, packed tower aeration (PTA) and package plant aerators with high air:water ratios like shallow tray aeration (STA) or multi-stage bubble aeration (MSBA), provide the most efficient transfer of radon from water to air, with the ability to remove greater than 99 percent of radon from water. A supply which requires a smaller reduction of radon, *e.g.*, 50 percent, could opt to install one of these technologies and treat 50 percent of its source water and subsequently blend the treated with raw water, or it may design a shorter packed tower to achieve compliance with the MCL, both of which are significantly cheaper than treating the entire flow to 99 percent radon removal. Other advantages of high performance aeration include: removal of hydrogen sulfide, carbon dioxide, and VOCs, and oxidation of iron and manganese. Full-scale PTA, STA, and MSBA installations have been constructed for the removal of radon for very small up to medium sized-systems (AWWARF 1998b, USEPA 1999a). In addition to these case studies, full-scale aeration facilities for VOCs removal for medium to large-sized systems have been reported in the literature (AWWA 1990). Since radon is more easily air stripped than most volatile organic compounds, and high performance aeration technologies have been shown to be efficient forms of aeration for VOC removal (Kavanaugh and Trussell 1989, Dyksen *et al.* 1995), these technologies are appropriate as BAT for radon.

Treatment issues regarding aeration have been discussed in the literature (*e.g.*, Dihm and Carr 1988, Kinner et al. 1990b, Dell'Orco et al. 1998, AWWARF 1998b) and by EPA (USEPA 1999d). These issues include the potential for bacteria fouling (*e.g.*, iron/manganese/sulfide oxidizing bacteria), iron and manganese chemical precipitation and scaling, and corrosivity changes. Bacteria fouling and Fe/Mn scaling may clog or otherwise impede operations at an aeration facility, requiring preventative maintenance and/or periodic cleaning. Regarding corrosivity, the aeration process tends to reduce carbon dioxide levels (and raise pH, which tends to decrease corrosivity) and introduce oxygen (which tends to increase corrosivity). Whether or not corrosivity increases or decreases depends on site specific factors. In general, the degree to which these treatment issues may occur depends on the source water quality, ambient water and air temperatures, pre- and post-treatments added or in place, the type of aeration used, and other factors. To account for the cost impacts of dealing with Fe/Mn/carbonate scaling, EPA has included the capital and operation and maintenance costs of pre-treatment with a scalant stabilizer (which also may serve as a corrosion inhibitor, depending upon the type of corrosivity). Pre-/Post-treatment with a disinfectant to control biological fouling and to provide four-log viral deactivation (assuming a five minute contact time at 1.0–1.5 mg/L chlorine) has also been assumed in cost estimates. EPA assumed that those groundwater systems without disinfection already in place will add disinfection when aerating.

The PTA process involves the use of packing materials to create pore spaces that greatly increase the air:water contact time for a given flow of air into water. In counter-current PTA, the water is pumped to the top of the tower, then distributed through the tower with spray nozzles or distribution trays. The water flows downward against a current of air, which is blown from the bottom of the tower by forced or induced draft. The air space at the top of the tower is continually refreshed with ventilators. This design results in continuous and thorough contact of the water with ambient air. The factors that determine the radon removal efficiency are the air:water ratio (the ratio of air blown into the bottom of the tower and the water pumped into the top of the tower), the type and number of packing material, the internal tower dimensions, the water loading rate, the radon level in the influent and in the ambient air, and the water and air temperatures. A typical packed tower aeration installation consists of: (1) the tower: a metal (stainless steel or aluminum), fiber-glass reinforced plastic, or concrete tower with internals consisting of packing material with supports and distributors, (2) a blower or blowers, (3) effluent storage, which is generally provided as a concrete clearwell (airwell) below the tower; very small systems may use metal or plastic storage tanks, and (4) effluent pumping. Pumping into the tower is performed either through modification or replacement of the original well pump.

Commercially available high performance package plant aerators (USEPA 1999a, AWWARF 1998b) include multi-stage bubble aerators (MSBA), shallow tray aerators (STA), and other high air:water ratio designs. MSBA units typically consist of shallow (typically less than 1.5 feet deep) high-density polyethylene tanks partitioned into multiple stages with stainless steel or plastic dividers. Each stage is provided with an aerator, each of which is connected to the air supply manifold. STA units typically consist of one to six stacked tray modules (each 18 to 30 inches deep). Water is pumped through each tray as air is blown through diffusers at the bottom of the tray, creating turbulent mixing of the air and water. These package plant aerators have several distinct advantages: they are low-profile and compact (small footprint), are considered straightforward to install, and are relatively easy to maintain.

Other varieties of active aeration include diffused bubble aeration, which involves the bubbling of air into the water basin (of varying depth and design) via a set of air bubble diffusors. Forms vary from designs with shallow depth tanks containing thousands of diffusers to ''low technology'' designs involving bubbling air into a storage tank via a perforated hose connected to a blower. Some forms of diffused bubble aeration can remove up to 99.9 percent of radon from drinking water; simpler varieties can remove from 80 to > 90 percent of radon. One of the main advantages of diffused bubble aeration is its potential for making use of existing basins for the aeration process, which substantially reduces construction costs. Even if the aeration basin must be newly constructed, this process can be more cost effective than PTA for small systems. The disadvantages of diffused aeration include the requirement for increased contact time, the impracticality of large air-to-water ratios because of air pressure drops, and overall less efficient mass transfer of radon from water. The level of contact between air and water achievable in a packed tower aerator is difficult to obtain in a simple diffused air system (*i.e.*, forms like MSBA can achieve comparable contacts).

The Radon Technology and Cost document (USEPA 1999h) summarizes treatability studies for four diffused bubble aeration installations. One of the case studies involves a full-scale diffused aeration plant in Belstone, England, which provided a long-term radon removal efficiency of 97 percent. This plant (design flow of 2.5 mgd) was designed with an air:water ratio, using 2,800 air diffusers, each designed to supply a maximum of 0.8 cubic feet per minute, and a 24-minute retention time. In a field test of a diffused bubble aeration system, Kinner et al. (1990) report that removals of 90 to 99 percent were achieved at air-to-water ratios of 5 and 15, respectively.

Spray aerators direct water upward, vertically, or at an angle, dispersing the water into small droplets, which provide a large air:water interfacial area for radon volatilization. In single pass mode, depending upon the air:water ratio, removal efficiencies of >50 to >85 percent can be achieved. In multiple pass mode, 99 percent removals can be achieved. Most of the advantages cited previously for diffused aeration also apply to spray aeration. Disadvantages include the need for a large operating area and operating problems during cold weather months when the temperature is below the freezing point. Costs associated with this option (for all sizes of water treatment plants) have not been developed by EPA, but case studies (USEPA 1999a, AWWARF 1998b) indicate that it is cost-competitive with other small systems aeration technologies.

EPA has evaluated other, less technology-intensive (''low-technology''), options which may be suitable for small water systems, and which may cost less than the options described previously to install and operate (Kinner et al. 1990b, USEPA 1999a, AWWARF 1998b). These options include: atmospheric storage, free fall with nozzle-type aerator, bubble aerators, blending, and slat tray aerators. Limited data concerning these low-technology alternatives are reviewed in USEPA 1999a and AWWARF 1998b. Case studies show that atmospheric storage with a detention time of nine hours resulted in removals of 7–13 percent and a detention time of 30 hours in removals of around 35 percent. Dixon and Lee (1987) report that blending 6.34 MG of well water with a radon level of 1079 pCi/L with 18.34 MG of surface water resulted in effluent water with 226 pCi/L. Other storage case studies (detention times ranging from 8 to 23 hours) show that free-fall into a tank, free-fall with simple bubble aeration, simple spray aeration with free-fall, and simple bubble aeration remove 50–70 percent, 85–95 percent, 60–70 percent, and 80–95 percent of radon, respectively. More detail on an example will illustrate the simplicity of the treatment involved: the case study for ''free-fall with simple bubble aeration'' cited previously involved the introduction of water through two feet of free fall into a tank equipped with garden hose (punctured) bubble aerators, where the air was supplied by a laboratory air pump. Kinner et al. (1990b) concluded that very effective radon reduction can be achieved by simple aeration technologies that may be easily applied in small communities.

(i) *Evaluation of Radon Off-Gas Emissions Risks.* Since this notice contains a proposal to reduce radon concentrations in drinking water by setting an MCL, and the EPA is proposing aeration as BAT for meeting the MCL, the Agency undertook an evaluation of risks associated with potential air emissions of radon from water treatment facilities due to aeration of drinking water. In the first evaluation (USEPA 1988a, 1993a), EPA used radon data from 20 drinking water systems in the U.S. which, according to the Nationwide Radon Survey (1985), contained the highest levels of radon in drinking water and affected the largest populations and/or drinking water communities. EPA estimated the potential annual emissions (in pCi radon/yr) from these facilities, assuming 100 percent radon removal.

These radon emissions estimates were used as inputs to the AIRDOS-EPA model, which is a dispersion model that can be used to estimate the concentration of radon at a point some distance from the point source (*e.g.*, a packed tower vent). This model is the predecessor to the newer CAP–88–PC model, which combined AIRDOS with the DARTAB model, which estimates the total lifetime risk to individuals and the total health impact for populations. The underlying physical models in CAP–88 are essentially the same as those underlying AIRDOS and DARTAB (USEPA 1992c). In fact, the main differences between CAP–88–PC model and its predecessors is that CAP–88–PC is intended for wide-spread use in a personal computer environment (the CAP–88–PC model and its supporting documentation can be downloaded from the EPA homepage, http://www.epa.gov/rpdweb00/assessment/cap88.html). EPA has made comparisons between the AIRDOS-EPA dispersion model results and actual annual-average ground-level concentrations and found very good agreement. EPA has studied the validity of AIRDOS-EPA and concluded that its predictions are within a factor of two within actual average ground-level concentrations, the results of which are as good as any existing comparable model (USEPA 1992c).

Estimates of ground-level radon exposure were made for the following parameters: air dispersion of radioactive emissions, including radon and progeny isotopes of radon decay; concentrations in the air and on the ground; amounts of radionuclides taken into the body via inhalation of air and ingestion of meat, milk, and fresh vegetables, dose rates to organs and estimates of fatal cancers to exposed persons within a 50 kilometer radius of the water treatment facilities. Estimates of individual risk and numbers of annual cancer cases were completed for each of the 20 water systems, as well as a crude estimate of U.S. risks (total national risks) based on a projection of results obtained for the 20 water systems. These estimates were based on exposure analyses on a limited number of model plants, located in urban, suburban and rural settings, which were scaled to evaluate a number of facilities. (A similar approach has been used by the Agency in assessing risks associated with dispersion of coal and oil combustion products.) The risk assessment results for the 20 systems indicate the following: a highest maximum lifetime risk of 2×10^{-5} for individuals within 50 km of one of these systems, with a maximum incidence at the same location of 0.003 cancer cases per year; an estimate of annual cancer cases for all 20 systems of 0.0038 per year; and a crude U.S. estimate of 0.09 fatal cancer cases/year due to air emissions if all drinking water supplies are treated by aeration to meet an MCL of 300 pCi/L. Two other cases were evaluated: (1) Assuming that small drinking water systems are treated by aeration to meet the MCL/MMM option of 4000 pCi/L and large systems are treated to meet the MCL of 300 pCi/L, the best estimate of total national fatal cancer cases per year due to radon off-gas emissions is 0.04 cases/year, and (2) Assuming that all systems treat by aeration to meet the (A)MCL/MMM option of 4000 pCi/L , the best estimate is 0.01 cases/year. These results of the risk assessment for potential radon emissions from drinking water facilities are summarized in Table VIII.A.7. For all MCL options shown, the maximum lifetime individual risks from radon off-gas are much smaller (100 to 70,000 times smaller) than the average lifetime individual risks from the untreated water. Regarding national population risks (fatal cancer cases per year), the estimated population risk from radon off-gas is 850 to 17,000 times smaller than the estimated population risk from the untreated water.

TABLE VIII.A.7.—ESTIMATES OF RISKS AT 20 SITES DUE TO POTENTIAL RADON EMISSIONS FROM AERATION UNITS AND CRUDE PROJECTION OF TOTAL U.S. RISK [1]

Modeling scenario	Concentration in water (pCi/L)	Emissions from facility (Ci Rn/Yr)	Maximum lifetime individual risk [2]	Population risk [2] (fatal cancer cases per year)
20 Facilities Modeled:				
1	1,839	2.79	3×10^{-7}	7×10^{-5}
2	5,003	6.22	6×10^{-7}	2×10^{-4}
3	2,175	2.85	3×10^{-7}	9×10^{-5}
4	1,890	20.89	6×10^{-6}	1×10^{-4}
5	1,310	1.81	5×10^{-7}	9×10^{-7}
6	1,329	91.80	9×10^{-6}	1×10^{-3}
7	4,085	2.26	2×10^{-7}	3×10^{-5}
8	10,640	1.18	1×10^{-7}	1×10^{-5}
9	3,083	0.55	5×10^{-8}	7×10^{-6}
10	3,270	9.04	2×10^{-5}	1×10^{-3}
11	2,565	3.54	7×10^{-6}	6×10^{-4}
12	4,092	13.75	2×10^{-7}	3×10^{-5}
13	16,135	2.23	2×10^{-7}	3×10^{-5}
14	3,882	0.27	8×10^{-8}	5×10^{-6}
15	1,244	1.03	3×10^{-7}	2×10^{-5}
16	2,437	1.35	4×10^{-7}	5×10^{-7}
17	996	8.94	9×10^{-7}	2×10^{-4}
18	7,890	0.87	3×10^{-7}	6×10^{-6}
19	9,195	1.02	3×10^{-7}	1×10^{-5}
20	7,500	1.04	3×10^{-7}	6×10^{-6}
Totals for All 20 Facilities		161		0.004
Totals Assuming All U.S. Community Water Systems Treat to 300 pCi/L [3], i.e., All Systems Meet MCL of 300 pCi/L.		3700		0.09
Totals Assuming All Small U.S. Drinking Water Facilities Treat to 4000 pCi/L [3] and All Large U.S. Drinking Water Treat to 300 pCi/L, i.e., All Small Systems Meet MCL of 4000 pCi/L and All Large Systems: meet MCL of 300 pCi/L.		1600		0.04
Totals Assuming All U.S. Drinking Water Facilities Treat to 4000 pCi/L [3], i.e., All Systems meet MCL of 4000 pCi/L.		240		0.01

Notes:

[1] Estimates of Risk Assessment Using AIRDOS–EPA to estimate radon exposure. The total U.S. risk is based on the very conservative projection that all CWSs will treat to 200 pCi/L, USEPA 1993b.

[2] Risks are based on the National Academy of Science's lifetime fatal cancer unit risk or radon in drinking water of 6.7 x 10^{-7}.

[3] USEPA 1999j.

A second ''worst case'' evaluation was performed using four scenarios with high radon influent levels (ranging from 1,323 pCi/L to 110,000 pCi/L) and/or high flows to further determine whether individuals living near water treatment plants would experience significant increases in cancer risks due to radon off-gas emissions. For this analysis, the MINEDOSE model was used in conjunction with radon emissions estimates to estimate lifetime fatal cancer risks for individuals living near the modeled facility. Emissions were estimated using MINDOSE 1.0 (1989), a predecessor to COMPLY–R (1.2), which can be downloaded from the EPA homepage (http://www.epa.gov/rpdweb00/assessment/comply.html). Comply–R (1.2, radon-specific) is intended for demonstrating compliance with the National Emissions Standards for Hazardous Air Pollutants (NESHAPS) in 40 CFR 61, Subpart B, which are the Federal standards for radon emissions from underground uranium mines. While these standards do not apply to drinking water facilities, the model can be used to estimate radon exposures from aeration vents at drinking water facilities. To check for consistency between MINEDOSE and COMPLY–R, several modeling scenarios done in the original analysis with MINEDOSE were repeated using COMPLY–R and the results from MINEDOSE were found to be conservative with respect to the COMPLY-R results, *i.e.,* COMPLY–R predicts lower exposures for the scenarios modeled. The MINEDOSE code was originally used instead of the AIRDOS code because of its relative ease of use. When modeling the same scenarios with MINEDOSE and AIRDOS, the predicted exposures were determined to be similar enough to warrant the use of MINEDOSE for this work. The results from the MINEDOSE modeling work and subsequent work (USEPA 1994a) concluded that even these ''worst case maximum individual risks'' from radon off-gas were much smaller (300 to 1,000 times smaller) than the average individual risks posed by the untreated water.

(ii) Permitting of Radon Off-Gas from Drinking Water Facilities. Radon emissions to ambient air are only Federally regulated under 40 CFR 61,

National Emission Standards for Hazardous Air Pollutants (NESHAPs). These regulations apply to radon emissions under very specific circumstances, including emissions of radon to ambient air from uranium mine tailings, phosphogypsum stacks (40 CFR 61, Subpart R), Department of Energy storage and disposal facilities for radium-containing materials (40 CFR 61, Subpart Q), and underground uranium mines (40 CFR 61, Subpart B). At present, there are no State or Federal regulations that directly apply to radon air emissions from water treatment facilities.

To assess potential procedures (*e.g.*, permit applications, off-gas risk modeling) and costs that could be associated with radon off-gas from aeration facilities, EPA gathered information from agencies responsible for air permitting (USEPA 1999h), using California as a case study. California air permitting requirements are expected to be more restrictive than most States, and for this reason, it is considered a conservative case study. The information gathered is not expected to be nationally representative, but is illustrative as a ''worst case scenario''.

EPA contacted representatives from nine air districts in California via telephone to determine the likely response of their district to promulgation of a radon rule with an associated radon MCL requirement (USEPA 1999h). The air boards were chosen to represent large, metropolitan areas, medium-sized cities, and smaller, more rural areas. The representatives responded to the following questions:

- What is the likely response of your permitting board to water systems installing aeration treatment to comply with the radon rule?
- What are the likely permitting procedures and costs for water systems installing aeration for radon? Who would be responsible, the permitting board or the water system, for carrying out each procedure and paying the costs?
- Will large water systems and small water systems follow different procedures, or are procedures uniform regardless of water system size (*e.g.*, off-gas volume)? How do permitting costs change with the applicant's system size?
- Will water systems be required to perform off-gas risk modeling as part of the permitting procedure or will they be required to do other environmental impact analyses?
- Would there be annual renewal procedures (*e.g.*, reapplication, compliance monitoring) and costs? Who would be responsible for carrying our the procedures and bearing the costs?
- Is ongoing monitoring likely to be required?

Where possible, representatives provided estimates of time and cost that could be incurred by water systems and the districts as a result of the potential district response to the radon rule.

Responses to these questions indicated that the likely response to a radon rule is similar across the California air districts contacted. Most districts indicated they are likely to follow the lead of the State. ''Following the State's lead'' means that, if the State includes radon on its Toxic Air Contaminants List and establishes potency factors (unit risk factors and expected exposure levels for radon), air districts will probably regulate drinking water system aeration facilities through permits. Permitting procedures are similar across air districts and generally do not vary for facilities of different sizes. However, permitting costs and who bears those costs can vary significantly from air district to air district. Some portion of the costs are likely to vary based on facility size or emissions level.

Currently, ''radionuclides'' (which includes radon) are on the Toxic Air Contaminant Identification List developed by the California Air Resources Board. Listed contaminants are categorized by priority, and depending on what category a substance is in, the substance may or may not have ''potency factors'' developed by California's Office of Environmental Hazard Health Assessment (OEHHA). At the present time, radon is ''Category 4A'', which means that OEHHA is *not* currently planning on publishing values for the radon unit risk factor and reference exposure level, indicating that air boards are not likely to require permitting for radon off-gas at the present time. However, radon has been proposed for elevation in priority to ''Category 3'', which means that it could be a candidate for the development potency numbers in the future. Since California air quality districts generally follow the lead of OEHHA, if OEHHA publishes a unit risk factor and reference exposure level for radon in the future, air districts are then likely to evaluate whether radon should be considered in their air permitting programs. If OEHHA decides not to establish potency factors for radon, California air districts are not likely to require permitting for radon off-gas from drinking water treatment plants.

Respondents indicated that typical permitting procedures were: a system applies for a permit to construct; the board evaluates the application and decides whether or not to issue a permit; a permit may then be issued, after which the system may construct the aerator; the District conducts an inspection and the system may or may not have to perform testing; a public notice is issued if required by risk level and proximity of schools; the District issues a permit to operate; system must annually renew the permit (no monitoring or inspection likely). It is likely that water systems in the more densely populated, Metropolitan areas are more likely to need to do a risk assessment and perform modeling as part of their permit application. Permitting costs ranged from < $500 for simple permitting up to $50,000 for more complicated situations, with typical permitting costs reported in the $1,000 to $5,000 range. These costs do not include any radon dispersion controls or other engineering controls that might be required for the permit.

(b) Centralized Liquid Phase Granular Activated Carbon (GAC) and Point-of-Entry GAC. GAC removes radon from water via sorption. ''Downflow'' designs are used, in which the raw water is introduced at the top of the carbon bed and flows under pressure downwards through the bed. The treated water may then be disinfected or otherwise post-treated and piped to the distribution system. Advantages to the use of GAC relative to aeration include the lack of a need to break pressure (and hence re-pump), the lack of radon off-gas emissions, and, in very small systems applications with good water quality, GAC typically has no moving parts and requires little maintenance. Details regarding the process of radon removal via GAC are provided elsewhere (USEPA 1999h, AWWARF 1998a,b). This discussion will focus on potential issues that small water systems may face if they choose GAC for radon removal. Of these, raw water quality is of paramount concern since it affects radon removal efficiency, unit lifetime, and the potential for secondary radiation hazards. Radon, iron, uranium, and radium levels are most important.

(i) Radon Influent Levels for POE GAC: Gamma Radiation Hazards. An upper limit of 5,000 pCi/L of radon in influent water being treated by POE GAC is suggested by Rydell et al. (1989) and Kinner et al. (1990b) to protect persons in frequent proximity to the carbon bed (*i.e.*, residents) from gamma ray exposures. This influent level is based on a residential exposure limit of 170 mRem/year, or 0.058 mR/hour based on 8 hours/day of maximum exposure, 365 days per year. The 170 mRem/year limit was established by the National Council on Radiation

Protection Bulletin (cited by Rydell et al. 1989). Note that this residential exposure limit is less conservative than the EPA recommended limit of 100 mRem/year for water treatment plant personnel. However, the assumption of 8 hours/day of maximum proximity is extremely conservative. The 100 mRem/year limit is achieved if a person gets maximum exposure for approximately 5 hours per day or less, 365 days per year, which is still a conservative assumption.

Rydell *et al.* determined this influent limit based on an empirical and theoretical relationship between radon influent level and gamma ray emissions from the carbon bed. As will be discussed next, based on recent work using improved gamma ray detection methodology, Hess *et al.* (1998) report that this limit may be too low by a factor of 2, *i.e.*, the suggested radon influent limit may be closer to 10,000 pCi/L. Note that these limits are based on assumptions about GAC contact basin configurations, type and extent of shielding, length of time and proximity of persons to the unit, *etc.* While the ''rules-of-thumb'' described previously are useful, appropriate radon influent limits may be higher or lower depending upon site-specific considerations and should be determined on a case-by-case basis.

The University of Maine reported results on the removal of radon from drinking water using GAC (Hess *et al.* 1998). Nine carbon beds (all in Maine), which had been in use for more than 10 years by public water systems and private homes for radon removal, were studied. Radon influent levels ranged from 330 to 107,000 pCi/L, with a mean of 24,500 pCi/L and a standard deviation of 11,800 pCi/L. Gamma ray emissions from the GAC units and accumulated radon progeny, uranium, and radium were analyzed. Gamma ray emissions from the GAC surface ranged from 11.5 uR/h to 301 uR/h, with a mean of 78 uR/h and a standard deviation of 82 uR/h, and were 2 to 4 times lower than predicted by theory. The authors concluded that the limit of 5,000 pCi/L suggested by Rydell *et al.* (1989) may be too low by a factor of 2 or more.

(ii) Radon Influent Levels for Centralized GAC: Gamma Radiation Hazards. Using the very conservative assumption that a water treatment operator will be in close proximity for 40 hours per week, the 100 mRem/year translates to around 0.05 mR/hour, which also corresponds to a maximum of 5,000–10,000 pCi/L of radon for small flows. However, since GAC is likely to be used only by very small water systems and does not involve intensive O&M, much shorter work weeks are likely. Using 10 hours/week, the maximum radon influent level would be higher. Again, these are ''rule-of-thumb'' suggestions only. The best means to ensure that 100 mRem/year maximum exposure limits are maintained is to implement appropriate monitoring of gamma levels in the treatment facility and to ensure that proper shielding and worker proximity restraints are engineered to minimize exposures.

(iii) Other Water Quality Considerations: Naturally-Occurring Iron and Dissolved Organic Materials. The adsorption of iron precipitates can reduce a unit's radon removal efficiency, so that the raw water may need to be pre-treated to stabilize and/or remove the dissolved iron. The American Water Works Association Research Foundation (AWWARF 1998a,b) reports that waters with low iron and low levels of naturally occurring organic matter (''total organic carbon'', TOC) can achieve good radon steady-state removals (*i.e.*, radon sorption equals radon decay), but that the negative effects of iron and TOC on removal efficiencies may necessitate pilot testing to ensure proper contactor design. For raw water with high iron and/or TOC, pre-filtration or pre-oxidation/filtration may be required to achieve good steady-state removals.

(iv) Other Water Quality Considerations: Naturally-Occurring Uranium and Radium: Uranium and radium raw water levels are also of concern since sorption may occur onto the GAC surface, which results in uranium and radium occurrence in the GAC filter backwash residuals and ultimately may create a final GAC bed disposal problem. Water quality (pH, iron levels, natural organic matter levels, alkalinity, *etc.*) determine the extent to which uranium and radium sorb to the GAC surface. AWWARF (1998b) reported results from case studies conducted over a two year period in New Hampshire, New Jersey, and Colorado, including findings regarding loadings of uranium and radium on the GAC surface and respective levels in backwash residuals. Radon influent levels were 15,000–17,000 pCi/L, 2,220 pCi/L, and <7,500 pCi/L at the New Hampshire, New Jersey, and Colorado sites, respectively. In the New Hampshire pilot study, backwash residuals contained ~200 pCi/g uranium and ~50 to 60 pCi/g radium. For water treatment residuals with uranium levels between 75 and 750 pCi/g, EPA suggests that disposal measures be determined on a case-by-case basis (USEPA 1994b). In general, disposal in a controlled landfill environment may be necessary. The GAC bed itself accumulated less than the limit of 75 pCi/g for all but one of the five GAC columns in New Hampshire. For the New Jersey and Colorado pilot plants, uranium, radium, and radon progeny levels were low enough in the backwash residuals and the GAC bed that special disposal considerations were not an issue. It should be noted that State disposal restrictions may be more stringent than EPA's suggestions, which may make GAC a less attractive alternative in these States.

(v) GAC Disposal Issues. Radon progeny (*e.g.*, Pb–210, a beta emitter) accumulation is also related to radon influent level. If radon influent levels are high, the GAC unit lifetime may decrease significantly, where this lifetime is defined as the length of time between start-up and when an unacceptable accumulation of radioactive Pb–210 occurs. While no Federal agency currently has the legislative authority to regulate the disposal of wastes generated by water treatment facilities on the basis of naturally occurring radioactive materials (NORM), EPA (USEPA 1994b) suggests that NORM solid wastes with radioactivity above 2,000 pCi/g be disposed of in appropriate low-level radioactive waste facilities. Furthermore, given the prohibitive expense and burden of disposing of low-level radioactive waste, EPA would suggest that water treatment facilities avoid situations where such high waste levels would expected to potentially occur. In the case of wastes containing Pb–210, EPA suggests that case-by-case determinations be made for determining appropriate disposal. In summary, for higher radon influent levels, shorter bed lifetimes may be appropriate to reduce Pb–210 build-up.

Hess *et al.* (1998), cited previously, also studied several methods of cleaning the GAC bed by removing Pb–210 and radium from the spent GAC with various chemical cleaning solutions (*e.g.*, solutions of hydrochloric acid, nitric acid, sodium hydroxide, *etc.*). Disposal of the cleaned GAC and the much smaller volume of concentrated radon progeny and radium is expected to be cheaper in some cases than disposal of the contaminated GAC bed to a controlled disposal-facility. The authors concluded that several of the cleaning solutions (hydrochloric acid at 1 mole/liter, nitric acid at 0.5 mole/liter, and acetic acid 0.5 mole/liter in quantities of 150 mL solution per 100 grams of carbon) show promise. Precipitates on the GAC surface (including iron oxides, sorbed radium and radon progeny, including Pb–210) were effectively removed. Removal efficiencies for Pb–210 ranged from 30 percent to 70 percent and radium removals from 70 to 90 percent. This work indicates that a viable system of collecting and cleaning spent GAC material may be feasible, potentially making GAC a more attractive small systems alternative. Work supporting programs of this type deserves further consideration.

(vi) The American Water Works Association Research Foundation Report on Radon Removal Using GAC. The American Water Works Association Research Foundation (AWWARF 1998a,b) has recently reported on radon removal by GAC. AWWARF suggests that water systems with design flows below 70 gallons per minute may want to evaluate GAC and POE GAC as potential radon removal technologies (AWWARF 1999a), but warns that they appear to be attractive technologies only for very small systems with radon influent levels below 5,000 pCi/L, iron and manganese levels low enough not to warrant pre-treatment, and uranium and radium levels low enough not to accumulate to levels of concern on the GAC bed (USEPA 1994b). These findings are generally consistent with EPA's findings.

B. Analytical Methods

1. Background

The SDWA directs EPA to set a contaminant's MCL as close to its MCLG as is ''feasible'', the definition of which includes an evaluation of the feasibility of performing chemical analysis of the contaminant at standard drinking water laboratories. Specifically, SDWA directs EPA to determine that it is economically and technologically feasible to ascertain the level of the contaminant being regulated in water in public water systems (Section 1401(1)(C)(i)). NPDWRs are also to contain ''criteria and procedures to assure a supply of drinking water which dependably complies with such [MCLs]; including accepted methods for quality control and testing procedures to insure compliance with such levels. * * *'' (Section 1401(1)(D)).

To comply with these requirements, EPA considers method performance under relevant laboratory conditions, their likely prevalence in certified drinking water laboratories, and the associated analytical costs. A critical part of the method performance evaluation involves an analysis of inter-laboratory collaborative study data. This analysis allows EPA to confirm that the method provides reliable and repeatable results when used within a given laboratory and when used ''identically'' in other standard laboratories. Other technical limitations, e.g., sampling and sample preservation requirements, requirements for non-standard apparatus, and hazards from wastestreams, are also considered.

In particular, the reliability of analytical methods at the maximum contaminant level is critical to the implementation and enforcement of the NPDWR. Therefore, each analytical method considered was evaluated for accuracy, recovery (lack of bias), and precision (good reproducibility over the range of MCLs considered). The primary purpose of this evaluation is to determine:

- Whether currently available analytical methods measure radon in drinking water with adequate accuracy, bias, and precision;
- If any newly developed analytical methods can measure radon in drinking water with acceptable performance;
- Reasonable expectations of technical performance for these methods by analytical laboratories conducting routine analysis at or near the MCL levels (interlaboratory studies); and
- Analytical costs. The selection of analytical methods for compliance with the proposed regulation includes consideration of the following factors:

(a) Reliability (*i.e.*, Precision/accuracy of the analytical results over a range of concentrations, including the MCL);

(b) Specificity in the presence of interferences;

(c) Availability of adequate equipment and trained personnel to implement a national compliance monitoring program (*i.e.*, laboratory availability);

(d) Rapidity of analysis to permit routine use; and

(e) Cost of analysis to water supply systems.

2. Analytical Methods for Radon in Drinking Water

(a) Proposed Analytical Methods for Radon. The analytical methods described here are the testing procedures EPA identified and evaluated to insure compliance with the MCL and AMCL. Two analytical methods for radon in water that fit EPA's criteria for acceptability as compliance monitoring methods were identified: Liquid Scintillation Counting (LSC) and the de-emanation method. The LSC method is here defined as Standard Method 7500-Rn, SM 1995; the de-emanation method is described in the report, ''Two Test Procedures for Radon in Drinking Water, Interlaboratory Study'' (USEPA 1987). EPA believes these methods are technically sound, economical, and generally available for radon monitoring, and is proposing their use for monitoring to determine compliance with the MCL or AMCL. The reliability of these methods has been demonstrated by a history of many years of use by State, Federal, and private laboratories. Both methods have undergone interlaboratory collaborative studies (multi-laboratory testing), demonstrating acceptable accuracy and precision. Thirty-six laboratories participated in the interlaboratory study for Standard Method 7500-Rn and sixteen labs in the de-emanation study. The American Society for Testing and Materials (ASTM) has also published an LSC method (ASTM 1992). Although its collaborative study (15 participating laboratories) was conducted at radon sample concentrations greater than 1,500 pCi/L, it is substantially equivalent to Standard Method (SM) 7500-Rn. EPA is proposing that ASTM D–5072–92 serve as an alternate method for radon for both the MCL and AMCL, under the restriction that the quality controls from SM 7500-Rn are met; namely, that the relative percent differences between duplicate analyses are less than the 95 percent confidence level counting uncertainty, as defined in SM 7500-Rn. Table VIII.B.1 summarizes the proposed analytical methods for radon in drinking water.

TABLE VIII.B.1.—PROPOSED ANALYTICAL METHODS FOR RADON IN DRINKING WATER

Method	References (method or page number)		
	SM	ASTM	EPA
Liquid Scintillation Counting	7500–Rn[1]	D 5072–92[2]	
De-emanation			EPA 1987[3]

Notes:
[1] *Standard Methods for the Examination of Water and Wastewater.* 19th Edition Supplement. Clesceri, L., A. Eaton, A. Greenberg, and M. Franson, eds. American Public Health Association, American Water Works Association, and Water Environment Federation. Washington, DC. 1996.
[2] American Society for Testing and Materials (ASTM). Standard Test Method for Radon in Drinking Water. Designation: D 5072–92. *Annual Book of ASTM Standards.* Vol. 11.02. 1996.
[3] Appendix D, Analytical Test Procedure, ''The Determination of Radon in Drinking Water''. In ''Two Test Procedures for Radon in Drinking Water, Interlaboratory Collaborative Study''. EPA/600/2–87/082. March 1987. p. 22.

Other analytical methods were evaluated, but they failed at least one of the criteria described previously. These methods included an ''activated charcoal passive radon collector'', a ''de-gassing Lucas Cell'' technique (a variant of the de-emanation method), the ''electret ionization chamber system'', and a ''delay-coincidence liquid scintillation counting system''. All of these methods are described and evaluated elsewhere (USEPA 1999g). As described next, if EPA implements the ''Performance Based Measurement System'' (PBMS) program, then any method that performs according to specified criteria may be used for compliance monitoring.

(b) Summary of Methods. Analysis of radon in drinking water by the LSC method involves preparation of the water sample (ca. 20 mL), which includes the selective partitioning of radon from the water sample into a water-immiscible mineral-oil scintillation cocktail and allowance for equilibration of radon-222 with its progeny. The prepared sample is then analyzed with an alpha-particle counting system that is optimized for detecting radon alpha particles. Scintillation counting methods are discussed later. One of the advantages of transferring the radon from the water sample into the water-immiscible cocktail is that potential interferents (other alpha emitters) are left behind in the water phase.

The de-emanation method involves bubbling radon-free helium or aged air (low background radon) through the water sample into an evacuated scintillation chamber. After equilibrium is reached (3 to 4 hours), this chamber is placed in a counter and the resulting scintillations are counted. This method generally allows measurement of lower level of radon than does low volume direct liquid scintillation. However, this method is more difficult to use, requiring specialized glassware and skilled technicians. Regions of the country with high radon levels in water (e.g., New Hampshire and Maine) may experience problems with this method, since the high radon levels in the samples can cause high backgrounds in the Lucas cell, forcing retirement of the cell for extended periods.

(c) Alpha Particle Counting Methods for Radon-222. One of the distinct characteristics of alpha particles is that they exhibit an intense loss of energy as they pass through matter, due to strong interactions between the alpha particles and the surrounding atoms. This intense loss of energy is used in differentiating alpha radioactivity from other types. Some of the alpha particle's energy loss is due to its ionization of atoms with which it comes in contact. Alpha particle detection is based on this phenomenon: when alpha particles ionize the phosphor coating of a detector, the energized phosphor ''scintillates'' (or emits light). The resulting light (or scintillations) are then detected and quantified with an appropriate detector that is calibrated to determine the concentration of the alpha emitter of interest. There are variants of detectors that measure these interactions, but this discussion will focus on the type relevant to the LSC and Lucas Cell methods.

In scintillation counting, the alpha particle transfers energy to a scintillator medium, e.g., a phosphor dissolved in a solvent ''cocktail'', which is enclosed within a ''light-tight'' container to reduce background light. The scintillation cocktail serves two roles: it contains the phosphor which is involved in quantifying the radon activity (concentration) and it selectively extracts the radon from the water sample, leaving behind other alpha emitters that may interfere with the analysis. The transfer of energy from the radon-derived alpha particles to the phosphor dissolved in the scintillator medium results in the production of light (scintillation) of energies characteristic of the phosphor and with an intensity proportional to the energy transmitted from the alpha particles, which are the ''signature'' of radon-222. A ''counter'' records the individual amplified pulses which are proportional to the number of alpha particles striking the scintillation detector, which is ultimately proportional to the radon activity in the original sample. The scintillation cell system used for the liquid scintillation method is as described previously. The system used for the de-emanation method is similar, with the exception that a scintillation flask (''Lucas Cell'', a 100–125 ml metal cup coated on the inside with a zinc sulfide phosphor and having a transparent window) replaces the liquid scintillation medium described. A counting system compatible with the scintillation flask is incorporated to quantify the radon concentration in the sample. Since radon has a short decay period (half-life of 3.8 days), correction methods are employed to account for the radon that decayed between the time of sample collection and the end of the analysis.

(d) Sampling Collection, Handling, and Preservation. In order to ensure that samples arriving at laboratories for analysis are in good condition, EPA is proposing requirements for sample collection, handling and preservation.

When sampling for dissolved gases like radon, special attention to sample collection is required. Either the sample collection method described in SM 7500-Rn, the VOC sample collection method, or one of the methods described in ''Two Test Procedures for Radon in Drinking Water, Interlaboratory Collaborative Study'' (USEPA 1987) should be used. In addition, because dissolved radon tends to accumulate at the interface between a water sample and some types of plastic containers, glass bottles with teflon lined caps must be used. Finally, EPA's assessment of laboratory performance is premised on the assumption that sample analysis occurs no later than 4 days after collection. Laboratories unable to comply with this holding time limit may have difficulty performing within the estimated precision and accuracy bounds. EPA solicits public comment on the proposed sample collection procedures for radon in drinking water.

In discussions between EPA and the water utility industry, concerns have been expressed about the difficulties in collecting samples and the requisite skills that may be required. EPA emphasizes that the skills required to sample for radon are the same as those required to sample for other currently regulated drinking water contaminants, namely volatile organic contaminants. In addition, the 1992 EPA collaborative study mentioned earlier evaluated four sample collection techniques and found them all capable of providing equivalent results. Supplementing this study, EPA has reviewed a sampling protocol for radon in water developed by the Department of Health Services Division of Drinking Water and Environmental Management (CA DHS 1998). This protocol employs one of the four techniques evaluated by EPA, the immersion technique.

Using the immersion technique, the well is purged for 15 minutes by running the sampling tap, to ensure that a representative sample is collected. After the purging period, a length of flexible plastic tubing is attached to the spigot, tap, or other connection, and the free end of the tubing is placed at the bottom of a small bucket. The water is allowed to fill the bucket, slowly, until the bucket overflows. The bucket is emptied and refilled at least once.

Once the bucket has refilled, a glass sample container of an appropriate size is opened and slowly immersed into the bucket in an upright position. Once the bottle has been placed on the bottom of the bucket, the tubing is placed into the bottle to ensure that the bottle is flushed with fresh water. After the bottle has been flushed, the tubing is removed while the bottle is resting on the bottom of the bucket. The cap is placed back on the bottle while the bottle is still submerged, and the bottle is tightly sealed. As noted in the California protocol cited earlier, the choice of the sample container is dependent on the laboratory that will perform the analysis, and will be a function of the liquid scintillation counter that is employed. If bottles are supplied by the laboratory, there is no question of what container to employ.

Once the sealed sample bottle is removed from the bucket, it is inverted and checked for bubbles that would indicate headspace. If there are no visible air bubbles, the outside of the sealed bottle is wiped dry and cap is sealed in place with electrical tape, wrapped clockwise. After the sample bottle is sealed, a second (duplicate) sample is collected in the same fashion from the same bucket. The date and time of the sample collection is recorded for each sample.

As can be surmised from the description, the sample collection procedures are not particularly labor intensive. Most of the time is spent allowing the water to overflow the bucket. Likewise, there are no significant manual skills required.

(e) Skill Considerations for Laboratory Personnel. While neither of these techniques is difficult relative to standard drinking water methods, a discussion of the skills required to employ the methods is appropriate. Given the long history of successful use of the liquid scintillation counting technique (it has been used in medical laboratories and environmental research laboratories for well over 30 years), EPA feels confident that State drinking water laboratories will be able to adequately use these methods. The skills required are primarily the ability to transfer and mix aliquots of the sample to a sealed container for further analysis. The counting process is highly automated and the equipment runs unattended for days, if needed.

The de-emanation process requires somewhat more manual skill. As noted in the 1991 proposed rule, EPA expects that this technique would require greater efforts be made to train technicians than for the liquid scintillation technique. The technique requires that the counting cell be evacuated to about 10 mTorr pressure and then a series of stopcocks or valves are manipulated to transfer the radon that is purged from the sample into the counting cell. Potential problems with the analysis, such as a high background level of radon that can develop over the course of the day, or aspirating water into the counting cell, can be minimized by a well-trained analyst. However, as EPA concluded in 1991, the Lucas cell technique is not expected to form the sole basis of a compliance monitoring program for radon in drinking water.

(f) Cost of Performing Analyses. The actual costs of performing analysis may vary with laboratory, analytical technique selected, the total number of samples analyzed by a lab, and by other factors. Based upon information collected in 1991, the average sample cost for radon in water was estimated to be $50 per sample. EPA recently updated this cost estimate to $57 per sample (USEPA 1999b) by conducting a similar survey of drinking water laboratories. The data from the 1991 and 1998 surveys and the descriptive statistics are summarized in Table VIII.B.2. There was no clear correlation between the estimated price and the method cited by the laboratory. The 1998 range of prices brackets those collected by EPA in 1991. It is expected that the ''market forces'' generated by a radon regulation will tend to lower per sample costs, especially in light of the fact the LSC is very amenable to automation, with feed capacities of more than 50 samples/load possible. However, as will be discussed later, there may be short-term laboratory capacity issues that resist a lowering of per sample prices.

TABLE VIII.B.2. RADON SAMPLE COST ESTIMATE

Arbitrary lab No.	Cost estimate	Year data collected	Descriptive statistics for 1991
1	$30	1991	Mean, $49.80; Median, $47.00; Std. Dev., $18.80; Range, $45; Minimum, $30; Maximum, $75.
2	44	1991	
3	50	1991	
4	75	1998	
			Descriptive Statistics for 1998 Data
5	75	1998	Mean, $56.88; Median, $52.50; Std. Dev., $15.80; Range, $35; Minimum, $40; Maximum, $75.
6	50	1998	
7	40	1998	
8	75	1998	
9	45	1998	
10	55	1998	
11	75	1998	
12	40	1998	

These cost data are preliminary and may be different in practice for the following reasons: (a) As the number of experienced laboratories increases, the costs can be expected to decrease; (b) analytical costs are determined, to some extent, by the quality control efforts and quality assurance programs adhered to by the analytical laboratory; (c) per-sample costs are influenced by the number of samples analyzed per unit time. EPA solicits comments on its cost estimates from laboratories experienced in performing these analyses.

(g) Method Detection Limits and Practical Quantitation Levels. Method detection limits (MDLs) and practical quantitation levels (PQLs) are two performance measures used by EPA to estimate the limits of performance of analytic chemistry methods for measuring contaminants in drinking water. An MDL is the lowest level of a contaminant that can be measured by a specific method under ideal research conditions. EPA usually defines the MDL as the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the true value is greater than zero. The term MDL is used interchangeably with minimum detectable activity (MDA) in radionuclide analysis, which is defined as that amount of activity which in the same counting time, gives a count which is different from the background count by three times the standard deviation of the background count. A PQL is the level at which a contaminant can be ascertained with specified methods on a routine basis (such as compliance monitoring) by accredited laboratories, within specified precision and accuracy limits.

The feasibility of implementing an MCL at a particular level is in part determined by the ability of analytical methods to ascertain contaminant levels with sufficient precision and accuracy at or near the MCL. The proposed methods demonstrate good reproducibility and accuracy at radon concentrations in the range of 150–300 pCi/L (half of the proposed MCL up to the proposed MCL), as demonstrated in the results from inter-laboratory studies. In inter-laboratory studies (or Performance Evaluation studies), prepared samples of known concentration are distributed for analysis to participating labs, which have no information on the concentrations of the samples. The results of the analyses by the participants are compared with the known value and with each other to estimate the precision and accuracy of both the methods used and the lab's proficiency in using the method. Table VIII.B.3 summarizes the statistical results of these inter-laboratory studies for the proposed methods.

In the 1991 proposed rule, EPA proposed using both the MDL and PQL as measures of performance for radon analytical methods. EPA also proposed acceptance limits based on the PQLs that were derived from these performance evaluation studies. The use of acceptance limits was confusing to commenters for various reasons. The important issue is the observation that true analytical method performance is related to within-laboratory conditions (including counting times in the case of radiochemicals) and that acceptance limits are based on multi-laboratory Performance Evaluation studies. For non-radiochemical contaminants this issue is less troublesome because their PQLs tend to be "fixed" since the MDLs to which they are related reflect optimized conditions for standard laboratory equipment, whereas for radiochemical contaminants, counting times can always be increased to increase the sensitivity and hence lower the appropriate acceptance limits. While the fifty minute counting time in Standard Method 7500-Rn reflects a balanced trade-off between time of analysis (and hence the cost of analysis) and sensitivity, it can obviously be adjusted as needed to adjust sensitivity. For this reason, commenters objected to the use of acceptance limits (and, relatedly, PQLs) for radiochemical contaminants.

EPA agrees that these comments have merit and has decided to seek comment on two proposals regarding the use of acceptance limits and PQLs for radon. The first proposal, and the preferred option, is to not use acceptance limits or PQL for radon, and to adopt the detection limit as the measure of sensitivity, as done in the 1976 Radionuclides rule. The existing definition of the detection limit takes into account the influence of the various factors (efficiency, volume, recovery yield, background, counting time) that typically vary from sample to sample. Thus, the detection limit applies to the circumstances specific to the analysis of an individual sample and not to an idealized set of measurement parameters, as with acceptance limits and PQLs. The proposed detection limit is 12 +/− 12 pCi/L, which is based on the detection limit described in SM 7500-Rn (50 minute counting time, 6 cpm background, 2.7 cpm/dpm efficiency, and under the energy window optimization procedure as described in the method). This detection limit should be applicable to all three approved methods.

One of the reasons for setting a sensitivity standard is to ensure that laboratories will perform acceptably well on a routine basis at contaminant levels near the MCL. Internal quality control/quality assurance procedures are of paramount importance. In addition, Proficiency Tests are administered by laboratory certifying authorities to ensure that laboratory performance is acceptable. Currently, the system for administering proficiency tests and certifying laboratories is in a state of transition. Up to the recent past, all primacy entities evaluated laboratory performance based on EPA's Performance Evaluation (PE) studies program, the National Exposure Research Laboratory (NERL–LV) Performance Evaluation (PE) Studies program for radioactivity in drinking water. Currently, the Proficiency Testing (PT) program for radionuclides is being privatized, *i.e.*, operated by an independent third party provider accredited by the National Institute of Standards and Technology (NIST). A lack of uniformity in state PT requirements may limit laboratory availability for a given public water system to laboratories that use PT samples approved by the state. It should be noted that this issue is general and is not specific to the proposed radon regulation. Efforts to encourage uniformity in state PT requirements are described in more detail in the laboratory capacity section.

Under the alternative of using the MDL as the measure of sensitivity, standard statistical procedures would be used to ensure that a laboratory has analyzed PT samples acceptably. Since the national PT program will still be overseen by EPA, the exact procedures for determining acceptable performance will be developed by EPA and NIST as the PT program develops. The respective roles of EPA and NIST in the PT program and discussed further in the Laboratory Approval and Certification section.

The second proposal is to use the concepts of the acceptance limit and PQL for radon. Using the standard relationship that PQLs are equal to 5 to 10 times the MDL yields a PQL for radon in the range of 60 to 240 pCi/L. EPA is proposing a PQL of 100 pCi/L and is seeking comment on this value. The proposed acceptance limit for a single sample is ±5 %. The proposed acceptance limits for triplicate analyses at the 95th and 99th percent confidence intervals are ±6 % and ±9 %, respectively. All of these acceptance limits are based on the inter-laboratory studies used for the precision and accuracy results reported in Table

VIII.B.3. EPA seeks comments on the relative merits between the first option (the preferred option) of using only an MDL as the measure of sensitivity and the second option of using a PQL with prescribed acceptance limits.

TABLE VIII.B.3.—INTER-LABORATORY PERFORMANCE DATA FOR PROPOSED RADON ANALYTICAL METHODS [1]

Method	Sample Conc. pCi/L	Accuracy %	Repeat-ability pCi/L	Reproduc-ibility pCi/Ls	Bias %
SM 7500-Rn	111	101–102	9	12	0.7–2.3
SM 7500-Rn	153	102–103	10	16–18	2.3–3.4
De-Emanation	111	114	16	23	14.5
De-Emanation	153	114	17	28	13.7
ASTM D5072–92	1,622	97	2,217	3,541	−2.6
ASTM D5072–92	16,324	95	14,950	44,400	−4.7
ASTM D5072–92	66,324	94	49,190	210,350	−6.0

Notes: (1) All results are reported in methods citations found in Table VIII.B.1.

(h) Accuracy and Precision of the Proposed Methods. While SM 7500-Rn has the best over-all results in precision and accuracy, the de-emanation method also shows acceptable performance. The ASTM method shows similar accuracy and bias, but much larger errors in repeatability (operator precision) and reproducibility (between-lab precision). Given this inferior demonstration of precision and the higher concentrations used in the intra-laboratory studies, it may be argued that this method should not be proposed as a drinking water method. However, EPA maintains that the method is similar enough in substance to SM 7500-Rn that it may serve as an alternate method if the laboratories use the appropriate quality control measures, *i.e.*, ensure that the relative percent difference between results on duplicate samples is within the counting uncertainty 95% confidence interval, where at least 10% of daily samples are duplicates. This procedure is described in the 4th edition of the Manual for the Certification of Laboratories Analyzing Drinking Water, Criteria and Procedures Quality Assurance (EPA 1997). EPA requests comment on including ASTM D5072–92 as an alternate test method.

C. Laboratory Approval and Certification

1. Background

The ultimate effectiveness of the proposed regulations depends upon the ability of laboratories to reliably analyze contaminants at relatively low levels. The Drinking Water Laboratory Certification Program is intended to ensure that approved drinking water laboratories analyze regulated drinking water contaminants within acceptable limits of performance. The Certification Program is managed through a cooperative effort between EPA's Office of Ground Water and Drinking Water and its Office of Research and Development. The program stipulates that laboratories analyzing drinking water compliance samples must be certified by U.S. EPA or the State. The program also requires that certified laboratories must analyze PT samples, use approved methods, and States must also require periodic on-site audits.

External checks of performance to evaluate a laboratory's ability to analyze samples for regulated contaminants within specific limits is one of the means of judging lab performance and determining whether to grant certification. Under a PT program, laboratories must successfully analyze PT samples (contaminant concentrations are unknown to the laboratory being reviewed) that are prepared by an organization that is approved by the primacy entity. Successful annual participation in the PT program is prerequisite for a laboratory to achieve certification and to remain certified for analyzing drinking water compliance samples. Achieving acceptable performance in these studies of known test samples provides some indication that the laboratory is following proper practices. Unacceptable performance may be indicative of problems that could affect the reliability of the compliance monitoring data.

EPA's previous PE sample program and the approaches to determine laboratory performance requirements are discussed in 63 FR 47097 (September 3, 1998, ''1998 methods update''). In that notice, EPA amended the regulations to adopt the universal requirement for laboratories to successfully analyze a PE sample at least once each year, addressing the fact that the Agency has not specified PE test frequency requirements in its current drinking water regulations. Though not specified in the methods update regulation, PE samples may be provided by EPA, the State, or by a third party with the approval of the State or EPA. Under the developing PT program, NIST has accredited a list of PT sample providers, including a radionuclides PT samples which will apply to radon.

In addition, guidance on minimum quality assurance requirements, conditions of laboratory inspections, and other elements of laboratory certification requirements for laboratories conducting compliance monitoring measurements are detailed in the 4th edition of the Manual for the Certification of Laboratories Analyzing Drinking Water, Criteria and Procedures Quality Assurance (EPA 1997), which can be downloaded via the internet at ''http://www.epa.gov/OGWDW/labindex.html''.

2. Laboratory Capacity—Practical Availability of the Methods

In order to determine the practical availability of the methods, EPA considered three major factors. First, the availability of the major instrumentation was reviewed. Secondly, several laboratories performing drinking water analyses were contacted to determine their potential capabilities to perform radon analyses. Lastly, EPA has reviewed the current status of the privatized Performance Evaluation studies program and the on-going measure to implement a uniform program, highlighting the potential impacts on short-term and long-term laboratory capacity for radon.

3. Laboratory Capacity: Instrumentation

Regarding instrumentation availability, the major instrumentation required for LSC is the liquid scintillation counter. Automated counters capable of what that method terms ''automatic spectral analysis'' are available from at least a dozen suppliers. The de-emanation Lucas cell apparatus is the same apparatus that has been used for radium analyses for many years. In light of the wide availability and the long history of accessibility of the proper instrumentation, EPA believes that instrument availability should not be an issue for radon analytical methods.

4. Laboratory Capacity: Survey of Potential Laboratories

In order to evaluate the availability of laboratory capacity to perform radon analyses, EPA contacted the drinking water certification authorities in the States of California, Maryland, and Pennsylvania. These states were chosen based both on estimated radon occurrence and the overall status of the programs. Ultimately, EPA collected information on the availability and relative costs of radon analyses for drinking water from a total of nine commercial laboratories.

Eight of the nine laboratories that were contacted do perform radon analyses. All the laboratories were certified in one or more states to perform radiochemical analyses. When asked what specific methods were used, the laboratories responded with either the technique (liquid scintillation counting) or a specific method citation. EPA Method 913 (which later was revised to become SM 7500-Rn) was cited by two of the laboratories. EPA Method ''EERF Appendix B'' was cited by another laboratory. The remaining laboratories indicated that they performed liquid scintillation analyses and could accommodate requests for methods employing that technique.

When asked about capacity, the laboratories indicated that they each perform between 100 and 12,000 analyses per year. The latter figure came from a laboratory that is currently involved in a large ground water monitoring project in the western United States. The next largest estimate was 300 samples per year. However, EPA expects that like any other type of environmental analysis, given a regulatory ''driver'' to perform the analysis, and given the ability of LSC analysis to be automated, the laboratory capacity will develop in a timely manner.

EPA's 1992 Annual Report on Radiation Research and Methods Validation reports the results of a collaborative study on radon analysis (EPA 1993) and is another useful source of information regarding potential radon laboratory capacity. This study employed 51 laboratories with the capability to perform liquid scintillation analyses. This suggests that at that time there already existed a substantial capacity for these analyses.

Further, the liquid scintillation apparatus is used for other radiochemical analyses, including tritium. Information from EPA regarding the performance evaluation program for tritium analyses suggests that there are approximately 100–200 laboratories with the necessary equipment. Much of the capacity for tritium analyses could also be used for radon (EPA 1997). As of September 1997, 136 of 171 participating laboratories achieved acceptable results for tritium. While the total number of participants and the number achieving acceptable results vary between studies, the data indicate that there is a substantial capability for liquid scintillation analysis nationwide.

5. Laboratory Capacity: Laboratory Certification and Performance Evaluation Studies

The availability of laboratories is also dependent on laboratory certification efforts in the individual states with regulatory authority for their drinking water programs. Until June of 1999, a major component of many of these certification programs was their continued participation in the current EPA Water Supply WS performance evaluation (PE) program, which included radiochemistry PE studies. Due to resource limitations, EPA has recently privatized EPA's PE programs, including the Water Supply studies. EPA has addressed this topic in public stakeholders meetings and in some recent publications, including **Federal Register** notices and its June 1997 ''Labcert Bulletin'', which can be downloaded from the Internet at ''http://www.epa.gov/OGWDW/labcert3.html''. The decision to privatize the PE studies programs was announced in the **Federal Register** on June 12, 1997 (62 FR 32112). This notice indicated that in the future the National Institute of Standards and Technology (NIST) would develop standards for private sector PT sample providers and would evaluate and accredit these providers, while the actual development and manufacture of PT samples would fall to the private sector. Further information regarding the respective roles of EPA and NIST in the privatized PT program can be downloaded from NIST's homepage at ''http://ts.nist.gov/ts/htdocs/210/210.htm''. EPA believes that this program will ensure the continued viability of the existing PT programs, while maintaining government oversight.

This externalized proficiency testing program is in the process of becoming operational. Under the externalized PT program:

- EPA issues standards for the operation of the program,
- NIST administers a program to accredit PT sample providers,
- Non-EPA PT sample providers develop and manufacture PT sample materials and conduct PT studies,
- Environmental laboratories purchase PT samples directly from PT Sample Providers (approved by NIST or the State), and
- Certifying authorities certify environmental laboratories performing sample analyses in support of the various water programs administered by the States and EPA under the Safe Drinking Water Act.

NIST is in the process of approving a provider for PT samples for radionuclides, including radon. States also have the option of approving their own PT sample providers. At this time, it is difficult to speculate to what degree this externalization of the PT program will affect short-term and long-term laboratory capacity for radon. EPA recognizes that initial implementation problems may arise because of the potential for near-term limited availability of radon PT samples. EPA also recognizes that insufficient laboratory capacity may lead to a short-term increase in analytical costs. In the absence of definitive information regarding the future PT program, EPA solicits public comment on this matter.

6. Efforts To Ensure a Uniform Proficiency Testing Program: NELAC

The National Environmental Laboratory Accreditation Conference (NELAC) is also evaluating the issues surrounding privatization of the SDWA PT program through its proficiency testing committee. NELAC serves as a voluntary national standards-setting body for environmental laboratory accreditation, and includes members from both state and Federal regulatory and non-regulatory programs having environmental laboratory oversight, certification, or accreditation functions. One of the goals for the re-designed SDWA PT program is to be consistent with NELAC's recommendations.

The members of NELAC meet bi-annually to develop consensus standards through its committee structure. These consensus standards are adopted by participants for use in their own programs in pursuit of a uniform national laboratory accreditation program in which environmental testing laboratories will be able to receive one annual accreditation that is accepted nationwide. As part of its accreditation program, NELAC is developing standards for a proficiency testing program that addresses all fields of testing, including drinking water. Recent meetings of the Proficiency Testing Committee of NELAC have reviewed several important issues, including State selection of PT sample providers and reciprocity between States.

These issues are described in more detail elsewhere (NELAC 1999a). The NELAC Proficiency Testing Committee is currently drafting requirements for radiochemical proficiency testing under SDWA. The June 15, 1999 draft (NELAC 1999b) of its radiochemical proficiency testing requirements describes radiochemical PT sample designs, acceptance limits, and other information.

The intent of the NELAC standards setting process is to ensure that the needs of EPA and state regulatory programs are satisfied in the context of a uniform national laboratory accreditation program. EPA recognizes that cooperating with NELAC is an important part of the re-design of the Proficiency Testing (PT) program for drinking water, since NELAC provides a means for states, environmental testing laboratories, and PT study providers to have direct input into the process. It is hoped that this mutual effort will minimize the potential disruption in the process of moving from the old EPA PE program towards the new privatized PT program. EPA shares NELAC's goal of encouraging uniformity in standards between primacy States regarding laboratory proficiency testing and accreditation.

7. Laboratory Capacity: Holding Time

The short holding time for radon, 4 days in Method 7500-Rn, presents concerns relative to the practical availability of laboratory capacity as well. The 4-day holding time was also the focus of a number of comments that EPA received in response to the 1991 proposed rule. Many commenters were concerned that if a local laboratory is not available, the only alternative will be to send the samples by overnight delivery to a laboratory elsewhere. However, this situation is not unique to the analysis of radon. As evidenced during the data gathering pursuant to the Disinfection By-Products Information Collection Rule (DBP ICR), several large commercial laboratories already account for a sizable share of the market for SDWA analyses for non-radon parameters, including organics, for which the holding times are often 7 days. Given that a day would be required for shipping the samples, only three days would remain for the laboratory to perform the radon analysis (the day on which the sample is collected being ''day zero''). Some commenters argued that for a large commercial laboratory serving the water utilities, this short holding time will make it difficult if not impossible to perform the necessary analyses within the holding time. However, through common sense scheduling efforts between the utility and the laboratory, such as not collecting samples on Thursdays and Fridays, the holding time issue should be able to be accommodated in light of the ability of the LSC method to be highly automated.

D. Performance-Based Measurement System (PBMS)

On October 6, 1997, EPA published a Notice of the Agency's intent to implement a Performance Based Measurement System (PBMS) in all of its programs to the extent feasible (62 FR 52098). EPA is currently determining how to adopt PBMS in its drinking water program, but has not yet made final decisions. When PBMS is adopted in the drinking water program, its intended purpose will be to increase flexibility in laboratories in selecting suitable analytical methods for compliance monitoring, significantly reducing the need for prior EPA approval of drinking water analytical methods. Under PBMS, EPA will modify the regulations that require exclusive use of Agency-approved methods for compliance monitoring of regulated contaminants in drinking water regulatory programs. EPA will probably specify ''performance standards'' for methods, which the Agency would derive from the existing approved methods and supporting documentation. A laboratory would then be free to use any method or method variant for compliance monitoring that performed acceptably according to these criteria. EPA is currently evaluating which relevant performance characteristics should be specified to ensure adequate data quality for drinking water compliance purposes. After PBMS is implemented, EPA may continue to approve and publish compliance methods for laboratories that choose not to use PBMS. After EPA makes final determinations to implement PBMS in programs under the Safe Drinking Water Act, EPA would then provide specific instruction on the specified performance criteria and how these criteria would be used by laboratories for radon compliance monitoring.

E. Proposed Monitoring and Compliance Requirements for Radon

1. Background

The monitoring regulation for radon proposed in 1991 by EPA required that groundwater systems monitor for radon at each entry point to the distribution system quarterly for one year initially. Monitoring could be reduced to one sample annually per entry point to the distribution system if the average of all first quarterly samples was below the MCL. States could allow systems to reduce monitoring to once every three years if the system demonstrated that results of all previous samples collected were below the MCL. The proposal also allowed States to grant waivers to groundwater systems to reduce the frequency of monitoring, up to once every 9 years, if States determined that radon levels in drinking water were consistently and reliably below the MCL. Comments made in response to the proposed monitoring requirements for radon were mainly concerned that the proposed monitoring requirements including number of samples and the frequency of monitoring did not adequately take into account the effect of seasonal variations in radon levels on determining compliance. Other commenters felt that sampling at the entry point of the distribution system was not representative of exposure to radon, and they suggested that sampling for radon should be done at the point of use.

Since the 1991 proposal EPA has obtained additional information from States, the waterworks industry and academia on the occurrence of radon, including data on the temporal variability of radon. Utilizing this additional data, the Agency performed extensive statistical analyses to predict how temporal, analytical variations and variations between individual wells may affect exposure to radon. The results of these analyses are described in detail in the report ''Methods, Occurrence and Monitoring Document for Radon'' in the docket for this rule (USEPA 1999g). As a result of the new information available, EPA was able to refine the requirements for monitoring and address the concerns expressed by the commenters on the 1991 proposal.

The proposed monitoring requirements for radon are consistent with the monitoring requirements for regulated drinking water contaminants, as described in the Standardized Monitoring Framework (SMF) promulgated by EPA under the Phase II Rule of the National Primary Drinking Water Regulations (NPDWR) and revised under Phases IIB and V. The goal of the SMF is to streamline the drinking water monitoring requirements by standardizing them within contaminant groups and by synchronizing monitoring schedules across contaminant groups. A summary of monitoring requirements in this proposal, the SMF and the 1991 proposal are provided in Table VIII.E.1.

TABLE VIII.E.1.—COMPARISON OF MONITORING REQUIREMENTS

Monitoring requirements for radon		
1991 Proposal	1999 Proposal—MCL/AMCL	SMF for IOCs in groundwater
	Initial Monitoring Requirements	
Four consecutive quarters of monitoring at each entry point for one year. Initial monitoring was proposed to have been completed by January 1, 1999.	Four consecutive quarters of monitoring at each entry point. Initial monitoring must begin by three years from date of publication of the final rule in FEDERAL REGISTER of 4.5 years from date of publication of the final rule in FEDERAL REGISTER (depending on effective date applicable to the State).	Four consecutive quarters of monitoring at each entry point for sampling points initially exceeding MCL.
	Routine Monitoring Requirements	
One sample annually if average from four consecutive quarterly samples taken initially is less than MCL.	One sample annually if average from four consecutive quarterly samples is less than MCL/AMCL, and at the discretion of State.	One sample at each sample point during the initial 3 year compliance period for groundwater systems for sampling points below MCL.
1991 Proposal	1999 Proposal—MCL	SMF for IOCs in Groundwater
	Reduced Monitoring Requirements	
State may allow groundwater systems to reduce the frequency of monitoring to once every three years provided that they have monitored quarterly in the initial year and completed annual testing in the second and third year of the first compliance period. Groundwater systems must demonstrate that all previous analytical samples were less than the MCL.	State may allow CWS using groundwater to reduce monitoring frequency to:. Once every three years if average from four consecutive quarterly samples is less than ½ the MCL/AMCL, provided no samples exceed the MCL/AMCL. and if the system is determined by State to be ''reliably and consistently below MCL/AMCL ''.	State may allow groundwater systems to reduce monitoring frequency to: Once every three years if samples subsequently detects less than MCL and determined by State to be ''reliably and consistently below MCL.''
	Monitoring Requirements for Radon	
1991 Proposal	1999 Proposal—MCL/AMCL	SMF for IOCs in Groundwater
	Increased Monitoring Requirements	
Systems monitoring annually or once per three year compliance period exceed the radon MCL in a single sample would be required to revert to quarterly monitoring until the average of 4 consecutive samples is less than the MCL. Groundwater systems with unconnected wells would be required to conduct increased monitoring only at those wells exceeding the MCL. The State may require more frequent monitoring than specified. Systems may apply to the State to conduct more frequent monitoring than the minimum monitoring frequencies specified.	Systems monitoring annually would be required to increase monitoring if the MCL/AMCL for radon is exceeded in a single sample, the system would be required to revert to quarterly monitoring until the average of 4 consecutive samples is less than the MCL/AMCL. Systems monitoring once every three years would be required to monitor annually if the radon level is less than MCL/AMCL but above ½ MCL/AMCL in a single sample. Systems may revert to monitoring once per three years if the average of the initial and three consecutive annual samples is lees than ½ MCL/AMCL. CWS using groundwater with un-connected wells would be required to conduct increased monitoring only at those well which are affected.	If the MCL is exceeded in a single sample, the system required to begin sampling quarterly until State determines that it is ''reliably and consistently'' below MCL.

TABLE VIII.E.1.—COMPARISON OF MONITORING REQUIREMENTS—Continued

Monitoring requirements for radon		
1991 Proposal	1999 Proposal—MCL/AMCL	SMF for IOCs in groundwater
Monitoring Requirements for Radon		
1991 Proposal	1999 Proposal—MCL	SMF for IOCs in Groundwater
Confirmation Samples		
Where the results of sampling indicate an exceedence of the maximum contaminant level, the State may require that one additional sample be collected as soon as possible after the initial sample was taken [but not to exceed two weeks] at the same sampling point. The results of the of the initial sample and the confirmation sample shall be averaged and the resulting average shall be used to determine compliance.	Systems may collect confirmation samples as specified by the State. The average of the initial sample and any confirmation samples will be used to determine compliance.	Where the results sampling indicate an exceedence of the maximum contaminant level, the State may require that one additional sample be collected as soon as possible after the initial sample was taken [but not to exceed two weeks] at the same sampling point. The results of the initial sample and the confirmation sample shall be averaged and the resulting average shall be used to determine compliance.
Grandfathering of Data		
If monitoring data collected after January 1, 1985 are generally consistent with the requirements specified in the regulation, than the State may allow the systems to use those data to satisfy the monitoring requirements for the initial compliance period.	If monitoring data collected after proposal of the rule are consistent with the requirements specified in the regulation, then the State may allow the systems to use those data to satisfy the monitoring requirements for the initial compliance period.	States may allow previous sampling data to satisfy the initial sampling requirements provided the data were collected after January 1, 1990.
Monitoring Requirements for Radon		
1991 Proposal	1999 Proposal—MCL	SMF for IOCs in Groundwater
Waivers		
State may grant waiver to groundwater systems to reduce the frequency of monitoring, up to nine years. If State determines that radon levels in drinking water are ''reliably and consistently'' below the MCL.	The State may grant a monitoring waiver to systems to reduce the frequency of monitoring to up to one sample every nine years based on previous analytical results, geological characteristics of source water aquifer and if a State determines that radon levels in drinking water are ''reliably and consistently'' below the MCL/AMCL. Analytical results of all previous samples taken must be below ½ the MCL/AMCL.	The State may grant waiver to groundwater systems after conducting vulnerability assessment to reduce the frequency of monitoring, up to nine years, if State determines that radon levels in drinking water are ''reliably and consistently'' below the MCL. System must have three previous samples. Analytical results of all previous samples taken must be below MCL.

In developing the proposed compliance monitoring requirements for radon, EPA considered:

(1) The likely source of contamination in drinking water;

(2) The differences between ground water and surface water systems;

(3) The collection of samples which are representative of consumer exposure;

(4) Sample collection and analytical methods;

(5) The use of appropriate historical data to identify vulnerable systems and to specify monitoring requirements for individual systems;

(6) The analytical, temporal and intra-system variance of radon levels;

(7) The use of appropriate historical data and statistical analysis to establish reduced monitoring requirements for individual systems; and

(8) The need to provide flexibility to the States to tailor monitoring requirements to site-specific conditions by allowing them to:

—Grant waivers to systems to reduce monitoring frequency, provided certain conditions are met.
—Require confirmation samples for any sample exceeding the MCL/AMCL.
—Allow the use of previous sampling data to satisfy initial sampling requirements.
—Increase monitoring frequency.
—Decrease monitoring frequency.

2. Monitoring for Surface Water Systems

CWSs relying exclusively on surface water as their water source will not be required to sample for radon. Systems that rely in part on ground water would be considered groundwater systems for purposes of radon monitoring. Systems that use ground water to supplement surface water during low-flow periods will be required to monitor for radon. Ground water under the influence of surface water would be considered ground water for this regulation.

3. Sampling, Monitoring Schedule and Initial Compliance for CWS Using Groundwater

EPA is retaining the quarterly monitoring requirement for radon as proposed initially in the 1991 proposal to account for variations such as sampling, analytical and temporal variability in radon levels. Results of analysis of data obtained since 1991, estimating contributions of individual sources of variability to overall variance in the radon data sets evaluated, indicated that sampling and analytical variance contributes less than 1 percent to the overall variance. Temporal variability within single wells accounts for between 13 and 18 percent of the variance in the data sets evaluated, and a similar proportion (12–17 percent) accounts for variation in radon levels among wells within systems. (USEPA 1999g)

The Agency performed additional analyses to determine whether the requirement of initial quarterly monitoring for radon was adequate to account for seasonal variations in radon levels and to identify non-compliance with the MCL/AMCL. Results of analysis based on radon levels modeled for radon distribution for ground water sources (USEPA 1999g) and systems (USEPA 1998a) in the U.S. show that the average of the first four quarterly samples provides a good indication of the probability that the long-term average radon level in a given source would exceed an MCL or AMCL. Tables VIII.E.2 and VIII.E.3 show the probability of the long-term average radon level exceeding the MCL and AMCL at various averages obtained from the first four quarterly samples from a source.

TABLE VIII.E.2.—THE RELATIONSHIP BETWEEN THE FIRST-YEAR AVERAGE RADON LEVEL AND THE PROBABILITY OF THE LONG-TERM RADON AVERAGE RADON LEVELS EXCEEDING THE MCL

If the average of the first four quarterly samples from a source is	Then the probability that the long-term average radon level in that source exceeds 300 pCi/L is
Less than 50 pCi/L	0 percent.
Between 50 and 100 pCi/L	0.5 percent.
Between 100 and 150 pCi/L.	0.4 percent.
Between 150 and 200 pCi/L.	7.2 percent.
Between 200 and 300 pCi/L.	26.8 percent.

TABLE VIII.E.3.—THE RELATIONSHIP BETWEEN THE FIRST-YEAR AVERAGE RADON LEVEL AND THE PROBABILITY OF THE LONG-TERM RADON AVERAGE RADON LEVELS EXCEEDING THE AMCL

If the average of the first four quarterly samples from a source is	Then the probability that the long-term average radon level in that source exceeds 4000 pCi/L is
Less than 2,000 pCi/L	Less than 0.1 percent.
Between 2,000 and 2,500 pCi/L.	9.9 percent.
Between 2,500 and 3,000 pCi/L.	15.1 percent.
Between 3,000 and 4,000 pCi/L.	32.9 percent.

The Agency proposes that systems relying wholly or in part on ground water will be required to initially sample quarterly for radon for one year at each well or entry point to the distribution system. All samples will be required to be of finished water, as it enters the distribution system after any treatment and storage. If the average of the four quarterly samples at each well is below the MCL/AMCL, monitoring may be reduced to once a year at State discretion. Systems may be required to continue monitoring quarterly in instances where the average of the quarterly samples at each well is below but close to the MCL/AMCL. The reason for this is that in such cases, there is a good chance for the long-term average radon level to exceed the MCL/AMCL.

Systems already on-line must begin initial monitoring for compliance with the MCL/AMCL by the compliance dates specified in the rule (*i.e.,* 3 years after the date of promulgation or 4.5 years after the date of promulgation). Monitoring requirements for new sources will be determined by the State. The compliance dates are discussed in detail in Section VII.E, Compliance Dates.

The Agency is retaining the requirement as proposed in 1991 to sample at the entry point to the distribution system. Sampling at the entry point allows the system to account for radon decay during storage and removal during the treatment process. The reason for not allowing sampling at the point of use is that this approach would not take into account higher exposure levels that may be encountered at locations upstream from the sampling site. In addition, sampling at the entry point will make it easier to identify and isolate possible contaminant sources within the system. The sample collection sites at each entry point to the distribution system and the monitoring schedule requiring sampling for four consecutive quarters proposed herein is consistent with the SMF. This approach streamlines monitoring since the same sampling points can be used for the collection of samples for other source-related contaminants.

EPA specifically requests comments on the following aspects of the proposed monitoring requirements:

- The appropriateness of the proposed initial monitoring period.
- The availability and capabilities of laboratories to analyze radon samples collected during the initial compliance period. The Agency recognizes that short-term implementation problems may arise to meet the initial monitoring deadline because of the potential limited availability of radon performance evaluation (PE) samples used to evaluate and certify laboratories.
- The appropriateness of the proposed number and frequency of samples required to monitor for radon.
- The designation of sampling locations at the entry point to the distribution system which is located after any treatment and storage. Comments are also solicited on the definition of sampling points that are representative of consumer exposure.
- Designating sampling locations and frequencies that permit simultaneous monitoring for all regulated contaminants, whenever possible and advantageous. The proposed sampling locations would be such that the same sampling locations could be used for the collection of samples for other source-related contaminants such as the volatile organic chemicals and inorganic chemicals, which would simplify sample collection efforts.

EPA also solicits comments on whether the monitoring requirements should include additional monitoring for radon as a source of consumer exposure from the distribution system. Results of investigations in Iowa indicate that in some instances, pipe scale deposited in the distribution system can be a source of exposure to radon. Community ground water systems could be required to collect an additional sample from the distribution system during the initial year of monitoring, at the same time the entry point sample is collected, and continue to collect samples from the distribution system annually if it is shown that exceedence of the MCL/AMCL is caused by the release of radon from deposited scale in the interior of the distribution system. Results obtained from distribution samples could provide information on the extent and frequency of occurrence of radon originating from distribution systems.

4. Increased/Decreased Monitoring Requirements

Initial compliance with the MCL/AMCL will be determined based on an average of four quarterly samples taken at individual sampling points in the initial year of monitoring. Systems with averages exceeding the MCL/AMCL at any sampling point will be deemed to be out of compliance. Systems in a non-MMM State exceeding the MCL will have the option to develop and implement a local MMM program in accordance with the timeframe discussed in Section VII.E, Compliance Dates without receiving a MCL violation.

Systems exceeding the MCL/AMCL will be required to monitor quarterly until the average of four consecutive samples is less than the MCL/AMCL. Systems will then be allowed to collect one sample annually if the average from four consecutive quarterly samples is less than the MCL/AMCL and if the State determines that the system is reliably and consistently below the MCL/AMCL.

Systems will be allowed to reduce monitoring frequency to once every three years (one sample per compliance period) per well or sampling point, if the average from four consecutive quarterly samples is less than ½ the MCL/AMCL and the State determines that the system is reliably and consistently below the MCL/AMCL. As shown in Tables VIII.E.2 and VIII.E.3, EPA believes that there is sufficient margin of safety to allow for this since there is a small probability that long term average radon levels will exceed the MCL/AMCL.

Systems monitoring annually that exceed the radon MCL/AMCL in a single sample will be required to revert to quarterly monitoring until the average of four consecutive samples is less than the MCL/AMCL. Community ground water systems with unconnected wells will be required to conduct increased monitoring only at those wells exceeding the MCL/AMCL. Compliance will be based on the average of the initial sample and three consecutive quarterly samples.

Systems monitoring once per compliance period or less frequently which exceed ½ the MCL/AMCL (but do not exceed the MCL/AMCL) in a single sample would be required to revert to annual monitoring. Systems may revert to monitoring once every three years if the average of the initial and three consecutive annual samples is less than ½ the MCL/AMCL. Community ground water systems with unconnected wells will be required to conduct increased monitoring only at those wells exceeding the MCL/AMCL.

States may grant a monitoring waiver reducing monitoring frequency to once every nine years (once per compliance cycle) provided the system demonstrates that it is unlikely that radon levels in drinking water will occur above the MCL/AMCL. In granting the monitoring waiver, the State must take into consideration factors such as the geological area where the water source is located, and previous analytical results which demonstrate that radon levels do not occur above the MCL/AMCL. The monitoring waiver will be granted for up to a nine year period. (Given that all previous samples are less than ½ the MCL/AMCL, then it is highly unlikely that the long-term average radon levels would exceed the MCL/AMCL.)

If the analytical results from any sampling point are found to exceed the MCL/AMCL (in the case of routine monitoring) or ½ the MCL/AMCL (in the case of reduced monitoring), the State may require the system to collect a confirmation sample(s). The results of the initial sample and the confirmation sample(s) shall be averaged and the resulting average shall be used to determine compliance.

EPA specifically requests comments on the following aspects of the proposed monitoring requirements :

- Allowing systems at State discretion, to reduce monitoring frequencies as long as the system demonstrates that its radon levels are maintained below the MCL/AMCL. For example, all community ground water systems would be required to collect one sample from each entry point to the distribution system (located after any treatment and storage) quarterly at first and annually after compliance is established. MCL/AMCL exceedence would trigger reverting to quarterly sampling until compliance with the MCL/AMCL is reestablished. Compliance is reestablished when the average of four consecutive quarterly samples is below the MCL/AMCL.
- Allowing States to reduce monitoring requirements to not less than once every three years if the average radon levels from four consecutive quarterly samples is less than ½ the MCL/AMCL, and the State determines that the radon levels in the drinking water are reliably and consistently below ½ the MCL/AMCL. A single sample exceeding ½ the MCL/AMCL would trigger reverting to sampling annually. Comments are solicited on the criteria allowing the utility to revert to monitoring once every three years if the average of the initial and three consecutive annual samples is less than ½ the MCL/AMCL.
- Factors affecting State discretion to grant waivers. In addition, the Agency solicits comments on the advisability of reducing the monitoring frequency up to nine years between samples. Comments are solicited on the requirement that all previous samples (that might be used to identify systems which are very unlikely to exceed the MCL/AMCL) must be below ½ the MCL/AMCL in order for a system to qualify for a waiver.
- Allowing States to require the collection of confirmation samples to verify initial sample results as specified by the State, and to use the average of the initial sample and the confirmation samples to determine compliance.

5. Grandfathering of Data

At a State's discretion, sampling data collected since the proposal could be used to satisfy the initial sampling requirements for radon, provided that the system has conducted a monitoring program and used analytical methods that meet proposal requirements. The Agency wants to provide water suppliers with the opportunity to synchronize their radon monitoring program with monitoring for other contaminants and to get an early start on their monitoring program if they wish to do so.

The Agency solicits comments on the advisability of allowing the use of monitoring data obtained since the proposal to satisfy the initial monitoring requirements.

IX. State Implementation

This section describes the regulations and other procedures and policies States have to adopt, or have in place, to implement today's proposed rule. States must continue to meet all other conditions of primacy in 40 CFR part 142.

Section 1413 of the SDWA establishes requirements that a State must meet to obtain or maintain primacy enforcement responsibility (primacy) for its public water systems. These include: (1) Adopting drinking water regulations that are no less stringent than Federal NPDWRs in effect under Section 1412(b) of the Act; (2) adopting and implementing adequate procedures for enforcement; (3) keeping records and making reports available on activities that EPA requires by regulation; (4) issuing variances and exemptions (if allowed by the State) under conditions no less stringent than allowed by Sections 1415 and 1416; (5) adopting and being capable of implementing an adequate plan for the provision of safe drinking water under emergency situations; and (6) adopting authority for administrative penalties.

40 CFR part 142 sets out the specific program implementation requirements for States to obtain primacy for the public water supply supervision (PWSS) program, as authorized under SDWA 1413 of the Act. In addition to meeting the basic primacy requirements, States may be required to adopt special primacy provisions pertaining to a specific regulation. States are required by 40 CFR 142.12 to include these regulation-specific provisions in an application for approval of their program revisions. To maintain primacy for the PWS program and to be eligible for interim primacy enforcement authority for future regulations, States must adopt today's rule, when final, along with the special primacy requirements discussed next. Interim primacy enforcement authority allows States to implement and enforce drinking water regulations once State regulations are effective and the State has submitted a complete and final primacy revision application. Under interim primacy enforcement authority, States are effectively considered to have primacy during the period that EPA is reviewing their primacy revision application.

A. Special State Primacy Requirements

In addition to adopting drinking water regulations at least as stringent as the regulations described in the previous sections, EPA requires that States adopt certain additional provisions related to this regulation, in order to have their drinking water program revision application approved by EPA. States have two options when implementing this rule. States may adopt the AMCL and implement a State-wide MMM program plan or States may adopt the MCL. If a State chooses to adopt the MCL, CWSs in that State have the option to develop and implement a State-approved local MMM program plan and comply with the AMCL.

To ensure that the State program includes all the elements necessary for a complete enforcement program, EPA is proposing that 40 CFR part 142 be amended to require the following in order to obtain primacy for this rule:

(1) Adoption of the promulgated Radon Rule, and

(2) One of the following, depending on which regulatory option the State chooses to adopt:

(a) If a State chooses to develop and implement a State-wide MMM program plan and adopt the AMCL, the primacy application must contain a copy of the State-wide MMM program plan meeting the four criteria in 40 CFR Part 141 Subpart R and the following: a description of how the State will make resources available for implementation of the State-wide MMM program plan, and a description of the extent and nature of coordination between interagency programs (*i.e.*, indoor radon and drinking water programs) on development and implementation of the MMM program plan, including the level of resources that will be made available for implementation and coordination between interagency programs (*i.e.*, indoor air and drinking water programs).

(b) If a State chooses to adopt the MCL, the primacy application must contain a description of how the State will implement a program to approve local CWS MMM program plans prepared to meet the criteria outlined in 40 CFR Part 141 Subpart R. In addition, the primacy application must contain a description of how the State will ensure local CWS MMM program plans are implemented and the extent and nature of coordination between interagency programs (*i.e.*, indoor radon and drinking water programs) on development and implementation of the MMM program, including the level of resources that will be made available for implementation and coordination between interagency programs (*i.e.*, indoor air and drinking water programs), as well as, a description of the reporting and record keeping requirements for the CWSs.

States are required to submit their primacy revision application packages by two years from the date of publication of the final rule in the **Federal Register**. For States adopting the AMCL, EPA approval of a State's primacy revision application is contingent on submission of and EPA approval of the State's MMM program plan. Therefore, EPA is proposing to require submission of State-wide MMM program plans as part of the complete and final primacy revision application. This will enable EPA to review and approve the complete primacy application in a timely and efficient manner in order to provide States with as much time as possible to begin to implement MMM programs. In accordance with Section 1413(b)(1) of SDWA and 40 CFR 142.12(d)(3), EPA is to review primacy applications within 90 days. Therefore, although the SDWA allows 180 days for EPA review and approval of MMM program plans, EPA expects to review and approve State primacy revision applications for the AMCL, including the State-wide MMM program plan, within 90 days of submission to EPA.

EPA is proposing that States notify CWSs of their decision to adopt the MCL or AMCL at the time they submit their primacy application package to EPA (24 months after publication of the final rule). If a State adopts the MCL, CWSs choosing to implement a local CWS MMM program and comply with the AMCL will be required to have completed initial monitoring, notify the State of their intention, and begin developing a plan 4 years after the rule is final. EPA is particularly concerned that these CWSs have sufficient time to develop MMM program plans with local input and allow for State approval. Therefore, it is EPA's expectation that States will be submitting complete and final primacy revision applications by 24 months from the date of publication of the final rule in **Federal Register**. In reviewing any State requests for extensions of time in submitting primacy revision applications, EPA will consider whether sufficient time will be provided to CWSs to develop and get State approval of their local MMM program plans prior to implementation.

B. State Record Keeping Requirements

Today's rule does not include changes to the existing recordkeeping provisions required by 40 CFR 142.14. MMM record keeping requirements will be addressed in each State's primacy revision application submission to meet the special primacy requirements for radon (40 CFR 142.16).

C. State Reporting Requirements

Currently States must report to EPA information under 40 CFR 142.15 regarding violations, variances and exemptions, enforcement actions and general operations of State public water supply programs.

In accordance with the Safe Drinking Water Act (SDWA), EPA is to review State MMM programs at least every five years. For the purposes of this review, the States with EPA-approved MMM program plans shall provide written reports to EPA in the second and fourth years between initial implementation of the MMM program and the first 5-year review period, and in the second and fourth years of every subsequent 5-year review period. EPA will review these programs to determine whether they continue to be expected to achieve risk reduction of indoor radon using the information provided in the two biennial reports. EPA requests comment on this approach. These reports are required to include the following information:

- A quantitative assessment of progress towards meeting the required goals described in Section VI. A., including the number or rate of existing homes mitigated and the number or rate of new homes built radon-resistant since implementation of the States' MMM program: and
- A description of accomplishments and activities that implement the program strategies outlined in the implementation plan and in the two required areas of promoting increased testing and mitigation of existing homes and promoting increased use of radon-resistant techniques in construction of new homes.
- If goals were defined as rates, the State must also provide an estimate of the number of mitigations and radon-resistant new homes represented by the reported rate increase for the two-year period.
- If the MMM program plan includes goals for promoting public awareness of the health effects of indoor radon, testing of homes by the public; testing and mitigation of existing schools; and construction of new public schools to be radon-resistant, the report is also required to include information on results and accomplishments in these areas.

EPA will use this information in discussions and consultations with the State during the five-year review to evaluate program progress and to consider what modifications or adjustments in approach may be needed. EPA envisions this review process will be one of consultation and collaboration between EPA and the States to evaluate the success of the program in achieving the radon risk reduction goals outlined in the approved programs. If EPA determines that a MMM program in not achieving progress towards its goals, EPA and the State shall collaborate to develop modifications and adjustments to the program to be implemented over the five year period following the review. EPA will prepare a summary of the outcome of the program evaluation and the proposed modification and adjustments, if any, to be made by the State.

States that submit a letter to the Administrator by 90 days after publication of the final rule committing to develop an MMM program plan, must submit their first 2-year report by 6.5 years from publication of the final rule. For States not submitting the 90-day letter, but choosing subsequently to submit an MMM program plan and adopt the AMCL, the first 2-year report must be submitted to EPA by 5 years from publication of the final rule. States shall make available to the public each of these two-year reports, as well as the EPA summaries of the five-year reviews of a State's MMM program, within 90 days of completion of the reports and the review.

In primacy States without a State-wide MMM program, the States shall provide a report to EPA every five-years on the status and progress of CWS MMM programs towards meeting their goals. The first of such reports would be due 5 years after CWSs begin implementing a local MMM program which is 5.5 years from publication of the final rule.

D. Variances and Exemptions

Section 1415 of the SDWA authorizes the State to issue variances from NPDWRs (the term ''State'' is used in this preamble to mean the State agency with primary enforcement responsibility, or ''primacy,'' for the public water supply system program or EPA if the State does not have primacy). The State may issue a variance under Section 1415(a) if it determines that a system cannot comply with an MCL due to the characteristics of its source water, and on condition that the system install BAT. Under Section 1415(a), EPA must propose and promulgate its finding identifying the best available technology, treatment techniques, or other means available for each contaminant, for purposes of Section 1415 variances, at the same time that it proposes and promulgates a maximum contaminant level for such contaminant. EPA's finding of BAT, treatment techniques, or other means for purposes of issuing variances may vary, depending upon the number of persons served by the system or for other physical conditions related to engineering feasibility and costs of complying with MCLs, as considered appropriate by the EPA. The State may not issue a variance to a system until it determines among other things that the variance would not pose an unreasonable risk to health (URTH). EPA has developed draft guidance, ''Guidance in Developing Health Criteria for Determining Unreasonable Risks to Health'' (USEPA 1990) to assist States in determining when an unreasonable risk to health exists. EPA expects to issue final guidance for determining when URTH levels exist later this year. When a State grants a variance, it must at the same time prescribe a schedule for (1) compliance with the NPDWR and (2) implementation of such additional control measures as the State may require.

Under Section 1416(a), the State may exempt a public water system from any MCL and/or treatment technique requirement if it finds that (1) due to compelling factors (which may include economic factors), the system is unable to comply or develop an alternative supply, (2) the system was in operation on the effective date of the MCL or treatment technique requirement, or, for a newer system, that no reasonable alternative source of drinking water is available to that system, (3) the exemption will not result in an unreasonable risk to health, and (4) management or restructuring changes cannot be made that would result in compliance with this rule. Under Section 1416(b), at the same time it grants an exemption the State is to prescribe a compliance schedule and a schedule for implementation of any required interim control measures. The final date for compliance may not exceed three years after the NPDWR effective date except that the exemption can be renewed for small systems for limited time periods.

EPA will not list ''small systems variance technologies'', as provided in Section 1415(e)(3) of the Act, since EPA has determined that affordable treatment technologies exist for all applicable system sizes and water quality conditions. As stated in this Section of the Act, if the Administrator finds that small systems can afford to comply through treatment, alternate water source, restructuring, or consolidation, according to the affordability criteria established by the Administrator, then systems are not eligible for small systems variances. Small systems will, however, still be able to apply for ''regular'' variances and exemptions, pursuant to Sections 1415 and 1416 of the Act.

E. Withdrawing Approval of a State MMM Program

If EPA determines that a State MMM program is not achieving progress towards its MMM goals, and the State repeatedly fails to correct, modify and adjust implementation of its MMM program after notice by EPA, EPA may withdraw approval of the State's MMM program plan. The State will be responsible for notifying CWSs of the Administrator's withdrawal of approval of the State-wide MMM program plan. The CWSs in the State would then be required to comply with the MCL within one year from date of notification, or develop a State-approved CWS MMM program plan. EPA will work with the State to develop a State process for review and approval of CWS MMM program plans that meet the required criteria and establish a time frame for submittal of program plans by CWSs that choose to continue complying with the AMCL. The review process will allow for local public participation in development and review of the program plan.

X. What Do I Need To Tell My Customers? Public Information Requirements

A. Public Notification

Sections 1414(c)(1) and (c)(2) of the SDWA, as amended, require that public water systems notify persons served when violations of drinking water standards occur. EPA recently proposed to revise the current public notification regulations to incorporate new statutory provisions enacted under the 1996 SDWA amendments (64 FR 25963, May 13, 1999). The purpose of public notification is to alert customers in a timely manner to potential risks from violations of drinking water standards and the steps they should take to avoid or minimize such risks.

Today's regulatory action would add violation of the radon NPDWR to the list of violations requiring public notice under the May 13, 1999, proposed public notification rule. Today's action would make three changes to the proposed public notification rule.

• First, Appendix A to Subpart Q would be modified to require a Tier 2 public notice for violations of the MCL and AMCL for all community water systems. Under the proposed rule, Tier 2 public notices would be required for violations and situations with potential to have serious adverse effects on human health. Tier 2 public notices must be distributed within 30 days after the violation is known, and must be repeated every three months until the violation is resolved.

• Second, Appendix A would also be modified to require a Tier 3 public notice for all radon monitoring and testing procedure violations and for violations of the Multimedia Mitigation (MMM) Program Plan. Tier 3 public notices must be distributed within a year of the violation and could, at the water system's option, be included in the annual Consumer Confidence Report (CCR).

• Third, Appendix B to Subpart Q would be modified to add standard health effects language, which public water systems are required to use in their notices when violations of the AMCL or MMM occur. EPA proposes that the standard health effects language for these violations, to be included in CCR annual reports and public notices. The language for violation of the (A)MCL would be as follows: ''People who use drinking water containing radon in excess of the (A)MCL for many years may have an increased risk of getting lung and stomach cancer.'' The language for violation of the MMM would be as follows: ''Your water system is not complying with requirements to promote the reduction of lung cancer risks from radon in indoor air, which is a problem in some homes. Radon is a naturally occurring radioactive gas which may enter homes from the surrounding soil and may also be present in drinking water. Because your system is not complying with applicable requirements, it may be required to install water treatment technology to meet more stringent standards for radon in drinking water. The best way to reduce radon risk is to test your home's indoor air and, if elevated levels are found, hire a qualified contractor to fix the problem. For more information, call the National Safety Council's Radon Hotline at 1–800–SOS–RADON.'' The standard health effects language public water systems are to use in their public notice would be identical to that used in the annual CCR.

The final public notification rule is expected to be published around December, 1999, well in advance of the August, 2000, deadline for the final radon regulation. The final public notification requirements for radon, therefore, will be published with the final radon rule. The Agency will republish the tables in Appendices A and B to Subpart Q of Part 141 with all necessary changes in the final rule.

B. Consumer Confidence Report

Section 1414(d) of the SDWA requires that all community water systems provide annual water quality reports (or consumer confidence reports (CCRs)) to their customers. In their reports, systems must provide, among other things, the levels and sources of all detected contaminants, the potential health effects of any contaminant found at levels that violate EPA or State rules, and short educational statements on contaminants of particular interest.

Today's action updates the standard CCR rule requirements in subpart O and adds special requirements that reflect the multimedia approach of this rule. The intent of these provisions is to assist in clearer communication of the relative risks of radon in indoor air from soil and from drinking water, and to encourage public participation in the development of the State or CWS MMM program plans. Systems that detect radon at a level that violates the A/MCL would have to include in their report a clear and understandable explanation of the violation including: the length of the violation, actions taken by the system to address the violation, and the potential health effects (using the language proposed today for Appendix C to subpart O: ''People who use drinking water containing radon in excess of the (A)MCL for many years may have an increased risk of getting lung and stomach cancer''). This approach is comparable to that used for other drinking water contaminants.

In addition, recognizing the novelty of the MMM approach and the interest that consumers may have in participating in the design of the MMM program, today's action also proposes that any system that has ground water as a source must include information in its report in the years between publication of the final rule and the date by which States, or systems, will be required to implement an MMM program. This information would include a brief educational statement on radon risks, explaining that the principal radon risk comes from radon in indoor air, rather than drinking water, and for that reason, radon risk reduction efforts may be focused on indoor air rather than drinking water. This information will also note that many States and systems are in the process of creating programs to reduce exposure to radon, and encourage readers to call the Radon Hotline (800–SOS–RADON) or visit EPA's radon web site (www.epa.gov/iaq/radon) for more information. A system would be able to use language provided in the proposed rule by EPA or could chose to tailor the wording to its specific local circumstances in consultation with the primacy agency. EPA recognizes that this creates a slight additional burden on community water system operators, but believes that the value of strong public support for, and participation in, the creation of the MMM program outweighs this burden. EPA also recognizes that this notice may provoke some confusion, since CCRs would alert consumers to the risks presented by a contaminant which most systems have never monitored in their water, although the notice would state that the system would be testing and would provide customers with the results. EPA is requesting comment on this proposed notice.

Finally, the Agency will republish the tables in Appendices A, B, and C to Subpart O of Part 141 with all necessary changes in the final rule.

Risk Assessment and Occurrence

XI. What Is EPA's Estimate of the Levels of Radon in Drinking Water?

A. General Patterns of Radon Occurrence

Radon levels in ground water in the United States are generally highest in New England and the Appalachian uplands of the Middle Atlantic and Southeastern States. There are also isolated areas in the Rocky Mountains, California, Texas, and the upper Midwest where radon levels in ground water tend to be higher than the United States average. The lowest ground water radon levels tend to be found in the Mississippi Valley, lower Midwest, and Plains States. The following map shows the general patterns of radon occurrence in those States for which data are available.

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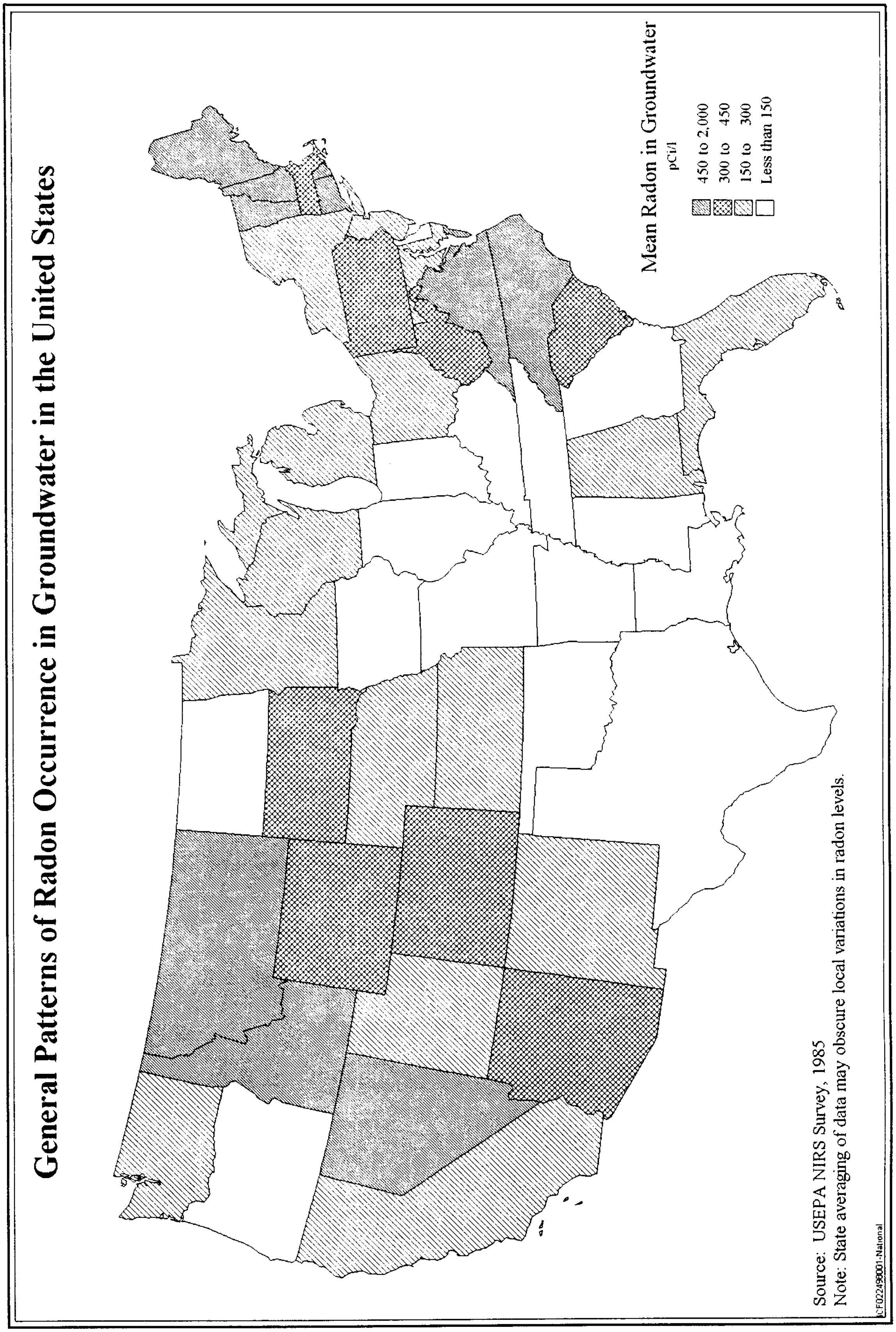

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In addition to large-scale regional variation, radon levels in ground water vary significantly over a smaller area. Local differences in geology tend to greatly influence the patterns of radon levels observed at specific locations. (This means, for example, that not all radon levels in New England are high and not all radon levels in the Gulf Coast region are low). Over small distances, there is often no consistent relationship between radon levels in ground water and uranium or other radionuclide levels in the ground water or in the parent bedrock (Davis and Watson 1989). Similarly, no significant geographic correlation has been found between radon levels in groundwater systems and the levels of other inorganic contaminants. Radon may be found in groundwater systems where other contaminants (for example, arsenic) also occur. However, finding a high (or low) level of radon does not indicate that a high (or low) level of other contaminants will also be found. Similarly, there is little evidence that radon occurrence is correlated with the presence of organic pollutants. In estimating the costs of radon removal, EPA has taken into account the fact that other contaminants, such as iron and manganese, may also be present in the water. High levels of iron and manganese may complicate the process of radon removal and increase the costs of mitigation.

Radon is released rapidly from surface water. Therefore, radon levels in supplies that obtain their water from surface sources (lakes or reservoirs) are very low compared to groundwater levels.

Because of its short half life, there are relatively few man-made sources of radon exposure in ground water. The most common man-made sources of radon ground water contamination are phosphate or uranium mining or milling operations and wastes from thorium or radium processing. Releases from these sources can result in high ground water exposures, but generally only to very limited populations; for instance, to persons using a domestic well in a contaminated aquifer as a source of potable water (USEPA 1994a).

B. Past Studies of Radon Levels in Drinking Water

A number of studies of radon levels in drinking water were undertaken in the 1970s and early 1980s. Most of these studies were limited to small geographic areas, or addressed systems that were not representative of community systems throughout the U.S. The first attempt to develop a comprehensive understanding of radon levels in public water supplies was the National Inorganics and Radionuclides Survey (NIRS), which was undertaken by the EPA in 1983–1984. As part of NIRS, radon samples were analyzed from 1,000 community groundwater systems throughout the United States. The size distribution of systems sampled was the same as the size distribution of groundwater systems in U.S., and the geographic distribution was approximately consistent with the regional distribution of systems. Because of the limited number of samples, however, the number of radon measurements in some States was quite small. Table XI.B.1 summarizes the regional patterns of radon in drinking water supplies as seen in the NIRS database.

TABLE XI.B.1.—RADON IN COMMUNITY GROUND WATER SYSTEMS BY REGION (ALL SYSTEM SIZES)

Region	Arithmetic mean (pCi/L)	Geometric mean (pCi/L)	Geometric standard deviation (pCi/L)
Appalachian	1,127	333	4.76
California	629	333	3.09
Gulf Coast	263	125	3.38
Great Lakes	278	151	3.01
New England	2,933	1,214	3.77
Northwest	222	161	2.23
Plains	213	132	2.65
Rocky Mountains	607	361	2.77

Source: USEPA 1999g.

Note: These distributions are described in two ways. First, the arithmetic means (average values) are given. In addition, the geometric mean and geometric standard deviation are given. This approach is taken because the distributions of radon in groundwater systems are not ''normal'' bell-shaped curves. Instead, like many environmental data sets, it was found that the √logarithms of the radon concentrations were normally distributed (''lognormal distribution.'') The geometric mean corresponds to the center of a bell-shaped ''normal'' distribution when radon concentrations are expressed in logarithms. The geometric standard deviation is a measure of the spread of the bell-shaped curve, expressed in logarithmic form.

The NIRS has the disadvantage that the samples were all taken from within the water distribution systems, making estimation of the naturally occurring influent radon levels difficult. In addition, the NIRS data provide no information to allow analysis of the variability of radon levels over time or within individual systems. Thus, while the NIRS data provide statistically valid estimates of radon levels in the systems that were sampled, they do not adequately represent radon levels in some individual States, especially in large systems.

The NIRS data formed the basis for EPA's first estimates of the levels of radon in community groundwater systems in the United States (Wade Miller 1990). They formed the basis for estimating the impacts of EPA's 1991 Proposed Rule. These estimates were updated in 1993, using improved statistical methods to estimate the distributions of radon in different size systems (Wade Miller 1993.)

C. EPA's Most Recent Studies of Radon Levels in Ground Water

EPA's current re-evaluation of radon occurrence in ground water (USEPA 1999g) uses data from a number of additional sources to supplement the NIRS information and to develop estimates of the national distribution of radon in community ground water systems of different sizes. EPA gathered data from 17 States where radon levels were measured at the wellhead, rather than in the distribution systems. The Agency then evaluated the differences between the State (wellhead) data and the NIRS (distribution system) data. These differences were then used to adjust the NIRS data to make them more representative of ground water radon levels in the States where no direct measurements at the wellhead had been made. EPA solicits any additional data on radon levels in community water systems, particularly in the largest size categories.

Table XI.C.1 summarizes EPA's latest estimates of the distributions of radon levels in ground water supplies of different sizes. It also provides information on the populations exposed to radon through community water systems (CWS). In this table, radon levels and populations are presented for systems serving population ranges from 25 to greater than 100,000 customers. The CWSs are broken down into the following system size categories:

- Very very small systems (25–500 people served), further subdivided into 25–100 and 101–500 ranges, in response to comments received on the 1991 proposal;
- Very small systems (501–3,300 people);
- Small systems (3,301–10,000 people);
- Medium systems (10,001–100,000 people); and
- Large systems (greater than 100,000 people).

TABLE XI.C.1.—RADON DISTRIBUTIONS IN COMMUNITY GROUNDWATER SYSTEMS

	System Size (Population Served)					
	25–100	101–500	501–3,300	3,301–10,000	>10,000	All systems
Total Systems	14,651	14,896	10,286	2,538	1,536	43,907
Geometric Mean Radon Level, pCi/L	312	259	122	124	132	232
Geometric Standard Deviation	3.0	3.3	3.2	2.3	2.3	3.0
Arithmetic Mean	578	528	240	175	187	442
Population Served (Millions)	0.87	3.75	14.1	14.3	55.0	88.1
Radon Level, pCi/L	Proportions of Systems Exceeding Radon Levels (percent)					
100	84.7	78.7	56.9	60.4	62.9	74.0
300	51.4	45.1	22.1	14.3	16.2	39.0
500	33.6	29.1	11.4	4.6	5.5	24.2
700	23.4	20.3	6.8	1.8	2.3	16.5
1000	14.7	12.9	3.6	0.6	0.8	10.2
2000	4.7	4.4	0.8	0.0	0.1	4.9
4000	1.1	1.1	0.1	0.0	0.0	0.8

Sources: USEPA 1999g; Safe Drinking Water Information System (1998).

Systems were broken down in this fashion because EPA's previous analyses have shown that the distributions of radon levels are different in different size systems. In the updated occurrence analysis, insufficient data were available to accurately assess radon levels in various subcategories of largest systems. Thus, data from the two largest size categories were pooled to develop exposure estimates.

D. Populations Exposed to Radon in Drinking Water

Based on data from the Safe Drinking Water Information System (SDWIS), the Agency estimates that approximately 88.1 million people were served by community ground water systems in the United States in 1998. Using the data in Table XI.C.1, systems serving more than 500 people account for approximately 95 percent of the population served by community ground water systems, even though they represent only about 33 percent of the total active systems. The largest systems (those serving greater than 10,000 people) serve approximately 62.5 percent of the people served by community ground water systems, even though they account for only 3.5 percent of the total number of systems.

As noted previously, the average radon levels vary across the system size categories. As shown in Table XI.C.1, the average system geometric mean radon levels range from approximately 120 pCi/L for the larger systems to 312 pCi/L for the smallest systems. The average arithmetic mean values for the various system size categories range from 175 pCi/L to 578 pCi/L, and the population-weighted arithmetic mean radon level across all the community ground water supplies is 213 pCi/L (calculations not shown). The bottom panel of Table XI.C.1 shows the proportions of the systems with average radon levels greater than selected values.

Table XI.D.1 presents the total populations in homes served by community ground water systems at different radon levels, broken down by system size category. These data show that approximately 20 percent of the total population served by community ground water systems are served by systems where the average radon levels entering the system exceed 300 pCi/L and 64 percent of this population are served by systems with average radon levels above 100 pCi/L. Less than one-tenth of one percent of the population is served by systems obtaining their water from sources with radon levels above 4,000 pCi/L.

TABLE XI.D.1.—POPULATION EXPOSED ABOVE VARIOUS RADON LEVELS BY COMMUNITY GROUND WATER SYSTEM SIZE (THOUSANDS)

Radon level (pCi/L)	Very very small		Very Small	Small	Medium	Large	Total
	25–100	101–500	501–3,300	3,301–10K	10K–100K	>100K	
4,000	9.4	46	20	0.2	0.9	0.4	77.2
2,000	41	183	119	5.7	21.7	11.0	381
1,000	128	541	513	85.5	289	147	1,695
700	202	848	962	267	859	436	3,558
500	290	1,210	1,620	672	2,070	1,050	6,893
300	445	1,880	3,140	2,080	6,060	3,070	16,641
100	733	3,290	8,080	8,760	23,400	11,900	56,054

XII. What Are the Risks of Radon in Drinking Water and Air?

A. Basis for Health Concern

The potential hazard of radon was first identified in the 1940s when an increased incidence of lung cancer in Bohemian underground miners was shown to be associated with inhalation of high levels of radon-222 in the mines. By the 1950s, the hazard was shown to be due mainly to the short half-life progeny of radon-222. Based on a clear relationship between radon exposure and risk of lung cancer in a number of studies in miners, national and international health organizations have concluded that radon is a human carcinogen. In 1988, the International Agency for Research on Cancer (IARC 1988) convened a panel of world experts who agreed unanimously that sufficient evidence exists to conclude that radon causes cancer in humans and in experimental animals. The Biological Effects of Ionizing Radiation (BEIR) Committee (NAS 1988, NAS 1999a), the International Commission on Radiological Protection (ICRP 1987), and the National Council on Radiation Protection and Measurement (NCRP 1984) also have reviewed the available data and agreed that radon exposure causes cancer in humans. EPA has concurred with these determinations and classified radon in Group A, meaning that it is considered by EPA to be a human carcinogen based on sufficient evidence of cancer in humans. After smoking, radon is the second leading cause of lung cancer deaths in the United States (NAS 1999a).

Most of the radon that people are exposed to in indoor and outdoor air comes from soil. However, radon in ground water used for drinking or other indoor purposes can also be hazardous. When radon in water is ingested, it is distributed throughout the body. Some of it will decay and emit radiation while in the body, increasing the risk of cancer in irradiated organs (although this increased risk is significantly less than the risk from inhaling radon). Radon dissolved in tap water is released into indoor air when it is used for showering, washing or other domestic uses, or when the water is stirred, shaken, or heated before being ingested. This adds to the airborne radon from other sources, increasing the risk of lung cancer (USEPA 1991, 1994a; NAS 1999b).

B. Previous EPA Risk Assessment of Radon in Drinking Water

1. EPA's 1991 Proposed Radon Rule

Because initial information on the cancer risks of radon came from studies of underground miners exposed to very high radon levels, not much consideration was given to non-occupational radon exposure until recently. As new miner groups at lower radon exposure levels were added to the data base, it became evident that radon exposures in indoor air, outdoor air, and drinking water might be important sources of risk for the U.S. population. In 1991, as part of developing a regulation for radionuclides and radon in water as required by the 1986 Safe Drinking Water Act, EPA drafted the Radon in Drinking Water Criteria Document (USEPA 1991) to assess the ingestion and inhalation risk associated with exposure to radon in drinking water. EPA estimated that a person's risk of fatal cancer from lifetime use of drinking water containing one picocurie of radon per liter (1 pCi/L) is close to 7 chances in 10 million ($7 \times 10{-}^{-7}$). Based on this and other considerations, EPA proposed a rule for regulating radon levels in public water systems (56 FR 33050).

2. SAB Concerns Regarding the 1991 Proposed Radon Rule

The Radiation Advisory Committee of EPA's Science Advisory Board (SAB) reviewed EPA's draft criteria document and proposed rule and identified a number of issues that had not been adequately addressed, including: (a) Uncertainties associated with the models, model parameters, and final risk estimates; (b) high exposure from water at the point of use (*e.g.,* shower); (c) risks from the disposal of treatment byproducts; and (d) occupational exposure due to regulation and removal of radon in drinking water. The SAB recommended that EPA investigate these issues before finalizing the radon rule. The EPA considered SAB's recommendations in developing the current proposal.

3. 1994 Report to Congress

In 1992, Congress passed Public Law 102–389 (the Chafee-Lautenberg Amendment to EPA's Appropriation Bill). This law directs the Administrator of the EPA to report to Congress on EPA's findings regarding the risks of human exposure to radon and their associated uncertainties, the costs for controlling or mitigating that exposure, and the risks posed by treating water to remove radon.

In response to the SAB's comments and the Chafee-Lautenberg Amendment, EPA drafted a report entitled Uncertainty Analysis of Risks Associated with Radon in Drinking Water (USEPA 1993b) and presented it to the SAB in February 1993. This document evaluated the variability and uncertainty in each of the factors needed to calculate human cancer risk from water-borne radon in residences served by community groundwater systems, and used Monte Carlo simulation techniques to derive quantitative confidence bounds for the risk estimates for each of the exposure routes to water-borne radon. In addition, the report summarized the risk estimates from exposure to radon in indoor and outdoor air.

Based on the data available at the time, EPA estimated that the total number of fatal cancers that will occur as a result of exposure to water-borne radon in homes supplied by community groundwater systems was 192 per year. EPA noted that the risk from water-borne radon is small compared to the risk of soil-derived radon in indoor air (13,600 lung cancer cases per year) or in outdoor air (520 lung cancer deaths per year) (USEPA 1992b, 1993b).

The EPA included the findings of this uncertainty analysis with the SAB review comments in the Report to the United States Congress on Radon in Drinking Water: Multimedia Risk and Cost Assessment of Radon (USEPA 1994a). This report also included an assessment of the risk from exposure to radon at drinking water treatment facilities. The SAB reviewed the report prepared by EPA, and commended the EPA's methodologies employed in the uncertainty analysis and the exposure assessment of radon at the point of use (*e.g.* showering). However, the SAB stated that the estimates of risk from ingested radon may have additional uncertainties in dose estimation and in the use of primarily the atomic bomb survivor exposure (gamma emission with low linear energy transfer) in deriving the organ-specific risk per unit dose for from radon and progeny (alpha particle emission with high linear energy transfer). The SAB also questioned EPA's estimates of the number of community water supplies affected, and the extrapolation of the risk of lung cancer associated with the high radon exposures of uranium miners to the low levels of exposure experienced in domestic environments. The SAB recommended that the Agency use a relative risk orientation as an important consideration in making risk reduction decisions on all sources of risks attributable to radon. Based on the comments and recommendations of the SAB, EPA revised several of the distributions used in the Monte Carlo analysis and finalized the Uncertainty Analysis of Risks Associated with Exposure to Radon in Drinking Water (USEPA 1995).

C. NAS Risk Assessment of Radon in Drinking Water

1. NAS Health Risk and Risk-Reduction Benefit Assessment Required by the 1996 Amendments to the Safe Drinking Water Act

The 1996 amendments to the Safe Drinking Water Act required EPA to arrange with the National Academy of Sciences (NAS) to conduct a risk assessment of radon in drinking water and an assessment of the health-risk reduction benefits associated with various measures to reduce radon concentrations in indoor air. The law also directed EPA to promulgate an alternative maximum contaminant level (AMCL) if the proposed MCL is less than the concentration of radon in water ''necessary to reduce the contribution of radon in indoor air from drinking water to a concentration that is equivalent to the national average concentration of radon in outdoor air.''

2. Charge to the NAS Committee

In accordance with the requirements of the 1996 amendments to the SDWA, in February 1997, EPA funded the NAS National Research Council to establish a multidisciplinary committee of the Board of Radiation Effects Research. This Committee on Risk Assessment of Exposure to Radon in Drinking Water (the NAS Radon in Drinking Water committee) was charged to use the best available data and methods to provide the following:

(a) The best estimate of the central tendency of the transfer factor for radon from water to air, along with an appropriate uncertainty range,

(b) Estimates of unit cancer risk (*i.e.*, the risk from lifetime exposure to water containing 1 pCi/L) for the inhalation and ingestion exposure routes, both for the general population and for subpopulations within the general population (*e.g.*, infants, children, pregnant women, the elderly, individuals with a history of serious illness) that are identified as likely to be at greater risk due to exposure to radon in drinking water than the general population,

(c) Unit cancer risks from inhalation exposure for people in different smoking categories,

(d) Descriptions of any teratogenic and reproductive effects in men and women due to exposure to radon in drinking water,

(e) Central estimates for a population-weighted average national ambient (outdoor) air concentration for radon, with an associated uncertainty range.

The NAS Radon in Drinking Water committee was also asked to estimate health risks that might occur as the result of compliance with a primary drinking water regulation for radon. The committee was to assess the health risk reduction benefits associated with various mitigation measures to reduce radon levels in indoor air.

3. Summary of NAS Findings

The NAS completed its charge and issued a report entitled ''Risk Assessment of Radon in Drinking Water'' (NAS 1999b). The NAS report provides detailed descriptions of the methods and assumptions employed by the NAS Radon in Drinking Water committee in completing its evaluation. The following text provides a summary of the NAS report.

(a) National Average Ambient Radon Concentration. Because radon levels in outdoor air vary from location to location, the NAS Radon in Drinking Water committee concluded that available data are not sufficiently representative to calculate a population-weighted annual average ambient radon concentration. Based on the data that are available, the NAS Radon in Drinking Water committee concluded that the best estimate of an unweighted arithmetic mean radon concentration in ambient (outdoor) air in the United States is 15 Bq/m^3 (equal to 0.41 pCi/L of air), with a confidence range of 14 to 16 Bq/m^3 (0.38–0.43 pCi/L air).

(b) Transfer Factor. The relationship between the concentration of radon in water and the average indoor air concentration of water-derived radon is described in terms of the transfer factor (pCi/L in air per pCi/L in water). Most researchers who have investigated this variable in residences find that it can be described as a lognormal distribution of values, most conveniently characterized by the arithmetic mean (AM) and the standard deviation (Stdev), or by the geometric mean (GM) and the geometric standard deviation (GSD). The NAS Radon in Drinking Water committee performed an extensive review of both measured and calculated values of the transfer factor in residences, with the results summarized in the following Table XII.1:

TABLE XII.1.—MEASURED AND MODELED TRANSFER FACTORS

Approach	AM	Stdev	GM	GSD
Measured	0.87×10^{-4}	1.2×10^{-4}	0.38×10^{-4}	3.3
Modeled	1.2×10^{-4}	2.4×10^{-4}	0.55×10^{-4}	3.5

[a] Calculated from, GM and GSD.

The committee concluded that there is reasonable agreement between the average value of the transfer factor estimated by the two approaches, and identified 1 in 10,000 (1.0×10^{-4}) as the best central estimate of the transfer factor for residences, with a confidence bound of about 0.8 to 1.2×10^{-4}. This central tendency value is the same as has been used in previous assessments (USEPA 1993b, 1995).

Based on this transfer factor, the NAS committee concluded that the AMCL for radon in drinking water would be 150,000 Bq/m^3 (about 4,000 pCi/L). That is, a concentration of 4,000 pCi/L of radon in water is expected to increase the concentration of radon in indoor air by an amount equal to that in outdoor air.

(c) Biologic Basis of Risk Estimation. Both the BEIR VI Report (NAS 1999a) and their report on radon in drinking water (NAS 1998b) represent the most definitive accumulation of scientific data gathered on radon since the 1988 NAS BEIR IV (NAS 1988). These committees' support for the use of linear non-threshold relationship for radon exposure and lung cancer risk came primarily from their review of the mechanistic information on alpha-particle-induced carcinogenesis, including studies of the effect of single versus multiple hits to cell nuclei.

The NAS BEIR VI Committee (NAS 1999a) conducted an extensive review of information on the cellular and molecular mechanism of radon-induced cancer in order to help support the assessment of cancer risks from low levels of radon exposure. In the BEIR VI report (NAS 1999a), the NAS concluded that there is good evidence that a single alpha particle (high-linear energy transfer radiation) can cause major genomic changes in a cell, including mutation and transformation that potentially could lead to cancer. Alpha particles, such as those that are emitted from the radon decay chain, produce dense trails of ionized molecules when they pass through a cell, causing cellular damage. Alpha particles passing through the nucleus of a cell can damage DNA. In their report, the BEIR VI Committee noted that even if substantial repair of the genomic damage were to occur, ''the passage of a single alpha particle has the potential to cause irreparable damage in cells that are not killed''. Given the convincing evidence that most cancers originate from damage to a single cell, the Committee went on to conclude that ''On the basis of these [molecular and cellular] mechanistic considerations, and in the absence of credible evidence to the contrary, the Committee adopted a linear non-threshold model for the relationship between radon exposure and lung-cancer risk. The Committee also noted that epidemiological data relating to low radon exposures in mines also indicate that a single alpha track through the cell may lead to cancer. Finally, while not definitive by themselves, the results from residential case-control studies provide some direct support for the conclusion that environmental levels of radon pose a risk of lung cancer. However, the BEIR VI Committee recognized that it could not exclude the possibility of a threshold relationship between exposure and lung cancer risk at very low levels of radon exposure.

The NAS Committee on radon in drinking water (NAS 1999b) reiterated the finding of the BEIR VI Committee's comprehensive review of the issue, that a ''mechanistic interpretation is consistent with linear non-threshold relationship between radon exposure and cancer risk''. The committee noted that the ''quantitative estimation of cancer risk requires assumptions about the probability of an exposed cell becoming transformed and the latent period before malignant transformation is complete. When these values are known for singly hit cells, the results might lead to reconsideration of the linear no-threshold assumption used at present.@ EPA recognizes that research in this area is on-going but is basing its regulatory decisions on the best currently available science and recommendations of the NAS that support use of a linear non-threshold relationship. EPA recognizes that research in this area is on-going but is basing its regulatory decisions on the best currently available science and recommendations of the NAS that support use of a linear non-threshold relationship.

(d) Unit Risk from Inhalation Exposure to Radon Progeny. The calculation of the unit risk from inhalation of radon progeny derived from water-borne radon depends on four key variables: (1) The transfer factor that relates the concentration of radon in air to the concentration in water, (2) the equilibrium factor (the level of radon progeny present compared to the theoretical maximum amount), (3) the occupancy factor (the fraction of full time that a person spends at home) and (4) the risk of lung cancer per unit exposure (the risk coefficient). The values utilized by NAS for each of these factors are summarized next.

Transfer Factor

The NAS Radon in Drinking Water committee (NAS 1999b) reviewed available data and concluded that the best estimate of the transfer factor is 1.0 $\times 10^{-4}$ pCi/L air per pCi/L water.

Equilibrium Factor

At radiological equilibrium, 1 pCi/L of radon in air corresponds to a concentration of 0.010 Working Levels (WL) of radon progeny. One WL is defined as any combination of radioactive chemicals that result in an emission of 1.3×10^5 MeV of alpha particle energy. One WL is approximately the total amount of energy released by the short-lived progeny in equilibrium with 100 pCi of radon. Under typical household conditions, processes such as ventilation and plating out of progeny prevent achievement of equilibrium, and the level of radon progeny present is normally less than 0.010 WL. The equilibrium factor (EF) is the ratio of the alpha energy actually present in respirable air compared to the theoretical maximum at equilibrium. Based on a review of measured values in residences, USEPA (1993b, 1995) identified a value of 0.4 as the best estimate of the mean, with a credible range of 0.35 to 0.45. NAS (1999a, 1999b) reviewed the data and also selected a value of 0.4 as the most appropriate point estimate of EF.

Occupancy Factor

The occupancy factor (the fraction of time that a person spends at home) varies with age and occupational status. Studies on the occupancy factor have been reviewed by EPA (USEPA 1992b, 1993b, 1995), who found that a value of 0.75 is the appropriate point estimate of the mean with a credible range of 0.65–0.80. Based on a review of available data, both the BEIR VI committee (NAS 1999a) and the NAS Radon in Drinking Water committee (NAS 1999b) identified an occupancy factor of 0.7 as the best estimate to employ in calculation of the inhalation unit risk from inhalation of radon progeny.

Risk of Lung Cancer Death per Unit Exposure (Risk Coefficient)

There are extensive data on humans (mainly from studies of underground miners) establishing that inhalation exposure to radon progeny causes increased risk of lung cancer (NAS 1999a, 1999b). The basic approach used by NAS to quantify the risk of fatal cancer (specifically death from lung cancer) from inhalation of radon progeny in air was to employ empirical dose-response relationships derived from studies of humans exposed to radon progeny in the environment. The most recent quantitative estimate of the risk of lung cancer associated with inhalation of radon progeny has been conducted by the BEIR VI committee (NAS 1999a), and this analysis was employed by the NAS Radon in Drinking Water committee (NAS 1999b). The BEIR VI committee reviewed all of the most current data from studies of humans exposed to radon, including cohorts of underground miners and residents exposed to radon in their home, as well as studies in animals and in isolated cells. Because of differences in exposure level and duration, studies of residential radon exposure would normally be preferable to studies of miners for quantifying risk to residents from radon progeny in indoor air. However, the BEIR VI committee found that the currently available epidemiological studies of residents exposed in their homes are not sufficient to develop reliable quantitative exposure-risk estimates because (a) the number of subjects is small, (b) the difference between exposure levels is limited, and (c) cumulative radon exposure estimates are generally incomplete or uncertain. Therefore, the BEIR VI committee focused their analysis on studies of radon-exposed underground miners.

The method used by the BEIR VI committee was essentially the same as used previously by the BEIR IV committee (NAS 1988), except that the database on radon risk in underground miners is now much more extensive, including 11 cohorts of underground miners, which, in all, include about 2,700 lung cancers among 68,000 miners, representing nearly 1.2 million person-years of observations. Details of these 11 cohorts are presented in the NAS BEIR VI Report (NAS 1999a). For historical reasons, the measure of exposure used in these studies is the Working Level Month (WLM), which is defined as 170 hours of exposure to one Working Level (WL) of radon progeny.

Based on evidence that risk per unit exposure increased with decreasing exposure rate or with increasing exposure duration (holding cumulative exposure constant), the BEIR VI committee modified the previous risk model to include a term to account for this ''inverse dose rate'' effect. Because the adjustment could be based on either the concentration of radon progeny or the duration of exposure, there are two alternative forms of the preferred model—the ''exposure-age-concentration'' model, and the ''exposure-age-duration'' model. For brevity, these will generally be referred to here as the ''concentration'' and ''duration'' models.

Mathematically, both models can be represented as:

$$RR=1+ERR=1+\beta(\omega_{5\text{-}14}+\theta_{15\text{-}24}\omega_{15\text{-}24}+\theta_{25+}\omega_{25+})\phi_{age}\gamma_{Z} \quad (1)$$

Where:

RR=relative risk of lung cancer in a person due to above-average radon exposure compared to the average background risk for a similar person in the general population

ERR=Excess relative risk (the increment in risk due to the above-average exposure to radon)

β=exposure-response parameter (excess relative risk per WLM)

$\omega_{5\text{-}14}$=exposures (WLM) incurred from 5–14 years prior to the current age

$\omega_{15\text{-}24}$=exposures (WLM) incurred from 15–24 years prior to the current age

ω_{25+}=exposures (WLM) incurred 25 or more years prior to the current age

$\theta_{15\text{-}24}$=time-since-exposure factor for risk from exposures incurred 15–24 years or more before the attained age

θ_{25+}=time-since-exposure factor for risk from exposures incurred 25 or more years or more before the attained age

ϕ_{age}=effect-modification factor for attained age

γ_{Z}=effect-modification factor for exposure rate or exposure duration

The BEIR VI committee used a two-stage approach for combining information from the 11 miner studies to derive parameters for the concentration and duration risk models. First, estimates of model parameters were derived for each study cohort, and then population-weighted averages of the parameters were calculated across studies to derive an overall estimate that takes variation between and within cohorts into account. The results of the pooled analysis of all of the miner data indicated that, for a given level of exposure to radon, the excess relative risk of lung cancer decreases with increasing time since exposure, decreases as a function of increased attained age, increases with increasing duration of exposure, and decreases with increasing exposure rate (the inverse dose rate effect).

The BEIR VI committee applied the risk models to 1985–89 U.S. mortality data to estimate individual and population risks from radon in air. At the individual level, the committee estimated the lifetime excess relative risk (ERR), which is the percent increase in the lifetime probability of lung cancer death from indoor radon exposure. For population risks, the committee estimated attributable risk (AR), which indicates the proportion of lung-cancer deaths that theoretically may be reduced by reduction of indoor radon concentrations to outdoor levels.

Extrapolation From Mines to Homes

Because of a number of potential differences between mines and homes, exposures to equal levels of radon progeny may not always result in equal doses to lung cells. The ratio of the dose to lung cells in the home compared to that in mines is described by the K factor. Based on the best data available at the time, NAS (1991) had previously concluded that the dose to target cells in the lung was typically about 30 percent lower for a residential exposure compared to an equal WLM exposure in mines (*i.e.*, K = 0.7). The BEIR VI committee re-examined the issue of the relative dosimetry in homes and mines. In light of new information regarding exposure conditions in home and mine environments, the committee concluded that, when all factors are taken into account, the dose per WLM is nearly the same in the two environments (*i.e.*, a best estimate for the K-factor is about 1) (NAS 1999a). The major factor contributing to the change was a downward revision in breathing rates for miners. Thus, for calculation of risks from residential exposures, Equation 1 can be applied directly without adjustment.

Combined Effect of Smoking and Radon

Because of the strong influence of smoking on the risk from radon, the BEIR VI committee (NAS 1999a) evaluated risk to ever-smokers and never-smokers separately. The committee had information on 5 of the miner cohorts, from which they concluded that the combined effects of radon and smoking were more than additive but less than multiplicative. As a best estimate the committee determined that never-smokers should be assigned a relative risk coefficient (β) about twice that for ever-smokers, in each of the two models defined previously. This means that the attributable risk, or the proportion of all lung cancers attributable to radon, is about twice as high for never-smokers as ever-smokers. Nevertheless, because the incidence of lung cancer is much greater for ever-smokers than never-smokers, the probability of a radon induced lung cancer is still much higher for ever-smokers. This higher risk in ever-smokers arises from the synergism between radon and cigarette smoke in causing lung cancer.

Based on the BEIR VI lifetime relative risk results, the NAS Radon in Drinking Water committee (NAS 1999b) calculated the lifetime risk (per Bq/m^3 air) for each of the two models using the following basic equation:

Excess lifetime risk=(Baseline risk)* (LRR–1)

Where LRR=lifetime relative risk

Baseline lung cancer risk values used by the NAS Radon in Drinking Water committee (NAS 1999b) are summarized in Table XII.2.

TABLE XII.2.—BASELINE LUNG CANCER RISK

Gender	Smoking prevalence	Ever-smokers [1]	Never-smokers
Male	0.58	0.116	0.0091
Female	0.42	0.068	0.0059

[1] Ever-smokers were defined as persons who had smoked at least 100 cigarettes in their entire life (CDC 1995).

The NAS Radon in Drinking Water committee (NAS 1999b) adopted the average of the results from each of the two models as the best estimate of lifetime risk from radon progeny.

Results: Inhalation Unit Risk for Water-Borne Radon Progeny

Based on the inputs and approaches summarized in the previous sections, NAS calculated the inhalation unit risk for radon progeny, by smoking category, with the results described in Table XII.3:

TABLE XII.3.—LIFETIME UNIT RISK

Smoking category	per Bq/m^3 in air	per pCi/L in water	Lifetime (yrs)	Annual unit risk (per pCi/L in water)	Inhalation risk coefficient (per WLM)
Combined	1.6×10^{-4}	5.93×10^{-7}	74.9	7.92×10^{-9}	5.49×10^{-4}
Ever Smokers	2.6×10^{-4}	9.63×10^{-7}	73.7	1.31×10^{-8}	9.07×10^{-4}
Never Smokers	0.5×10^{-4}	1.85×10^{-7}	76.1	2.43×10^{-9}	1.68×10^{-4}

The NAS Radon in Drinking Water committee (NAS 1999b) estimated that the uncertainty around the inhalation risk coefficient for radon progeny can be characterized by a lognormal distribution with a GSD of 1.2 (based on the duration model) to 1.3 (based on the concentration model). This corresponds to an uncertainty range for the combined population of about 3.4 × 10–4 to 8.1 × 10–4 lung cancer deaths per person per WLM.

Inhalation Risks to Subpopulations, Including Children

The NAS Radon in Drinking Water committee concluded that, except for the lung-cancer risk to smokers, there is insufficient information to permit quantitative evaluation of radon risks to susceptible sub-populations such as infants, children, pregnant women, elderly and seriously ill persons.

The BEIR VI committee (NAS 1999a) noted that there is only one study (tin miners in China) that provides data on whether risks from radon progeny are different for children, adolescents, and adults. Based on this study, the committee concluded that there was no clear indication of an effect of age at exposure, and the committee made no adjustments in the lung cancer risk model for exposures received at early ages.

(e) Unit Risk for Ingestion Exposure. The calculation of the unit risk from ingestion of radon in water depends on three key variables: (1) The amount of radon-containing water ingested, (2) the fraction of radon lost from the water before ingestion, and (3) the risk to the tissues per unit of radon absorbed into the body (risk coefficient). The values utilized by NAS for each of these factors are summarized next.

Water Ingestion Rate

EPA (USEPA 1993b, 1995) performed a review of available data on the amount of water ingested by residents. In brief, water ingestion can be divided into two categories: direct tap water (that which is ingested as soon as it is taken from the tap) and indirect tap water (water used in cooking, for making coffee, *etc.*). Available data indicate nearly all radon is lost from indirect tap water before ingestion, so only direct tap water is of concern. Based on available data (Pennington 1983; USEPA 1984; Ershow and Cantor 1989, USEPA 1993b, USEPA 1995) scientists estimated that the mean of the direct tap water ingestion rate was 0.65 liters per day (L/day), with a credible range of about 0.57 to 0.74 L/day. Based mainly on this analysis, NAS (1999b) identified 0.6 L/day as the best estimate of direct tap water intake, and utilized this value in the calculation of the unit risk from radon ingestion. This value includes direct tap water ingested at all locations, and so includes both residential and non-residential exposures.

The analysis conducted for radon in drinking water uses radon-specific estimates of water consumption, based on guidance from the NAS Radon in Drinking Water committee. Based on radon's unique characteristics, this approach is different from the Agency's approach to other drinking water contaminants.

In general, in calculating the risk for all other water contaminants, EPA uses 2 liters per day as the average amount of water consumed by an individual. For radon, the Agency used 0.6 liters per day to estimate the risks of radon ingestion. The NAS ingestion risk number is derived from an average risk/radiation coefficient, an average drinking water ingestion rate, and an average life expectancy. NAS chose to use an ingestion rate of 0.6 liter per day, based on an assumption that only 0.6 liters of the ''direct'' water will retain radon. Since radon is very readily released during normal household water use, we assume that radon in water used for indirect purposes (cooking, making coffee, etc) is released before drinking. Only direct water (drinking from tap directly) is used to estimate ingestion risk.

The Agency solicits comments on this approach to estimating the ingestion risk of radon in drinking water, particularly the assumption of 0.6 liters per day direct consumption.

Fraction of Radon Remaining During Water Transfer From the Tap

Because radon is a gas, it tends to volatilize from water as soon as the water is discharged from the plumbing system into any open container or utensil. As would be expected, the fraction of radon volatilized before consumption depends on time, temperature, surface area-to-volume ratio, and degree of mixing or aeration. A previous analysis by EPA (USEPA 1995) identified a value of 0.8 as a reasonable estimate of the mean fraction remaining before ingestion, with an estimated credibility interval about the mean of 0.7 to 0.9. Because data are so sparse, and in order to be conservative, NAS assumed a point estimate of 1.0 for this factor (NAS 1999b).

Risk per Unit of Radon Absorbed (Risk Coefficient)

The NAS Radon in Drinking Water committee reviewed a number of publications on the risk from ingestion of radon, and noted that there was a wide range in the estimates, due mainly to differences and uncertainties in the way radon is assumed to be absorbed across the gastrointestinal tract. Therefore, the committee developed new mathematical models of the diffusion of radon in the stomach and the behavior of radon dissolved in blood and other tissues to calculate the radiation dose absorbed by tissues following ingestion of radon dissolved in water (NAS 1999b).

NAS determined that the stomach wall has the largest exposure (and hence the largest risk of cancer) following oral exposure to radon in water, but that there is substantial uncertainty on the rate and extent of radon entry into the wall of the stomach from the stomach contents. The ''base case'' used by NAS assumed that diffusion of radon from the stomach contents occurs through a surface mucus layer and a layer of non-radiosensitive epithelial cells before coming into proximity with the radiosensitive stem cells. Below this layer, diffusion into capillaries was assumed to remove radon and reduce the concentration to zero. Based on this model, the concentration of radon near the stem cells was about 30 percent of that in the stomach contents.

The distribution of absorbed radon to peripheral tissues was estimated by NAS using a physiologically-based pharmacokinetic (PBPK) model based on the blood flow model of Leggett and Williams (1995). The committee's analysis considered that each radioactive decay product formed from radon decay in the body exhibited its own behavior with respect to tissues of deposition, retention, and routes of excretion with the ICRP's age-specific biokinetic models The computational method used by the NAS Radon in Drinking Water committee to calculate the age-and gender-averaged cancer death risk from lifetime ingestion of radon is described in EPA's Federal Guidance Report 13 (USEPA 1998d).

Results: Ingestion Unit Risk

The NAS Radon in Drinking Water committee estimated that an age- and gender-averaged cancer death risk from lifetime ingestion of radon dissolved in drinking water at a concentration of 1 Bq/L probably lies between 3.8×10^{-7} and 4.4×10^{-6}, with 1.9×10^{-6} as the best central value. This is equivalent to a lifetime risk of 7.0×10^{-8} per pCi/L, with a credible range of 1.4×10^{-8} to 1.6×10^{-7} per pCi/L. This uncertainty range is based mainly on uncertainty in the estimated dose to the stomach and in the epidemiologic data used to estimate the risk (NAS 1999b), and does not include the uncertainty in exposure factors such as average daily direct tap water ingestion rates or radon loss before ingestion. The lifetime risk estimate of 7.0×10^{-8} per pCi/L corresponds to an ingestion risk coefficient of 4.29×10^{-12} per pCi ingested.

Ingestion Risk to Children

NAS (1999b) performed an analysis to investigate the relative contribution of radon ingestion at different ages to the total risk. This analysis considered the age dependence of: radon consumption, behavior of radon and its decay products in the body, organ size, and risk. The results indicated that even though water intake rates are lower in children than in adults, dose coefficients are higher in children because of their smaller body size. In addition, the cancer risk coefficient for ingested radon is greater for children than for adults. Based on dose and stomach cancer risk models, NAS (1999b) estimated that about 30% of lifetime ingestion risk was due to exposures occurring during the first 10 years of life. However, the NAS found no direct epidemiological evidence to suggest that any sub-population is at increased risk from ingestion of radon. In addition, ingestion risk as a whole accounts for only 11% of total risk from radon exposure from drinking water for the general population, with inhalation accounting for the remaining 89%. The NAS did not identify children, or any other groups except smokers, as being at significantly higher overall risk from exposure to radon in drinking water.

(f) Summary of NAS Lifetime Unit Risk Estimates. Table XII.4 summarizes the lifetime average unit risk estimates derived by the NAS Radon in Drinking Water committee.

TABLE XII.4.—NAS RADON IN DRINKING WATER COMMITTEE ESTIMATE OF LIFETIME UNIT RISK POSED BY EXPOSURE TO RADON IN DRINKING WATER

Exposure route	Smoking status	Gender-averaged lifetime unit risk	
		Risk per Bq/L in water	Risk per pCi/L in water
Inhalation	Ever	2.6×10^{-5}	9.6×10^{-7}
	Never	0.50×10^{-5}	1.9×10^{-7}
	All	1.6×10^{-5}	5.9×10^{-7}
Ingestion	All	0.19×10^{-5}	7.0×10^{-8}
Total Risk (inhalation + ingestion)	All	1.8×10^{-5}	6.6×10^{-7}

(g) Other Health Effects. The NAS Radon in Drinking Water committee was asked to review teratogenic and reproductive risks from radon. The committee concluded there is no scientific evidence of teratogenic and reproductive risks associated with either inhalation or ingestion of radon.

(h) Relative Magnitude of the Risk from Radon in Water. The NAS Radon in Drinking Water committee concluded that radon in water typically adds only a small increment to the indoor air concentration. The committee estimated the cancer deaths per year due to radon in indoor air (total), radon in outdoor air, radon progeny from waterborne radon, and ingestion of radon in water are 18, 200, 720, 160, and 23, respectively. However, the committee recognized that radon in water is the largest source of cancer risk in drinking water compared to other regulated chemicals in water.

D. Estimated Individual and Population Risks

Based on the findings and recommendations of the NAS Radon in Drinking Water committee, EPA has performed a re-evaluation of the risks posed by radon in water (USEPA 1999b). This assessment relied upon the inhalation and ingestion unit risks derived by NAS (1999b), and calculated risks to individuals and the population by combining the unit risks derived by NAS with the latest available data on the occurrence of radon in public water systems (USEPA 1999g).

In brief, the risk to a person from exposure to radon in water is calculated by multiplying the concentration of radon in the water (pCi/L) by the unit risk factor (risk per pCi/L) for the exposure pathway of concern (ingestion, inhalation). The population risk (the total number of fatal cancer cases per year in the United States due to radon ingestion in water) is estimated by multiplying the average annual individual risk (cases per person per year) by the total number of people exposed. Data which EPA used to calculate individual risks and population risks are summarized next.

Radon Concentration in Community Water Systems

The EPA has recently completed a detailed review and evaluation of the latest available data on the occurrence of radon in community water systems (USEPA 1999g; see Section XI). In brief, the concentration of radon in drinking water from surface water sources is very low, and exposures from surface water systems can generally be ignored. However, radon does occur in most groundwater systems, with the concentration values tending to be highest in areas where groundwater is in contact with granite. In addition, radon concentrations tend to vary as a function of the size of the water system, being somewhat higher in small systems than in large systems (USEPA 1999g). Based on EPA's analysis, the population-weighted average concentration of radon in community ground water systems is estimated to be 213 pCi/L, with a credible range of about 190 to 240 pCi/L (USEPA 1999g).

Total Exposed Population

Based on data available from the Safe Drinking Water Information System (SDWIS), EPA estimates that 88.1 million people (about one-third of the population of the United States) are served in their residence by community water supply systems using ground water (USEPA 1998a).

Based on these data on radon occurrence and size of the exposed population, EPA calculated the risks from water-borne radon to people exposed at residences served by community groundwater systems. EPA also calculated revised quantitative uncertainty analysis of the risk estimates at residential locations, incorporating NAS estimates of the uncertainty inherent in the unit risks for each pathway. In addition, EPA performed screening level estimates of risk to people exposed to water-borne radon in various types of non-residential setting. EPA's findings are summarized next.

1. Risk Estimates for Ingestion of Radon in Drinking Water

Table XII.5 presents EPA's estimate of the mean individual risk (fatal cancer cases per person per year) for the people who ingest water from community ground water systems. This includes exposures that occur both in the residence and in non-residential settings (the workplace, restaurants, etc). The lower and upper bounds around the best estimate were estimated using Monte Carlo simulation techniques (USEPA 1999b).

TABLE XII.5.—ESTIMATED RISK FROM RADON INGESTION AT RESIDENTIAL AND NON-RESIDENTIAL LOCATIONS SERVED BY COMMUNITY WATER SYSTEMS

Parameter	Lower bound	Best estimate	Upper bound
Mean Annual Individual Risk (cancer deaths per person per year)	3.2×10^{-8}	2.0×10^{-7}	4.3×10^{-7}
Population Risk (cancer deaths per year)	3	18	38

2. Risk Estimates for Inhalation of Radon Progeny Derived From Waterborne Radon

(a) Inhalation Exposure to Radon Progeny in the Residential Environment. Table XII.6 presents the EPA's best estimate of the mean individual risk and population risk of lung cancer fatality due to inhalation of radon progeny derived from water-borne radon at residences served by community groundwater systems. Lower and upper bounds on the individual and population risk estimates were derived using Monte Carlo simulation techniques.

TABLE XII.6.—ESTIMATED RISKS FROM INHALATION OF WATER-BORNE RADON PROGENY IN RESIDENCES SERVED BY COMMUNITY GROUND WATER SUPPLY SYSTEMS

Parameter	Lower bound	Best estimate	Upper bound
Mean Annual Individual Risk (lung cancer deaths per person per year)	7.9×10^{-7}	1.7×10^{-6}	3.0×10^{-6}
Population Risk (lung cancer deaths per year)	70	148	263

Of the total number of lung cancer deaths due to water-borne radon, most (about 84 percent) are expected to occur in ever-smokers, with the remainder (about 16 percent) occurring in never-smokers.

Analysis of Peak Exposures and Risks Due to Showering

Both NAS and EPA have paid special attention to the potential hazards associated with high exposures to radon that may occur during showering. High exposure occurs during showering because a large volume of water is used, release of radon from shower water is nearly complete, and the radon enters a fairly small room (the shower/bathroom). However, both NAS (1999b) and USEPA (1993b, 1995) concluded that the risk to humans from radon released during showering was likely to be small. This is because the inhalation risk from radon is due almost entirely to radon progeny and not to radon gas itself, and it takes time (several hours) for the radon progeny to build up from the decay of the radon gas released from the water. For example, in a typical shower scenario (about 10 minutes), the level of progeny builds up to only 2 to 4 percent of its maximum possible value. Thus, showering is one of many indoor water uses that contribute to the occurrence of radon in indoor air, but hazards from inhalation of radon during showering are not of special concern.

(b) Inhalation Exposure to Radon Progeny in the Non-Residential Environment. The results summarized to this point relate to exposures which occur in homes. However, on average, people spend about 30 percent of their time at other locations. Surveys of human activity patterns reveal that time outdoors or in cars accounts for about 13 percent of the time (USEPA 1996), and about 17 percent of the time, on average across the entire population (including both workers and non-workers), is spent in non-residential structures. Such non-residential buildings are presumably all served with water, so exposure to radon and radon progeny is expected to occur, at least in buildings served by groundwater. Because data needed to quantify exposure at non-residential locations are limited, EPA has performed only a screening

level evaluation to date. This evaluation may be revised in the future, depending on the availability of more detailed and appropriate input data.

As with exposures in the home, the largest source of exposure and risk from water-borne radon in non-residential buildings is inhalation of radon progeny. Limited data were found on measured transfer factors in non-residential buildings, so values were estimated for several different types of buildings based on available data on water use rates, building size, and ventilation rate, based on the following basic equation:

$TF = (W \bullet e)/(V \bullet \lambda)$

Where:

W = Water use (L/person/day)
e = Use-weighted fractional release of radon from water to air
V = Building volume (L/person)
λ = Ventilation rate (air changes/day)

The resulting transfer factor values varied as a function of building type, based on limited data, but the average across all building types was about 1×10^{-4} (the same as for residences). Very few data were located for the equilibrium factor in non-residential buildings, so a value of 0.4 (the same as in a residence) was assumed (USEPA 1999b).

Based on an estimated average transfer factor of 1×10^{-4} and assuming an average occupancy factor of 17 percent at non-residential locations, the estimated lifetime and annual risks of death from lung cancer due to exposure per unit concentration of radon (1pCi/L) in water are 1.4×10^{-7} per pCi/L and 1.9×10^{-9} per pCi/L, respectively.

Assuming a mean radon concentration in water of 213 pCi/L, these unit risks correspond to lifetime and annual individual risks of 3.1×10^{-5} and 4.1×10^{-7} lung cancer deaths per person. Assuming the same population size of 88.1 million population exposed to radon through community ground water supplies, EPA's best estimate of the number of fatal cancer cases per year resulting from the inhalation of radon progeny in non-residential environments is 36 lung cancer deaths per year (USEPA 1999b) (from the population of individuals exposed in non-residential settings served by community ground water supplies).

(c) Analysis of Risk Associated with Exposure at NTNC Locations. A subset of the water systems serving non-residential populations are the non-transient non-community (NTNC) systems. Statistics from SDWIS indicate there are about 5.2 million individuals exposed at buildings served by NTNC groundwater systems (USEPA 1999b).

Data on radon exposures at locations served by NTNC systems are limited. However, data are available for water used and population size at each of 40 strata of NTNC systems (USEPA 1998a). Assuming (a) the exposure at NTNC locations is occupational in nature with about 8 hr/day, 250 days/yr, and 25 years per lifetime for workers and 8 hr/day, 180 days/yr, and 12 years per lifetime for students, (b) the same transfer factor (1×10^{-4}) and equilibrium factor (0.4) assumed for other non-residential buildings apply at NTNC locations, and (c) the concentration of radon in water at NTNC locations is about 60 percent higher than in community water systems (mean concentration = 341 pCi/L) (see Section XI of this preamble), then the estimated population-weighted average individual annual and lifetime lung cancer risks are 2.6×10^{-7} and 2.0×10^{-5}, respectively.

3. Risk Estimates for Inhaling Radon Gas

NAS (1999b) did not derive a unit risk factor for inhalation of radon gas, but provided in their report a set of annual effective doses to tissues (liver, kidney, spleen, red bone marrow, bone surfaces, other tissues) from continuous exposure to 1Bq/m^3 of radon in air. These doses to internal organs from the decay of radon gas absorbed across the lung and transported to internal sites were based on calculations by Jacobi and Eisfeld (1980). Based on these dose estimates, EPA estimated a unit risk value using an approach similar to that used by NAS to derive the unit risk for ingestion of radon gas in water. The organ-specific doses reported by Jacobi and Eisfeld were multiplied by the lifetime-average organ-specific and gender-specific risk coefficients (risk of fatal cancer per rad) from Federal Guidance Report No. 13 (USEPA 1998d). Based on an average transfer factor of 1×10^{-4}, and assuming 70 percent occupancy, the estimated annual average unit risk is 8.5×10^{-11} cancer deaths per pCi/L in water. This corresponds to a lifetime average unit risk of 6.3×10^{-9} per pCi/L. This unit risk excludes the risk of lung cancer from inhaled radon gas, since this risk is already included in the unit risk from radon progeny. Based on the population-weighted average radon concentration of 213 pCi/L, the lifetime average individual risk is 1.35×10^{-6} cancer deaths per person, and the average annual individual risk is 1.8×10^{-8} cancer deaths per person per year. Based on an exposed population of 88.1 million people, the annual population risk is about 1.6 cancer deaths/year. The uncertainty range around this estimate, derived using Monte Carlo simulation techniques, is about 1.0 to 2.7 cancer deaths per year (USEPA 1999b).

4. Combined Fatal Cancer Risk

The best estimates of fatal cancer risks to residents from ingesting radon in water, inhalation of waterborne progeny, and inhalation of radon gas are presented in Table XII.7. As seen, EPA estimates that an individual's combined fatal cancer risk from lifetime residential exposure to drinking water containing 1 pCi/L of radon is slightly less than 7 chances in 10 million (7×10^{-7}), and that the population risk is about 168 cancer deaths per year (uncertainty range = 80 to 288 per year). Of this risk, most (88 percent) is due to inhalation of radon progeny, with 11 percent due to ingestion of radon gas, and less than 1 percent due to inhalation of radon gas.

TABLE XII.7.—SUMMARY OF UNIT RISK, INDIVIDUAL RISK AND POPULATION RISK ESTIMATES FOR RESIDENTIAL EXPOSURE TO RADON IN COMMUNITY GROUNDWATER SUPPLIES

Exposure pathway	Lifetime unit risk (fatal cancer cases per person per pCi/L)	Annual individual risk (fatal cancer cases per person per year)	Annual population risk (fatal cancer cases per year)
Radon Gas Ingestion	7.0×10^{-8}	2.0×10^{-7}	18
Radon Progeny Inhalation	5.9×10^{-7}	1.7×10^{-6}	148

TABLE XII.7.—SUMMARY OF UNIT RISK, INDIVIDUAL RISK AND POPULATION RISK ESTIMATES FOR RESIDENTIAL EXPOSURE TO RADON IN COMMUNITY GROUNDWATER SUPPLIES—Continued

Exposure pathway	Lifetime unit risk (fatal cancer cases per person per pCi/L)	Annual individual risk (fatal cancer cases per person per year)	Annual population risk (fatal cancer cases per year)
Radon Gas Inhalation	6.3×10^{-9}	1.8×10^{-8}	1.6
Total (credible bounds)	6.7×10^{-7} (3.6×10^{-7} – 9.7×10^{-7})	1.9×10^{-6} (0.9×10^{-6} – 3.3×10^{-6})	168 (80–288)

EPA believes that radon in community groundwater water systems also contributes exposure and risk to people when they are outside the residence (e.g., at school, work, etc.). Although data are limited, a screening level estimate suggests that this type of exposure could be associated with about 36 additional lung cancer deaths per year.

Request for Comment

EPA solicits public comments on its assessment of risk from radon in drinking water. In particular, EPA requests comment and recommendations on the best data sources and best approaches to use for evaluating ingestion and inhalation exposures that occur for members of the public (including both workers and non-workers) at non-residential buildings (e.g. restaurants, churches, schools, offices, factories, etc).

E. Assessment by National Academy of Sciences: Multimedia Approach to Risk Reduction

The NAS report, ''Risk Assessment of Radon in Drinking Water,'' summarized several assessments of possible approaches relating reduction of radon in indoor air from soil gas to reduction of radon in drinking water. The NAS Report provided useful perspectives on multimedia mitigation issues that EPA used in developing the proposed criteria and guidance for multimedia mitigation programs. The NAS Committee focused on how the multimedia approach might be applied at the community level and defined a series of scenarios, assuming that multimedia programs would be implemented by public water systems. The report may provide useful perspectives of interest to public water systems if their State does not develop an EPA-approved MMM program.

For most of the scenarios, the Committee chose primarily to focus on how to compare the risks posed by radon in indoor air from soil gas to the risks from radon in drinking water in a home in a local community. They assessed the feasibility of different activities based on costs, radon concentrations, different assumptions about risk reduction actions that might be taken, and other factors.

Overall, the Committee suggested that reduction of indoor radon can be an alternative and more effective means of reducing the overall risk from radon. They went on to conclude that mitigation of airborne radon to achieve equal or greater radon risk reduction ''makes good sense from a public health perspective.'' They also noted that non-economic issues, such as equity concerns, could factor into a community's decision whether to undertake a multimedia mitigation program.

The Committee also discussed the role of various indoor air mitigation program strategies, or ''mitigation measures'' as they are described in SDWA. The Committee concluded that an education and outreach program is important to the success of indoor radon risk reduction programs, but would not in and of itself be sufficient to claim that risk reduction took place. Based on an assessment of several State indoor radon programs, they found that States with effective programs had several factors in common in the implementation of their programs. They concluded that the effectiveness of these State programs were the result of: (1) Promoting wide-spread testing of homes, (2) conducting radon awareness campaigns, (3) providing public education on mitigation, and (4) ensuring the availability of qualified contractors to test and mitigate homes.

These views are consistent with the examples of indoor radon activities that Congress set forth in the radon provision in SDWA on which State Multimedia Mitigation programs may rely. These include ''public education, testing, training, technical assistance, remediation grants and loans and incentive programs, or other regulatory or non-regulatory measures.'' These measures also represent many of the same strategies that are integral to the current national and State radon programs, as well as those outlined in the 1988 Indoor Radon Abatement Act, sections 304 to 307 (15 U.S.C. 2664–2667).

EPA recognizes, as does the National Academy of Sciences, that these activities and strategies are important to achieving public awareness and action to reduce radon, but that these actions are not in and of themselves actual risk reduction. Therefore, EPA has determined that State MMM plans will need to set and track actual risk reduction goals. However, the criteria and guidance for States to use in designing MMM program plans provides extensive flexibility in choosing strategies that reflect the needs of individual States.

The Committee discussed the effectiveness of various indoor radon control technologies and recommended that active sub-slab depressurization techniques are most effective for controlling radon in the mitigation of elevated radon levels in existing buildings and in the prevention of elevated levels in new buildings. (Active systems rely on mechanically-driven techniques (powered fans) to create a pressure gradient between the soil and building interior and thus, prevent radon entry.) The Committee expressed concern over the adequacy of the scientific basis for ensuring that such methods can be used reliably as a consistent outcome of normal design and construction methods. The Committee also noted the limited amount of data available to quantify the reduction in indoor radon levels expected when such techniques were used.

The Committee found that much of the comparative data available on the impact of the passive radon-resistant new construction features is confined to the impact of the passive thermal stack on radon levels and not on the other features of the passive radon-resistant new construction system, such as eliminating leakage paths, sealing utility penetrations, and prescribing the extent and quality of aggregate beneath the foundation. The Committee found that the passive stack alone yielded reductions in radon levels as great as 90%, that reductions in radon levels of about 40% are more typical, and that the effect of the passive stack may be considerably less in slab-on-grade houses that in houses with basements. However, the Committee also stated that the other features in the passive radon-resistant new construction system contribute to reducing radon levels. EPA notes that there are substantial difficulties in gathering good comparative data on these other features because of the significant variability of radon potential across building sites, even within a small area. In addition it is impractical to test the same house with and without radon resistant features. However, based on the Committee's discussion of the contributions of these other features to reducing radon levels, it is reasonable to expect that passive systems as a whole achieve greater reductions in radon than the passive stack alone.

EPA agrees with the Committee's perspective that active radon-reduction systems, while slightly more expensive, assure the greatest risk reduction in not only the mitigation of existing homes, but also in the construction of new homes. EPA also agrees with the Committee's perspective that more data on passive new construction systems would allow for more precise estimation of average expected reductions in radon levels in new homes from application of passive radon-resistant new construction techniques. However, EPA believes there is sufficient data and application experience to have a reasonable assurance that the passive techniques when used in new homes reduce indoor radon levels by about 50% on average. Further, these techniques have been adopted by the home construction industry into national model building codes and by many State and local jurisdictions into their building codes. EPA recommends that new homes built with passive radon-resistant new construction features be tested after occupancy and if elevated levels still exist, the passive systems be converted to active ones. For these reasons, EPA believes it is appropriate to consider passive radon-resistant new construction techniques for new homes as one means of achieving risk reduction through new construction in multimedia mitigation programs.

Economics and Impacts Analysis

XIII. What Is the EPA's Estimate of National Economic Impacts and Benefits?

A. Safe Drinking Water Act (SDWA) Requirements for the HRRCA

Section 1412(b)(13)(C) of the SDWA, as amended, requires EPA to prepare a Health Risk Reduction and Cost Analysis (HRRCA) to be used to support the development of the radon NPDWR. EPA was to publish the HRRCA for public comment and respond to significant comments in this preamble. EPA published the HRRCA in the **Federal Register** on February 26, 1999 (64 FR 9559). Responses to significant comments on the HRRCA are provided in Section XIII.H.

The HRRCA addresses the requirements established in Section 1412(b)(3)(C) of the amended SDWA, namely: (1) Quantifiable and non-quantifiable health risk reduction benefits for which there is a factual basis in the rulemaking record to conclude that such benefits are likely to occur as the result of treatment to comply with each level; (2) quantifiable and non-quantifiable health risk reduction benefits for which there is a factual basis in the rulemaking record to conclude that such benefits are likely to occur from reductions in co-occurring contaminants that may be attributed solely to compliance with the MCL, excluding benefits resulting from compliance with other proposed or promulgated regulations; (3) quantifiable and non-quantifiable costs for which there is a factual basis in the rulemaking record to conclude that such costs are likely to occur solely as a result of compliance with the MCL, including monitoring, treatment, and other costs, and excluding costs resulting from compliance with other proposed or promulgated regulations; (4) the incremental costs and benefits associated with each alternative MCL considered; (5) the effects of the contaminant on the general population and on groups within the general population, such as infants, children, pregnant women, the elderly, individuals with a history of serious illness, or other subpopulations that are identified as likely to be at greater risk of adverse health effects due to exposure to contaminants in drinking water than the general population; (6) any increased health risk that may occur as the result of compliance, including risks associated with co-occurring contaminants; and (7) other relevant factors, including the quality and extent of the information, the uncertainties in the analysis, and factors with respect to the degree and nature of the risk.

The HRRCA discusses the costs and benefits associated with a variety of radon levels. Summary tables and figures are presented that characterize aggregate costs and benefits, impacts on affected entities, and tradeoffs between risk reduction and compliance costs. The HRRCA serves as a foundation for the Regulatory Impact Analysis (RIA) for this proposed rule.

B. Regulatory Impact Analysis and Revised Health Risk Reduction and Cost Analysis (HRRCA) for Radon

Under Executive Order 12866, Regulatory Planning and Review, EPA must estimate the costs and benefits of the proposed radon rule in a Regulatory Impact Analysis (RIA) and submit the analysis to the Office of Management and Budget (OMB) in conjunction with the proposed rule. To comply with the requirements of E.O. 12866, EPA has prepared an RIA, a copy of which is available in the public docket for this proposed rulemaking. The revised HRRCA is now included as part of the RIA (USEPA 1999f). This section provides a summary of the information from the RIA for the proposed radon rule.

1. Background: Radon Health Risks, Occurrence, and Regulatory History

Radon is a naturally occurring volatile gas formed from the normal radioactive decay of uranium. It is colorless, odorless, tasteless, chemically inert, and radioactive. Uranium is present in small amounts in most rocks and soil, where it decays to other products including radium, then to radon. Some of the radon moves through air or water-filled pores in the soil to the soil surface and enters the air, and can enter buildings through cracks and other holes in the foundation. Some radon remains below the surface and dissolves in ground water (water that collects and flows under the ground's surface). Due to their very long half-life (the time required for half of a given amount of a radionuclide to decay), uranium and radium persist in rock and soil.

Exposure to radon and its progeny is believed to be associated with increased risks of several kinds of cancer. When radon or its progeny are inhaled, lung cancer accounts for most of the total incremental cancer risk. Ingestion of radon in water is suspected of being associated with increased risk of tumors of several internal organs, primarily the stomach. As required by the SDWA, as amended, EPA arranged for the National Academy of Sciences (NAS) to assess the health risks of radon in drinking water. The NAS released the pre-publication draft of the ''Report on the Risks of Radon in Drinking Water,'' (NAS Report) in September 1998 and published the Report in July 1999 (NAS 1999b). The analysis in this RIA uses information from the 1999 NAS Report (see Section XII.C of this preamble). The NAS Report represents a comprehensive assessment of scientific data gathered to date on radon in drinking water. The report, in general, confirms earlier EPA scientific conclusions and analyses of radon in drinking water.

NAS estimated individual lifetime unit fatal cancer risks associated with exposure to radon from domestic water use for ingestion and inhalation pathways (Table XIII.1). The results show that inhalation of radon progeny accounts for most (approximately 88 percent) of the individual risk associated with domestic water use, with almost all of the remainder (11 percent) resulting from directly ingesting radon in drinking water. Inhalation of radon progeny is associated primarily with increased risk of lung cancer, while ingestion exposure is associated primarily with elevated risk of stomach cancer.

TABLE XIII.1.—ESTIMATED RADON UNIT LIFETIME FATAL CANCER RISKS IN COMMUNITY WATER SYSTEMS

Exposure pathway	Cancer unit risk per pCi/L in water	Proportion of total risk (percent)
Inhalation of radon progeny[1]	5.9×10^{-7}	88
Ingestion of radon[1]	7.0×10^{-8}	11
Inhalation of radon gas[2]	6.3×10^{-9}	1
Total	6.7×10^{-7}	100

[1] Source: NAS 1998B.
[2] Source: Calculated by EPA from radiation dosimetry data and risk coefficients provided by NAS (NAS 1998B).

The NAS Report confirmed that indoor air contamination arising from soil gas typically accounts for the bulk of total individual risk due to radon exposure. Usually, most radon gas enters indoor air by diffusion from soils through basement walls or foundation cracks or openings. Radon in domestic water generally contributes a small proportion of the total radon in indoor air.

The NAS Report is one of the most important inputs used by EPA in the RIA. EPA has used the NAS's assessment of the cancer risks from radon in drinking water to estimate both the health risks posed by existing levels of radon in drinking water and also the cancer deaths prevented by reducing radon levels.

In updating key analyses and developing the framework for the cost-benefit analysis presented in the RIA, EPA has consulted with a broad range of stakeholders and technical experts. Participants in a series of stakeholder meetings held in 1997, 1998, and 1999 included representatives of public water systems, State drinking water and indoor air programs, Tribal water utilities and governments, environmental and public health groups, and other Federal agencies.

The RIA builds on several technical components, including estimates of radon occurrence in drinking water, analytical methods for detecting and measuring radon levels, and treatment technologies. Extensive analyses of these issues were undertaken by the Agency in the course of previous rulemaking efforts for radon and other radionuclides. Using data provided by stakeholders, and from published literature, the EPA has updated these technical analyses to take into account the best currently available information and to respond to comments on the 1991 proposed NPDWR for radon.

The analysis presented in the RIA uses updated estimates of the number of active public drinking water systems obtained from EPA's Safe Drinking Water Information System (SDWIS). Treatment costs for the removal of radon from drinking water have also been updated. The RIA follows current EPA policies with regard to the methods and assumptions used in cost and benefit assessment.

As part of the regulatory development process, EPA has updated and refined its analysis of radon occurrence patterns in ground water supplies in the United States (USEPA 1998l). This new analysis incorporates information from the EPA's 1985 National Inorganic and Radionuclides Survey (NIRS) of approximately 1000 community ground water systems throughout the United States, along with supplemental data provided by the States, water utilities, and academic research. The new study also addressed a number of issues raised by public comments in the previous occurrence analysis that accompanied the 1991 proposed NPDWR, including characterization of regional and temporal variability in radon levels, and the impact of sampling point for monitoring compliance.

In general, radon levels in ground water in the United States have been found to be the highest in New England and the Appalachian uplands of the Middle Atlantic and Southeastern States. There are also isolated areas in the Rocky Mountains, California, Texas, and the upper Midwest where radon levels in ground water tend to be higher than the United States average. The lowest ground water radon levels tend to be found in the Mississippi Valley, lower Midwest, and Plains States. When comparing radon levels in ground water to radon levels in indoor air at the States level, the distributions of radon concentrations in indoor air do not always mirror distributions of radon in ground water.

2. Consideration of Regulatory Alternatives

(a) Regulatory Approaches. The RIA evaluates MCL options for radon in ground water supplies of 100, 300, 500, 700, 1000, 2000, and 4000 pCi/L. As Table VII.1 in Section VII of the preamble illustrates, the costs and benefits increase as the radon level decreases and the benefit-cost ratios are very similar at each level. The RIA also presents information on the costs and benefits of implementing multimedia mitigation (MMM) programs. The scenarios evaluated are described in detail in Sections 9 and 10 of the RIA (USEPA 1999f). Based on the analysis shown in the report, the selected regulatory alternative discussed next has a significant multimedia mitigation component. For more information on this analysis, please refer to the RIA.

(b) Selected Regulatory Alternatives. A CWS must monitor for radon in drinking water in accordance with the regulations, as described in Section VIII of this preamble, and report their results to the State. If the State determines that

the system is in compliance with the MCL of 300 pCi/L, the CWS does not need to implement a MMM program (in the absence of a State program), but must continue to monitor as required.

As discussed in Section VI, EPA anticipates that most States will choose to develop a State-wide MMM program as the most cost-effective approach to radon risk reduction. In this case, all CWSs within the State may comply with the AMCL of 4000 pCi/L. Thus, EPA expects the vast majority of CWSs will be subject only to the AMCL. In those instances where the State does not adopt this approach, the proposed regulation provides the following requirements:

(i) Requirements for Small Systems Serving 10,000 People or Less. The EPA is proposing that small CWSs serving 10,000 people or less must comply with the AMCL, and implement a MMM program (if there is no state MMM program). This is the cut-off level specified by Congress in the 1996 Amendments to the Safe Drinking Water Act for small system flexibility provisions. Because this definition does not correspond to the definitions of ''small'' for small businesses, governments, and non-profit organizations previously established under the RFA, EPA requested comment on an alternative definition of ''small entity'' in the preamble to the proposed Consumer Confidence Report (CCR) regulation (63 FR 7620, February 13, 1998). Comments showed that stakeholders support the proposed alternative definition. EPA also consulted with the SBA Office of Advocacy on the definition as it relates to small business analysis. In the preamble to the final CCR regulation (63 FR 4511, August 19, 1998), EPA stated its intent to establish this alternative definition for regulatory flexibility assessments under the RFA for all drinking water regulations and has thus used it for this radon in drinking water rulemaking. Further information supporting this certification is available in the public docket for this rule.

EPA's regulation expectation for small CWSs is the MMM and AMCL because this approach is a much more cost-effective way to reduce radon risk than compliance with the MCL. (While EPA believes that the MMM approach is preferable for small systems in a non-MMM State, they may, at their discretion, choose the option of meeting the MCL of 300 pCi/L instead of developing a local MMM program). The CWSs will be required to submit MMM program plans to their State for approval. (See Sections VI.A and F for further discussion of this approach).

SDWA Section 1412(b)(13)(E) directs EPA to take into account the costs and benefits of programs to reduce radon in indoor air when setting the MCL. In this regard, the Agency expects that implementation of a MMM program and CWS compliance with 4000 pCi/L will provide greater risk reduction for indoor radon at costs more proportionate to the benefits and commensurate with the resources of small CWSs. It is EPA's intent to minimize economic impacts on a significant number of small CWSs, while providing increased public health protection by emphasizing the more cost-effective multimedia approach for radon risk reduction.

(ii) Requirements for Large Systems Serving More Than 10,000 People. The proposal requires large community water systems, those serving populations greater than 10,000, to comply with the MCL of 300 pCi/L unless the State develops a State-wide MMM program, or the CWS develops and implements a MMM program meeting the four regulatory requirements, in which case large systems may comply with the AMCL of 4,000pCi/L. CWSs developing their own MMM plans will be required to submit these plans to their State for approval.

(c) Background on the Selection of the MCL and AMCL. For a description of EPA's process in selecting the MCL and AMCL, see Section VII.D of today's preamble.

C. Baseline Analysis

Data and assumptions used in establishing baselines for the comparison of costs and benefits are presented in the next section. While the rule as proposed does not require 100 percent compliance with an MCL, an analysis of these full compliance scenarios are required by the SDWA, as amended, and were an important feature in the development of the NPDWR for radon.

1. Industry Profile

Radon is found at appreciable levels only in systems that obtain water from ground water sources. Thus, only ground water systems would be affected by the proposed rule. The following discussion addresses various characteristics of community ground water systems that were used in the assessment of regulatory costs and benefits. Table XIII.2 shows the estimated number of community ground water systems in the United States. This data originally came from EPA's Safe Drinking Water Information System (SDWIS) and are summarized in EPA's Drinking Water Baseline Handbook (USEPA, 1999c). EPA estimates that there were 43,908 community ground water systems active in December 1997 when the SDWIS data were evaluated. Approximately 96.5 percent of the systems serve fewer than 10,000 customers, and thus fit EPA's definition of a ''small'' system (see 63 FR 44512 at 44524–44525, August 19, 1998). Privately-owned systems comprise the bulk of the smaller size categories, whereas most larger systems are publicly owned.

TABLE XIII.2.—NUMBER OF COMMUNITY GROUND WATER SYSTEMS IN THE UNITED STATES[1]

Primary source/ ownership	System size category									
	25–100	101–500	501–1,000	1,001–3,301	3,301–10,000	10,001–50,000	50,001–100,000	100,001–1,000,000	>1,000,000	Total
Total	14,232	15,070	4,739	5,726	2,489	1,282	139	70	2	43,908
Public	1,202	4,104	2,574	3,792	1,916	997	113	52	2	14,764
Private	12,361	9,776	1,705	1,531	459	243	24	14	0	26,252
Purchased-Public	114	427	265	272	84	36	1	4	0	1,203
Purchased-Private	171	347	101	79	13	3	1	0	0	718
Other	384	416	94	52	17	3	0	0	0	971

[1] Source: USEPA 1999c.

In addition to the number of affected systems, the total number of sources (wells) is an important determinant of potential radon mitigation costs. Larger systems tend to have larger numbers of sources than small ones, and it has been conservatively assumed in the mitigation cost analysis that each source out of compliance with the MCL or AMCL would need to install control equipment.

Table XIII.3 summarizes the estimated number of wells per ground water system. Both the number of wells and the variability in the number of wells increases with the number of customers served. These characteristics of community ground water sources are included in the mitigation cost analysis discussed in Section 7 of the RIA (USEPA 1999f).

2. Baseline Assumptions

In addition to the characteristics of the ground water suppliers, other important ''baseline'' assumptions were made that affect the estimates of potential costs and benefits of radon mitigation. Two of the most important assumptions relate to the distribution of radon in ground water sources and the technologies that are currently in place for ground water systems to control radon and other pollutants.

As noted in Section 3 of the RIA (USEPA 1999f), EPA has recently completed an analysis of the occurrence patterns of radon in groundwater supplies in the United States (USEPA 1999g). This analysis used the NIRS and other data sources to estimate national distributions of groundwater radon levels in community systems of various sizes. The results of that analysis are summarized in Table XIII.4. These distributions are used to calculate baseline individual and population risks, and to predict the proportions of systems of various sizes that will require radon mitigation.

TABLE XIII.3.—ESTIMATED AVERAGE NUMBER OF WELLS PER GROUNDWATER SYSTEM [1]

	System size category							
	25–100	101–500	501–1,000	1001–3,301	3,301–10,000	10,001–50,000	50,001–100,000	100,001–1,000,000
Average Number of Wells (Confidence Interval)	1.5 (0.2)	2.0 (0.2)	2.3 (0.2)	3.1 (0.3)	4.6 (1.1)	9.8 (1.8)	16.1 (2.2)	49.9 (12.7)

[1] Source: USEPA 1999c.

TABLE XIII.4.—DISTRIBUTION OF RADON LEVELS IN U.S. GROUNDWATER SOURCES

Statistic	Population served				
	25–100	101–500	501–3,300	3,301–10,000	>10,000
Geometric Mean, pCi/L	312	259	122	124	132
Geometric Standard Deviation, pCi/L	3.04	3.31	3.22	2.29	2.31
Arithmetic Mean	578	528	240	175	187

The costs of radon mitigation are affected to some extent by the treatment technologies that are currently in place to mitigate radon and other pollutants, and by the existence of pre- and post-treatment technologies that affect the costs of mitigation. EPA has conducted an extensive analysis of water treatment technologies currently in use by ground-water systems. Table XIII.5 shows the proportions of ground water systems with specific technologies already in place, broken down by system size (population served). Many ground water systems currently employ disinfection, aeration, or iron/manganese removal technologies. This distribution of pre-existing technologies serves as the baseline against which water treatment costs are measured. For example, costs of disinfection are attributed to the radon rule only for the estimated proportion of systems that would have to install disinfection as a post-treatment because they do not already disinfect. The cost analysis assumes that any system affected by the rule will continue to employ pre-existing radon treatment technology and pre- and post-treatment technologies in their efforts to comply with the rule. Where pre- or post-treatment technologies are already in place it is assumed that compliance with the radon rule will not require any upgrade or change in the pre- or post-treatment technologies. Therefore, no incremental cost is attributed to pre- or post-treatment technologies. This may underestimate costs if pre- or post-treatment technologies need to be changed (e.g., a need for additional chlorination after the installation of packed tower aeration). The potential magnitude of this cost underestimation is not known, but is likely to be a very small fraction of total treatment costs.

Table XIII.5.—Estimated Proportions of Groundwater Systems With Water Treatment Technologies Already in Place (Percent) [1]

Water treatment technologies in place	System Size (Population Served)							
	25–100	101–500	501–1,000	1,001–3,300	3,301–10,000	10,001–50,000	50,001–100,000	100,001 1,000,000
Fe/Mn removal & aeration & disinfection	0.4	0.2	1.2	0.6	2.9	2.2	3.1	2
Fe/Mn removal & aeration	0	0.1	0.2	0.1	0.4	0.1	0.4	0.1
Fe/Mn removal & disinfection	2.1	5.1	8.3	3	7.8	7.4	9.7	6.8
Fe/Mn removal	1.9	1.5	1.5	1	1.1	0.4	1.1	0.2
Aeration & disinfection only	0.9	3.2	9.8	13.7	20.9	19.7	18.6	19.9
Aeration only	0.8	1	1.8	2.9	2.9	1	2.1	0.6
Disinfection only	49.6	68.2	65	65	56.3	66	58.3	68.3

Table XIII.5.—Estimated Proportions of Groundwater Systems With Water Treatment Technologies Already in Place (Percent) [1]—Continued

Water treatment technologies in place	System Size (Population Served)							
	25–100	101–500	501–1,000	1,001–3,300	3,301–10,000	10,001–50,000	50,001–100,000	100,001 1,000,000
None	44.3	20.7	12.2	13.7	7.7	3.2	6.7	2.1

[1]. Source: EPA analysis of data from the Community Water System Survey (CWSS), 1997, and Safe Drinking Water Information System (SDWIS), 1998.

The treatment baseline assumptions shown in Table XIII.5 were used in the initial analysis for the development of the NPDWR for radon. These assumptions were used to establish the costs of 100 percent compliance with an MCL. Another analysis, which portrays the costs of the rule as recommended in this proposed rulemaking, is provided in the results section of this summary and also in Section 9 of the RIA.

D. Benefits Analysis

11. Quantifiable and Non-Quantifiable Health Benefits

The quantifiable health benefits of reducing radon exposures in drinking water are attributable to the reduced incidence of fatal and non-fatal cancers, primarily of the lung and stomach. Table XIII.6 shows the health risk reductions (number of fatal and non-fatal cancers avoided) and the residual health risk (number of remaining cancer cases) at various radon in water levels.

TABLE XIII.6.—RESIDUAL CANCER RISK AND RISK REDUCTION FROM REDUCING RADON IN DRINKING WATER

Radon Level (pCi/L in water)	Residual fatal cancer risk (cases per year)	Residual non-fatal cancer risk (cases per year)	Risk reduction (fatal cancers avoided per year)[1]	Risk reduction (non-fatal cancers avoided per year)[1]
(Baseline)	168	9.7	0	0
4,0002 [2]	165	9.5	2.9	0.2
2,000	160	9.4	7.3	0.4
1,000	150	8.8	17.8	1.1
700	141	8.3	26.1	1.5
500	130	7.6	37.6	2.2
300	106	6.1	62.0	3.6
100	46.8	2.8	120	7.0

Notes:
[1] Risk reductions and residual risk estimates are slightly inconsistent due to rounding.
[2] 4000 pCi/L is equivalent to the AMCL estimated by the NAS based on SDWA provisions of Section 1412(b)(13).

Since preparing the prepublication edition of the NAS Report, the NAS has reviewed and slightly revised their unit risk estimates. EPA uses these updated unit risk estimates in calculating the baseline risks, health risk reductions, and residual risks. Under baseline assumptions (no control of radon exposure), approximately 168 fatal cancers and 9.7 non-fatal cancers per year are associated with radon exposures through CWSs. At a radon level of 4,000 pCi/L, approximately 2.9 fatal cancers and 0.2 non-fatal cancers per year are prevented. At 300 pCi/L, approximately 62.0 fatal cancers and 3.6 non-fatal cancers are prevented each year.

The Agency has developed monetized estimates of the health benefits associated with the risk reductions from radon exposures. The SDWA, as amended, requires that a cost-benefit analysis be conducted for each NPDWR, and places a high priority on better analysis to support rulemaking. The Agency is interested in refining its approach to both the cost and benefit analysis, and in particular recognizes that there are different approaches to monetizing health benefits. In the past, the Agency has presented benefits as cost per life saved, as in Table XIII.7.

The costs of reducing radon to various levels, assuming 100 percent compliance with an MCL, are summarized in Table XIII.7, which shows that, as expected, aggregate radon mitigation costs increase with decreasing radon levels. For CWSs, the costs per system do not vary substantially across the different radon levels evaluated. This is because the menu of mitigation technologies for systems with various influent radon levels remains relatively constant and are not sensitive to percent removal.

TABLE XIII.7.—ESTIMATED ANNUALIZED NATIONAL COSTS OF REDUCING RADON EXPOSURES

[$Million, 1997]

Radon level (pCi/L)	Central tendency estimate of annualized costs [2]	Total annualized national costs [3]	Total cost per fatal cancer case avoided
4000 [1]	34.5	43.1	14.9
2000	61.1	69.7	9.5

TABLE XIII.7.—ESTIMATED ANNUALIZED NATIONAL COSTS OF REDUCING RADON EXPOSURES—Continued

[$Million, 1997]

Radon level (pCi/L)	Central tendency estimate of annualized costs [2]	Total annualized national costs [3]	Total cost per fatal cancer case avoided
1000	121.9	130.5	7.3
700	176.8	185.4	7.1
500	248.8	257.4	6.8
300	399.1	407.6	6.6
100	807.6	816.2	6.8

[1] 4000 pCi/L is equivalent to the AMCL estimated by the NAS based on SDWA requirements of Section 1412(b)(13).
[2] Costs include treatment, monitoring, and O&M costs only.
[3] Costs include treatment, monitoring, O&M, recordkeeping, reporting, and state costs for administration of water programs.

An alternative approach presented here for consideration as one measure of potential benefits is the monetary value of a statistical life (VSL) applied to each fatal cancer avoided. Since this approach is relatively new to the development of NPDWRs, EPA is interested in comments on these alternative approaches to valuing benefits, and will have to weigh the value of these approaches for future use.

Estimating the VSL involves inferring individuals' implicit tradeoffs between small changes in mortality risk and monetary compensation. In the HRRCA, a central tendency estimate of $5.8 million (1997$) is used in the monetary benefits calculations. This figure is determined from the VSL estimates in 26 studies reviewed in EPA's recent draft guidance on benefits assessment (USEPA 1998e), which is currently under review by the Agency's Science Advisory Board (SAB) and the Office of Management and Budget (OMB).

It is important to recognize the limitations of existing VSL estimates and to consider whether factors such as differences in the demographic characteristics of the populations and differences in the nature of the risks being valued have a significant impact on the value of mortality risk reduction benefits. Also, medical care or lost-time costs are not separately included in the benefits estimate for fatal cancers, since it is assumed that these costs are captured in the VSL for fatal cancers.

For non-fatal cancers, willingness to pay (WTP) data to avoid chronic bronchitis is used as a surrogate to estimate the WTP to avoid non-fatal lung and stomach cancers. The use of such WTP estimates is supported in the SDWA, as amended, at Section 1412(b)(3)(C)(iii): ''The Administrator may identify valid approaches for the measurement and valuation of benefits under this subparagraph, including approaches to identify consumer willingness to pay for reductions in health risks from drinking water contaminants.''

A WTP central tendency estimate of $536,000 is used to monetize the benefits of avoiding non-fatal cancers (Viscusi et al. 1991). The combined fatal and non-fatal health benefits are summarized in Table XIII.8. The annual health benefits range from $17.0 million for a radon level of 4000 pCi/L to $702 million at 100 pCi/L.

TABLE XIII.8.—ESTIMATED MONETIZED HEALTH BENEFITS FROM REDUCING RADON IN DRINKING WATER

Radon level (pCi/L)	Monetized health benefits, central tendency (annualized, $millions, 1997) [1]
4,000 [2]	17.0
2,000	42.7
1,000	103
700	152
500	219
300	362
100	702

Notes:
[1] Includes contributions from fatal and non-fatal cancers, estimated using central tendency estimates of the VSL of $5.8 million (1997$), and a WTP to avoid non-fatal cancers of $536,000 (1997$).
[2] 4000 pCi/L is equivalent to the AMCL estimated by the NAS based on SDWA provisions of Section 1412(b)(13).

Reductions in radon exposures might also be associated with non-quantifiable benefits. EPA has identified several potential non-quantifiable benefits associated with regulating radon in drinking water. These benefits may include any customer peace of mind from knowing drinking water has been treated for radon. In addition, if chlorination is added to the process of treating radon via aeration, arsenic pre-oxidation will be facilitated. Neither chlorination nor aeration will remove arsenic, but chlorination will facilitate conversion of Arsenic (III) to Arsenic (V). Arsenic (V) is a less soluble form that can be better removed by arsenic removal technologies. In terms of reducing radon exposures in indoor air, it has also been suggested that provision of information to households on the risks of radon in indoor air and available options to reduce exposure may be a non-quantifiable benefit that can be attributed to some components of a MMM program. Providing such information might allow households to make more informed choices than they would have in the absence of an MMM program about the need for risk reduction given their specific circumstances and concerns. In the case of the proposed radon rule, it is not likely that accounting for these non-quantifiable benefits would significantly alter the overall assessment.

The benefits calculated for this proposal are assumed to begin to accrue on the effective date of the rule and are based on a calculation referred to as the ''value of a statistical life'' (VSL), currently estimated at $5.8 million. The VSL is an average estimate derived from a set of 26 studies estimating what people are willing to pay to avoid the risk of premature mortality. Most of these studies examine willingness to pay in the context of voluntary acceptance of higher risks of immediate accidental death in the workplace in exchange for higher wages. This value is sensitive to differences in population characteristics and perception of risks being valued.

For the present rulemaking analysis, which evaluates reduction in premature mortality due to carcinogen exposure, some commenters have argued that the Agency should consider an assumed time lag or latency period in these calculations. Latency refers to the difference between the time of initial exposure to environmental carcinogens and the onset of any resulting cancer. Use of such an approach might reduce significantly the present value estimate.

The BEIR VI model and U.S. vital statistics, on which the estimate of lung cancers avoided is based, imply a probability distribution of latency periods between inhalation exposure to radon and increased probability of cancer death. EPA is interested in receiving comments on the extent to which the presentation of more detailed information on the timing of cancer risk reductions would be useful in evaluating the benefits of the proposed rule.

Latency is one of a number of adjustments or factors that are related to an evaluation of potential benefits associated with this rule, how those benefits are calculated, and when those economic benefits occur. Other factors which may influence the estimate of economic benefits associated with avoided cancer fatalities include (1) A possible ''cancer premium'' (i.e., the additional value or sum that people may be willing to pay to avoid the experiences of dread, pain and suffering, and diminished quality of life associated with cancer-related illness and ultimate fatality); (2) the willingness of people to pay more over time to avoid mortality risk as their income rises; (3) a possible premium for accepting involuntary risks as opposed to voluntary assumed risks; (4) the greater risk aversion of the general population compared to the workers in the wage-risk valuation studies; (5) ''altruism'' or the willingness of people to pay more to reduce risk in other sectors of the population; and (6) a consideration of health status and life years remaining at the time of premature mortality. Use of certain of these factors may significantly increase the present value estimate. EPA therefore believes that adjustments should be considered simultaneously. The Agency also believes that there is currently neither a clear consensus among economists about how to simultaneously analyze each of these adjustments nor is there adequate empirical data to support definitive quantitative estimates for all potentially significant adjustment factors. As a result, the primary estimates of economic benefits presented in the analysis of this rule rely on the unadjusted $5.8 million estimate. However, EPA solicits comment on whether and how to conduct these potential adjustments to economic benefits estimates together with any rationale or supporting data commenters wish to offer. Because of the complexity of these issues, EPA will ask the Science Advisory Board (SAB) to conduct a review of these benefits transfer issues associated with economic valuation of adjustments in mortality risks. In its analysis of the final rule, EPA will attempt to develop and present an analysis and estimate of the latency structure and associated benefits transfer issues outlined previously consistent with the recommendations of the SAB and subject to resolution of any technical limitations of the data and models.

E. Cost Analysis

1. Total National Costs of Compliance with MCL Options

Table XIII.9 summarizes the estimates of total national costs of compliance with the range of potential MCLs considered. The table is divided into two major groupings; the first grouping displays the estimated costs to systems and the second grouping displays the estimated costs to States. State costs, presented in Table XIII.9, were developed as part of the analyses to comply with the Unfunded Mandates Reform Act (UMRA) and also the Paperwork Reduction Act (PRA). Additional information on State costs is provided in Section 8 of the RIA and also in Section VIII of this preamble.

TABLE XIII.9.—SUMMARY OF ESTIMATED COSTS UNDER THE PROPOSED RADON RULE ASSUMING 100% COMPLIANCE WITH AN MCL OF 300 pCi/L

[$ Millions] [1]

	3 percent cost of capital	7 percent cost of capital	10 percent cost of capital
Costs to Water Systems			
Total Capital Costs (20 years, undiscounted)	2,463	2,463	2,463
Annual Costs			
Annualized Capital	165.6	232.5	289.4
Annual O&M	152.4	152.4	152.4
Total Annual Treatment	318.0	385.0	441.8
Monitoring Costs	14.1	14.1	14.1
Recordkeeping and Reporting Costs [2]	6.1	6.1	6.1
Total Annual Costs to Water Systems [3]	338.2	405.1	461.6
Costs to States			
Administration of Water Programs	2.5	2.5	2.5
Total Annual State Costs	2.5	2.5	2.5
Total Annual Costs of Compliance [4]	340.6	407.6	464.4

1. Assumes no MMM program implementation costs (*e.g.,* all systems comply with 300 pCi/L).
2. Figure represents average annual burden over 20 years.
3. Costs include treatment, monitoring, O&M, recordkeeping, and reporting costs to water systems.
4. Totals have been rounded. Costs include treatment, monitoring, O&M, recordkeeping, reporting, and state costs for administration of water programs.

2. Quantifiable and Non-quantifiable Costs

The capital and operating and maintenance (O&M) costs of mitigating radon in Community Water Systems (CWSs) were estimated for each of the radon levels evaluated. The costs of reducing radon in community ground water to specific target levels were calculated using the cost curves discussed in Section 7.5 and the matrix of treatment options presented in Section 7.6 of the RIA. For each radon level and system size stratum, the number of systems that need to reduce radon levels by up to 50 percent, 80 percent and 99 percent were calculated. Then, the cost curves for the distributions of technologies dictated by the treatment matrix were applied to the appropriate proportions of the systems. Capital and O&M costs were then calculated for each system, based on typical estimated design and average flow rates. These flow rates were calculated on spreadsheets using equations from EPA's Baseline Handbook (USEPA 1999e). The equations and parameter values relating system size to flow rates are presented in Appendix C of the RIA. The technologies addressed in the cost estimation included a number of aeration and granular activated carbon (GAC) technologies described in Section 7.2 of the RIA, as well as storage, regionalization, and disinfection as a post-treatment. To estimate costs, water systems were assumed, with a few exceptions to simulate site-specific problems, to select the technology that could reduce radon to the selected target level at the lowest cost. CWSs were also assumed to treat separately at every source from which water was obtained and delivered into the distribution system.

EPA has attempted to note potential non-quantifiable benefits when the Agency believes they might occur, as in the case of peace-of-mind benefits from radon reduction. The Agency recognizes that there may also be non-quantifiable disbenefits, such as anxiety on the part of those near aeration plants or those who find out that their radon levels are high. It is not possible to determine whether the net results of such psychological effects would be positive or negative. The inclusion of non-quantifiable benefits and costs in this analysis are not likely to alter the overall results of the benefit-cost analysis for the proposed radon rule.

F. Economic Impact Analysis

A summary analysis of the impacts on small entities is shown in Section XIV.B of this preamble (Regulatory Flexibility Act). An analysis of the impacts on State, local, and tribal governments is shown in Section XIV.C (Unfunded Mandates Reform Act). For information on how this proposed rulemaking may impact Indian tribal governments, see Section XIV.I of today's preamble. Information on the types of information that States will be required to collect, as well as EPA's estimate of the burden and reporting requirements for this proposed rulemaking, is shown in Section XIV.D (Paperwork Reduction Act). EPA's assessment of the impacts that this proposed rulemaking may have on low-income and minority populations, as well as any potential concerns regarding children's health, are shown in Section XIV.F (Environmental Justice) and Section XIV.G (Protection of Children from Environmental Health Risks and Safety Risks) of today's preamble.

G. Weighing the Benefits and Costs

1. Incremental Costs and Benefits of Radon Removal

TABLE XIII.10.—ESTIMATES OF THE ANNUAL INCREMENTAL RISK REDUCTION, COSTS, AND BENEFITS OF REDUCING RADON IN DRINKING WATER ASSUMING 100% COMPLIANCE WITH AN MCL

[$ Millions 1997]

	Radon Level, pCi/L						
	4000 [1]	2000	1000	700	500	300	100
Incremental Risk Reduction, Fatal Cancers Avoided Per Year	2.9	4.4	10.5	8.4	11.5	24.4	58.4
Incremental Risk Reduction, Non-Fatal Cancers Avoided Per Year	0.2	0.3	0.6	0.4	0.8	1.3	3.5
Annual Incremental Monetized Benefits, $ Million Per Year	17.0	25.7	61.0	48.7	67.1	142	341
Annual Incremental Radon Mitigation Costs, $ Million Per Year [2]	34.5	26.6	60.8	54.9	72.0	150.3	408.5

[1] 4000 pCi/L is equivalent to the AMCL estimated by the NAS based on SDWA requirements of Section 1412(b)(13).
[2] Costs include treatment, monitoring, and O&M costs only.

2. Impacts on Households

The cost impact of reducing radon in drinking water at the household level was also assessed. As expected, costs per household increase as system size decreases as shown in Table XIII.11.

TABLE XIII.11.—ANNUAL COSTS PER HOUSEHOLD FOR COMMUNITY WATER SYSTEMS TO TREAT TO VARIOUS RADON LEVELS [1]

[$, 1997]

Radon level (pCi/L)	VVS (25–100)	VVS (101–500)	VS (501–3300)	S (3301–10K)	M (10,001–100K)	L (> 100K)
Households Served by PUBLIC Systems Above Radon Level by Population Served						
4000 [2]	256.5	91.0	22.7	14.3	6.2	4.5
2000	259.0	92.8	23.5	14.9	7.1	5.2
1000	262.5	94.8	24.6	15.4	8.6	6.4
700	264.4	96.0	25.2	15.9	9.6	7.2
500	266.3	97.1	25.9	16.4	10.6	8.1

TABLE XIII.11.—ANNUAL COSTS PER HOUSEHOLD FOR COMMUNITY WATER SYSTEMS TO TREAT TO VARIOUS RADON LEVELS [1]—Continued

[$, 1997]

Radon level (pCi/L)	VVS (25–100)	VVS (101–500)	VS (501–3300)	S (3301–10K)	M (10,001–100K)	L (> 100K)
300	269.5	99.3	26.9	17.4	12.4	9.5
100	278.8	107.1	29.1	20.1	16.2	12.8
Households Served by PRIVATE Systems Above Radon Level by Population Served						
4000 [2]	372.4	141.1	30.3	22.8	6.6	4.4
2000	375.8	143.7	31.2	23.7	7.5	5.1
1000	380.5	146.3	32.6	24.7	9.1	6.3
700	383.1	147.8	33.4	25.4	10.1	7.1
500	385.6	149.4	34.2	26.2	11.2	7.9
300	389.8	152.2	35.5	27.7	13.1	9.4
100	401.5	162.4	37.9	32.1	17.1	12.6

[1] Reflects total household costs for systems to treat down to these levels. Because EPA expects that most systems will comply with the AMCL/MCL, most systems will not incur these household costs.
[2] 4000 pCi/L is equivalent to the AMCL estimated by the NAS based on SDWA requirements of Section 1412(b)(13).

Costs to households are higher for households served by smaller systems than larger systems for two reasons. First, smaller systems serve far fewer households than larger systems and, consequently, each household must bear a greater percentage share of the capital and O&M costs. Second, smaller systems tend to have higher influent radon concentrations that, on a per-capita or per-household basis, require more expensive treatment methods (e.g., one that has an 85 percent removal efficiency rather than 50 percent) to achieve the applicable radon level.

To further evaluate the impacts of these household costs, the costs per household were compared to median household income data for each system-size category. The results of this calculation, presented in Table XIII.12 for public and private systems, indicate a household's likely share of average incremental costs in terms of the median income. Actual costs for individual households will reflect higher or lower income shares depending on whether they are above or below the median household income (approximately $30,000 per year) and whether the water system incurs above average or below average costs for installing treatment. For all system sizes but very very small private systems, average household costs as a percentage of median household income are less than one percent for households served by either public or private systems. Average impacts exceed one percent only for households served by very very small private systems, which are expected to face average impacts of 1.12 percent at the 4,000 pCi/l level and 1.35 percent at the 300 pCi/l level and for households served by very very small public systems at the 300 pCi/l level, whose average costs barely exceed one percent. Similar to the average cost per household results on which they are based, average household impacts exhibit little variability across radon levels.

TABLE XIII.12.—PER HOUSEHOLD IMPACT BY COMMUNITY GROUNDWATER SYSTEMS AS A PERCENTAGE OF MEDIAN HOUSEHOLD INCOME

[Percent]

Radon level, pCi/L	Average Impact to Households Served by Public Systems Exceeding Radon Levels						Average Impact to Households Served by Private Systems Exceeding Radon Levels					
	VVS (25–100)	VVS (101–500)	VS	S	M	L	VVS (25–100)	VVS (101–500)	VS	S	M	L
4000 [1]	0.86	0.30	0.13	0.06	0.03	0.02	1.12	0.35	0.16	0.07	0.04	0.02
2000	0.92	0.36	0.12	0.05	0.02	0.01	1.19	0.42	0.16	0.09	0.02	0.01
1000	0.96	0.38	0.13	0.05	0.02	0.01	1.24	0.44	0.16	0.09	0.03	0.01
700	0.98	0.38	0.13	0.06	0.03	0.02	1.27	0.45	0.17	0.09	0.03	0.01
500	1.00	0.39	0.13	0.06	0.03	0.02	1.30	0.45	0.17	0.09	0.03	0.01
300	1.05	0.40	0.14	0.06	0.03	0.02	1.35	0.47	0.18	0.10	0.04	0.02
100	1.17	0.44	0.15	0.07	0.05	0.03	1.51	0.51	0.19	0.12	0.05	0.02

[1] 4000 pCi/L is equivalent to the AMCL estimated by the NAS based on SDWA requirements of Section 1412(b)(13).

3. Summary of Annual Costs and Benefits

Table XIII.13 reveals that at a radon level of 4000 pCi/L (equivalent to the AMCL estimated in the NAS Report), annual costs of 100 percent compliance with an MCL are approximately twice the annual monetized benefits. For radon levels of 1000 pCi/L to 300 pCi/L, the central tendency estimates of annual costs are above the central tendency estimates of the monetized benefits.

TABLE XIII.13.—ESTIMATED NATIONAL ANNUAL COSTS AND BENEFITS[1] OF REDUCING RADON EXPOSURES ASSUMING 100% COMPLIANCE WITH AN MCL—CENTRAL TENDENCY ESTIMATE

[$ Millions, 1997]

Radon level (pCi/L)	Annualized treatment costs[2]	Total annualized costs[3]	Cost per fatal cancer avoided	Annual monetized benefits
4000[4]	34.5	43.1	14.9	17.0
2000	61.1	69.7	9.5	42.7
1000	121.9	130.5	7.3	103
700	176.8	185.4	7.1	152
500	248.8	257.4	6.8	219
300	399.1	407.6	6.6	362
100	807.6	816.2	6.8	702

Notes:

[1] Benefits are calculated for stomach and lung cancer assuming that risk reduction begins immediately. Estimates assume a $5.8 million value of a statistical life and willingness to pay of $536,000 for non-fatal cancers.

[2] Costs are annualized over twenty years using a discount rate of seven percent. Costs include treatment, monitoring, and O&M costs.

[3] Costs include treatment, monitoring, O&M, recordkeeping, reporting, and state costs for administration of water programs.

[4] 4000 pCi/L is equivalent to the AMCL estimated by the NAS based on SDWA requirements of Section 1412(b)(13).

Because the costs of compliance with an MCL for small systems outweigh the benefits at each radon level (Table XIII.14), the MMM option was recommended for small systems to alleviate some of the financial burden to these systems and the households they serve and to realize equivalent or greater benefits at much lower costs. The results of the benefit-cost analyses for MMM implementation scenarios are shown at the end of this section and also in Section 9 of the RIA.

TABLE XIII.14.— ESTIMATED ANNUAL COSTS AND BENEFITS FOR 100% COMPLIANCE WITH AN MCL BY SYSTEM SIZE

[$Millions, 1997]

Radon level (pCi/l)	Parameter[1]	System size					
		25–100	101–500	501–3300	3301–10,000	10,001–100K	>100K
4000	Benefits	0.16	0.79	2.7	2.8	7.0	3.6
	Costs	7.8	14.3	6.3	2.9	2.7	0.5
2000	Benefits	0.41	2.0	6.8	6.9	17.7	9.0
	Costs	13.2	22.7	11.6	5.7	6.3	1.6
1000	Benefits	1.0	4.8	16.3	16.7	42.6	21.6
	Costs	23.1	36.5	24.7	13.4	18.9	5.3
700	Benefits	1.5	7.1	24.1	24.6	62.9	31.9
	Costs	30.6	46.5	36.3	21.1	32.8	9.5
500	Benefits	2.1	10.2	34.7	35.4	90.6	45.9
	Costs	39.4	57.9	50.8	32.0	53.0	15.6
300	Benefits	3.5	16.9	57.3	58.6	150	75.9
	Costs	55.6	79.3	78.8	56.1	99.3	26.9
100	Benefits	7.2	32.7	111	113	290	147
	Costs	93.4	134	147	122	238	73.5

[1] Costs do not include recordkeeping, reporting, or state costs for administration of water programs. Recordkeeping and reporting costs are estimated at $6.1 million for all system sizes and State administration costs for water programs are estimated at $2.5 million.

Total costs to public and private water systems, by size, were also evaluated in the RIA. Table XIII.15 presents the total annualized costs for public and private systems by system size category for all radon levels evaluated in the RIA. The costs are comparable for public and private systems across system sizes for all options. This pattern may be due in large part to the limited number of treatment options assumed to be available to either public or private systems in mitigating radon.

TABLE XIII.15.—AVERAGE ANNUAL COST PER SYSTEM

[$Thousands, 1997]

Radon Level (pCi/l)	Average costs to public systems exceeding radon levels						Average costs to private systems exceeding radon levels					
	VVS (25–100)	VVS (101–500)	VS	S	M	L	VVS (25–100)	VVS (101–500)	VS	S	M	L
4000	8.2	12.4	18.5	49.3	82.3	484.9	7.6	10.1	15.6	43.7	72.1	468.5
2000	8.3	12.6	19.1	51.3	94.1	560.7	7.7	10.3	16.2	45.5	82.4	541.8
1000	8.4	12.9	26.6	60.1	115.9	693.4	7.8	10.5	16.8	47.3	100.2	670.2
700	8.5	13.0	27.2	61.9	129.0	758.3	7.9	10.6	17.1	48.7	111.7	752.7
500	8.5	13.2	27.8	63.7	143.2	847.8	7.9	10.7	17.5	50.3	123.9	841.6
300	8.6	13.5	28.8	67.4	167.1	1000.4	8.0	10.9	18.1	53.3	144.7	992.9
100	8.9	14.6	31.0	77.2	219.1	1345.3	8.2	11.6	19.1	61.8	189.6	1333.1

TABLE XIII.15.—AVERAGE ANNUAL COST PER SYSTEM—Continued

[$Thousands, 1997]

Radon Level (pCi/l)	Average costs to public systems exceeding radon levels						Average costs to private systems exceeding radon levels					
	VVS (25–100)	VVS (101–500)	VS	S	M	L	VVS (25–100)	VVS (101–500)	VS	S	M	L
Annual Per System Cost for those Systems Below Radon Levels: Monitoring Costs Only												
All	0.3	0.3	0.4	0.6	1.1	2.6	0.3	0.3	0.4	0.6	1.1	2.6

4. Benefits From the Reduction of Co-Occurring Contaminants

The occurrence patterns of industrial pollutants are difficult to clearly define at the national level relative to a naturally occurring contaminant such as radon. Similarly, the Agency's re-evaluation of radon occurrence has revealed that the geographic patterns of radon occurrence are not significantly correlated with other naturally occurring inorganic contaminants that may pose health risks. Thus, it is not likely that a clear relationship exists between the need to install radon treatment technologies and treatments to remove other contaminants. On the other hand, technologies used to reduce radon levels in drinking water have the potential to reduce concentrations of other pollutants as well. Aeration technologies will also remove volatile organic contaminants from contaminated ground water. Similarly, granular activated carbon (GAC) treatment for radon removal effectively reduces the concentrations of organic (both volatile and nonvolatile) chemicals and some inorganic contaminants. Aeration also tends to oxidize dissolved arsenic (a known carcinogen) to a less soluble form that is more easily removed from water. The frequency and extent that radon treatment would also reduce risks from other contaminants has not been quantitatively evaluated.

5. Impacts on Sensitive Subpopulations

The SDWA, as amended, includes specific provisions in Section 1412(b)(3)(C)(i)(V) to assess the effects of the contaminant on the general population and on groups within the general population such as children, pregnant women, the elderly, individuals with a history of serious illness, or other subpopulations that are identified as likely to be at greater risk of adverse health effects due to exposure to contaminants in drinking water than the general population. The NAS Report concluded that there is insufficient scientific information to permit separate cancer risk estimates for potential subpopulations such as pregnant women, the elderly, children, and seriously ill persons. The NAS Report did note, however, that according to the NAS model for the cancer risk from ingested radon, which accounts for 11 percent of the total fatal cancer risk from radon in drinking water, approximately 30 percent of the fatal lifetime cancer risk is attributed to exposure between ages 0 to 10.

The NAS Report identified smokers as the only group that is more susceptible to inhalation exposure to radon progeny (NAS 1999b). Inhalation of cigarette smoke and radon progeny result in a greater increased risk than if the two exposures act independently to induce lung cancer. NAS estimates that ''ever smokers'' (more than 100 cigarettes over a lifetime) may be more than five times as sensitive to radon progeny as ''never smokers'' (less than 100 cigarettes over a lifetime). Using current smoking prevalence data, EPA's preliminary estimate for the purposes of the HRRCA is that approximately 85 percent of the cases of radon-induced cancer will occur among current and former smokers. This population of current and former smokers, which consists of 58 percent of the male and 42 percent of the female population, will also experience the bulk of the risk reduction from radon exposure reduction in drinking water supplies.

6. Risk Increases From Other Contaminants Associated With Radon Exposure Reduction

As discussed in Section 7.2 of the RIA, the need to install radon treatment technologies may require some systems that currently do not disinfect to do so. Case studies (US EPA 1998j) of twenty-nine small to medium water systems that installed treatment (24 aeration, 5 GAC) to remove radon from drinking water revealed only two systems that reported adding disinfection (both aeration) with radon treatment (the other systems either had disinfection already in place or did not add it). In practice, the tendency to add other disinfection with radon treatment may be much more significant than these case studies indicate. EPA also realizes that the addition of chlorination for disinfection may result in risk-risk tradeoffs, since, for example, the disinfection technology reduces potential for infectious disease risk, but at the same time can result in increased exposures to disinfection by-products (DBPs). This risk-risk trade-off is addressed by the recently promulgated Disinfectants and Disinfection By-Products NPDWR (63 FR 69390). This rule identified MCLs for the major DBPs, with which all CWSs and NTNCWSs must comply. These MCLs set a risk ceiling from DBPs that water systems adding disinfection in conjunction with treatment for radon removal could face. The formation of DBPs correlates with the concentration of organic precursor contaminants, which tend to be much lower in ground water than in surface water. In support of this statement, the American Water Works Association's WATERSTATS survey (AWWA 1997) reports that more than 50% of the ground water systems surveyed have average total organic carbon (TOC) raw water levels less than 1 mg/L and more than 80% had TOC levels less than 3 mg/L. On the other hand, WATERSTATS reports that less than 6% of surface water systems surveyed had raw water TOC levels less than 1 mg/L and more than 50% had raw water TOC levels greater than 3 mg/L. In fact, this survey reports that more than 85% of surface water systems had finished water TOC levels greater than 1 mg/L.

The NAS Report addressed several important potential risk-risk tradeoffs associated with reducing radon levels in drinking water, including the trade-off between risk reduction from radon treatment that includes post-disinfection with the increased potential for DBP formation (NAS 1999b). The report concluded that, based upon median and average total trihalomethane (THM) levels taken from a 1981 survey, ground water systems would face an incremental individual lifetime cancer risk due to chlorination byproducts of 5×10^{-5}. It should be emphasized that this risk is based on average and median Trihalomethane (THM) occurrence information that does not segregate systems that disinfect from those that do. It should also be noted that this survey pre-dates the promulgation of the Stage I Disinfection Byproducts Rule by almost twenty years. Further, the NAS Report points out that this average DBP risk is smaller than the average individual lifetime fatal cancer risk associated with baseline radon exposures from ground water (untreated for radon), which is estimated at 1.2×10^{-4} using a mean radon concentration of 213 pCi/L.

While this risk comparison is instructive, a more meaningful relationship for the proposed radon rule would be to compare the trade-off between radon risk reduction from radon treatment and introduced DBP risk from disinfection added along with radon treatment. EPA emphasizes that this risk trade-off is only of concern to the small minority (<1%) of small ground water systems with radon levels above the AMCL of 4000 pCi/L and to the small minority of large ground water systems that are not already disinfecting. Presently, approximately half of all small community ground water systems already have disinfection in place, as shown in Table XIII.5. The proportion of systems having disinfection in place increases as the system's size increases; >95% of large ground water systems currently disinfect. In terms of the populations served, 83% of persons served by small community ground water systems (those serving 10,000 persons or fewer) already receive disinfected drinking water and 95% of persons served by large ground water systems already receive disinfected drinking water. As shown in Tables XIII.16 and XIII.17, even for those ground water systems adding both radon treatment and disinfection, this risk-risk trade-off tends to be very favorable, since the risk reduction from radon removal greatly outweighs the added risk from DBP formation.

An estimate of the risk reduction due to treatment of radon in water for various removal percentages and finished water concentrations is provided in Table XIII.16. These risk reductions are much greater than NAS's estimate of the average lifetime risk from DBP exposure for ground water systems, by factors ranging from 3.5 for low radon removal efficiencies (50%) to more than 130 for higher radon removal efficiencies (>95%).

TABLE XIII.16.—RADON RISK REDUCTIONS RESULTING FROM WATER TREATMENT

Radon Influent (Raw Water) level, pCi/L	Required removel efficiency (percent)	Reduced lifetime risk resulting from Water Treatment for Radon in Drinking Water [1]
500	52	1.7×10^{-4}
750	68	3.4×10^{-4}
1000	76	5.1×10^{-4}
2500	90	1.5×10^{-3}
4000	94	2.5×10^{-3}
10000	98	6.5×10^{-3}

[1] Assumes that water is treated to 80% of the radon MCL.

Table XIII.17 demonstrates the risk-risk trade-off between the risk reduction from radon removal and the risks introduced from total trihalomethanes (TTHM) for two scenarios: (1) the resulting TTHM level is 0.008 mg/L (10% of the TTHM MCL) and (2) the resulting TTHM level is 0.080 mg/L (the TTHM MCL). The table demonstrates that the risk-risk trade-off is favorable for treatment with disinfection, even for situations where radon removal efficiencies are low (50%) and TTHM levels are present at the MCL. While accounting quantitatively for the increased risk from DBP exposure for systems adding chlorination in conjunction with treatment for radon may somewhat decrease the monetized benefits estimates, disinfection may also produce additional benefits from the reduced risks of microbial contamination.

TABLE XIII.17.—RADON RISK REDUCTION FROM TREATMENT COMPARED TO DBP RISKS

Radon influent (Raw Water) level pCi/L	Estimated risk ratios: (lifetime risk reduction from radon removal [1] / lifetime average risk from TTHMs in chlorinated groundwater)		
	(NAS) [2]	TTHMs present at 10% of TTHM MCL (0.080 mg/L) [3]	TTHMs present at MCL
500	4	30	3
750	7	60	6
1000	10	90	9
2500	30	300	30
4000	50	500	50
10000	130	1200	120

Notes: [1] From Table XIII.16.

[2] From Appendix D in: National Research Council, *Risk Assessment of Radon in Drinking Water,* National Academy Press, Washington, DC. 1999. DBP concentrations are from a 1981 study and therefore pre-date the Stage 1 DBP NPDWR.

[3] US EPA Regulatory Impact Analysis for the Stage 1 Disinfectants/Disinfection Byproducts Rule. Prepared by The Cadmus Group. November 12, 1998. Analysis is based on the 95% upper confidence interval value from the Integrated Risk Information System (IRIS) lifetime unit risks for each THM. TTHM is assumed to comprised by 70% chloroform, 21% bromodichloromethane, 8% dibromochloromethane, and 1% bromoform.

[4] US EPA. Regulatory Impact Analysis for the Stage 1 Disinfectants/Disinfection Byproducts Rule. Based on the 95% upper confidence interval value from the Integrated Risk Information System (IRIS) for the lifetime unit risk for dibromochloromethane (2.4×10^{-6} risk of cancer case over 70 years of exposure).

7. Other Factors: Uncertainty in Risk, Benefit, and Cost Estimates

Estimates of health benefits from radon reduction are uncertain. EPA is including an uncertainty analysis of radon in drinking water risks in Section XII of the preamble to the proposed radon rule. A brief discussion on the uncertainty analysis is also shown in Section 10 of the RIA (USEPA 1999f) for radon in drinking water. Monetary benefit estimates are also affected by the VSL estimate that is used for fatal cancers. The WTP valuation for non-fatal cancers has less impact on benefit estimates because it contributes less than 1 percent to the total benefits estimates, due to the fact that there are few non-fatal cancers relative to fatal cancers and they receive a much lower monetary valuation.

8. Costs and Benefits of Multimedia Mitigation Program Implementation Scenarios

In addition to evaluating the costs and benefits across a range of radon levels, EPA has evaluated five scenarios that reduce radon exposure through the use of MMM programs. The implementation assumptions for each scenario are described in the next section. These five scenarios are described in detail in Section 9 of the RIA. For the MMM implementation analysis, systems were assumed to mitigate water to the 4,000 pCi/L Alternative Maximum Contaminant Level (AMCL), if necessary, and that equivalent risk reduction between the AMCL and the radon level under evaluation would be achieved through a MMM program. Therefore, the actual number of cancer cases avoided is the same for the MMM implementation scenarios as for the water mitigation only scenario. A complete discussion on why MMM is expected to achieve equal or greater risk reduction is shown in Section VI.B of the preamble for the proposed radon rule.

For the RIA, EPA used a simplified approach to estimating costs of mitigating indoor air radon risks. A point estimate of the average cost per life saved under the current voluntary radon mitigation programs served as the basis for estimating the costs of risk reduction under the MMM options. The Agency has estimated the average screening and mitigation cost per fatal lung cancer avoided to be approximately $700,000, assuming the current distribution of radon in indoor air, that all homes would be tested for radon in indoor air, and that all homes at or above EPA's voluntary action level of 4 pCi/L would be mitigated. This value was originally derived based on data gathered in 1991. The same value has been used in the RIA, without adjustment for inflation, after discussions with personnel from EPA's Office of Radiation and Indoor Air indicated that screening and mitigation costs have not increased since 1991.

9. Implementation Scenarios

EPA evaluated the annual cost of five MMM implementation scenarios that span the range of participation in MMM programs that might occur when a radon NPDWR is implemented. Each scenario assumes a different proportion of States will comply with the AMCL and implement MMM programs. It has been assumed that ''50 percent of States'' implies 50 percent of systems in the U.S; ''60 percent of States'' implies 60 percent of systems, and so on.

Scenario A: 50 percent of States implement MMM programs.
Scenario B: 60 percent of States implement MMM programs.
Scenario C: 70 percent of States implement MMM programs.
Scenario D: 80 percent of States implement MMM programs.
Scenario E: 95 percent of States implement MMM programs.

States that do *not* implement MMM programs instead must review and approve any system-level MMM programs prepared by community water systems. In these States, regardless of scenario, 90 percent of systems are assumed to comply with the AMCL *and* to implement a system-level MMM program and 10 percent are assumed to comply with the MCL. EPA requests comment on whether this is an appropriate assumption.

10. Costs and Benefits of MMM Implementation Scenarios

Table XIII.18 shows the total annual system-level and State-level costs for each MMM scenario, assuming an MCL of 300 pCi/L and AMCL of 4,000 pCi/L. Additional MMM scenario cost and benefit tables for MCL levels of 100, 500, 700, 1000, 2000, and 4000 pCi/L are shown in Appendix E of the RIA. System, State, and MMM mitigation costs decrease from $121.1 million to $60.4 million as the percentage of States implementing MMM programs increases from 50 to 95 percent. System-level costs decrease from $104 million to $47 million as the percentage of States implementing MMM programs increases from 50 to 95 percent. Costs for actual mitigation of radon in indoor air rise from $3.9 million to $4.1 million as the percentage of States implementing MMM programs rises from 50 to 95 percent. Note that these mitigation costs are relatively flat because all scenarios assume that 95 percent or more of the risk reduction will be achieved through MMM at either the State or local level.

Table XIII.19 represents the ratios of benefits to costs of MMM programs for each scenario, by system size. Only the ratios in the bottom row of the table include costs to the States. The balance of the numbers presented here represent local benefits and costs only and as such, somewhat overstate the net benefits of the scenarios. Benefit-cost ratios are generally less than one for the smallest system size category (systems serving less than 500 people), but greater than one for larger systems under all five scenarios. For larger systems, benefit-cost ratios range from 2.6 for systems serving 501–3,300 people under Scenario A to approximately 41.4 for systems serving 10,001 to 100,000 people under Scenario E. Overall benefit-cost ratios are over one for all five scenarios. This pattern is seen primarily because a larger proportion of smaller systems have influent radon levels exceeding 4000 pCi/L. A larger proportion of small systems versus large systems therefore, incur water mitigation costs to comply with the AMCL.

Table XIII.20 shows the net benefits (benefits minus costs) of the various MMM implementation scenarios. As would be expected from the benefit-cost ratios shown in Table XIII.19, all systems serving more than 500 people realize net positive benefits under all five scenarios. By far the largest proportion of net benefits is realized by systems serving 10,001 to 100,000 people.

TABLE XIII.18 (A).—ANNUAL SYSTEM—LEVEL AND STATE—LEVEL COSTS ASSOCIATED WITH THE MULTIMEDIA MITIGATION AND AMCL OPTION

[$ Millions/Year] [MCL=300 pCi/L]

System size	Scenario A 45% implement system-level MMM program; 5% mitigate water to 300 piC/L MCL; 95% mitigate water to 4000 piC/L AMCL	Scenario B 36% implement system-level MMM program; 4% mitigate water to 300 piC/L MCL; 96% mitigate water to 4000 piC/L AMCL	Scenario C 27% implement system-level MMM program; 3% mitigate water to 300 piC/L MCL; 97% mitigate water to 4000 piC/L AMCL	Scenario D 18% implement system-level MMM program; 2% mitigate water to 300 piC/L MCL; 98% mitigate water to 4000 piC/L AMCL	Scenario E 5% implement system-level MMM program; 5% mitigate water to 300 piC/L MCL; 99.5% mitigate water to 4000 piC/L AMCL
System Costs for Water Mitigation ($ millions/year)					
25–100	10.2	9.7	9.3	8.8	8.1
101–500	17.6	16.9	16.3	15.6	14.6
501–3300	9.9	9.2	8.5	7.7	6.7
3301–10,000	5.5	5.0	4.5	3.9	3.1
10,001–100,000	7.5	6.6	5.6	4.6	3.2
>100,000	2.0	1.7	1.4	1.1	0.7
Total CWS Water Mitigation Costs	52.7	49.1	45.4	41.8	36.3
Water System Administration Costs ($ millions/year)					
25–100	17.0	14.0	11.0	8.0	3.7
101–500	17.4	14.3	11.3	8.2	3.8
501–3300	12.0	9.9	7.8	5.7	2.6
3301–10,000	3.0	2.5	1.9	1.4	0.6
10,001–100,000	1.7	1.4	1.1	0.8	0.4
>100,000	0.1	0.1	0.1	0.0	0.0
Total CWS Administrative Costs	51.2	42.1	33.1	24.1	11.1
Total CWS Water Mitigation and Administrative Costs	104.0	91.2	78.5	65.9	47.4

TABLE XIII.18 (B).—STATE MMM ADMINISTRATIVE COSTS

[$ millions/year]

	Scenario A 50% of states implement state-wide MMM programs; 45% of CWS implement system-level MMM program	Scenario B 60% of states implement state-wide MMM program; 35% of CWS implement system-level MMM program	Scenario C 70% of states implement state-wide MMM program; 25% of CWS implement system-level MMM program	Scenario D 80% of states implement state-wide MMM program; 15% of CWS implement system-level MMM program	Scenario E 95% of states implement state-wide MMM program; 5% of CWS implement system-level MMM program
State costs associated with State-wide MMM program administration, reviewing system-level MMM programs, and reviewing system-level water mitigation requirements are not distributable across different system sizes.					
State Administration Costs for Water Mitigation	2.5	2.5	2.5	2.5	2.5
State Administration Costs for State-Level MMM Mitigation	2.9	3.5	4.1	4.7	5.6
State Administration Costs for System-Level MMM Mitigation	7.8	6.1	4.4	2.6	0.9
Total State Administration Costs	13.2	12.1	10.9	9.8	8.9

TABLE XIII.18 (C).—MMM TESTING AND MITIGATION COSTS

[$ million/year]

	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
CWS MMM Costs	1.9	1.5	1.1	0.7	0.2
State MMM Costs	2.1	2.5	2.9	3.3	3.9
Total MMM Costs	3.91	3.95	3.99	4.03	4.12

TABLE XIII.18 (C).—MMM TESTING AND MITIGATION COSTS—Continued

[$ million/year]

	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
Total Costs (From Tables XIII.18 A, B, and C)	121.1	107.3	93.4	79.7	60.4

TABLE XIII.19.—RATIO OF BENEFITS AND COSTS BY SYSTEM SIZE FOR EACH SCENARIO (MCL=300 PCI/L)

System size	Benefits, $M	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
25–100	3.5	0.13	0.14	0.17	0.21	0.30
101–500	16.9	0.48	0.53	0.61	0.70	0.92
501–3,300	58.0	2.59	2.98	3.51	4.27	6.23
3,301–10,000	59.2	6.87	7.85	9.16	11.0	15.61
10,001–100,000	147.3	15.82	18.35	21.84	26.96	41.43
>100,000	76.7	37.16	43.70	53.04	67.44	113.68
OVERALL	361.6	2.98	3.37	3.87	4.54	5.99

TABLE XIII.20.—NET BENEFITS BY SYSTEM SIZE FOR EACH SCENARIO [1]

System size	Benefits, $M	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
25–100	3.5	(24.3)	(20.7)	(17.1)	(13.5)	(8.3)
101–500	16.9	(18.7)	(14.8)	(11.0)	(7.1)	(1.6)
501–3,300	58.0	35.6	38.6	41.5	44.4	48.7
3,301–10,000	59.2	50.6	51.7	52.7	53.8	55.4
10,001–100,000	147.3	138.0	139.3	140.6	141.8	143.7
>100,000	76.7	74.6	74.9	75.3	75.6	76.0
OVERALL	361.6	240.5	254.3	268.2	281.9	301.2

[1] Parentheses indicate negative numbers.

H. Response to Significant Public Comments on the February 1999 HRRCA

To provide the public with opportunities to comment on the Health Risk Reduction and Cost Analysis (HRRCA) for radon in drinking water, the Agency published the HRRCA in the **Federal Register** on February 26, 1999 (64 FR 9559). The HRRCA was published six months in advance of this proposal and illustrated preliminary cost and benefit estimates for various MCL options under consideration for the proposed rule. The comment period on the HRRCA ended on April 12, 1999, and EPA received approximately 26 written comments from a variety of stakeholders, including the American Water Works Association, the National Rural Water Association, the National Association of Water Companies, the Association of Metropolitan Water Agencies, State departments of environmental protection, State health departments, State water utilities and local water utilities.

Significant comments on the HRRCA addressed the topics of radon occurrence, exposure pathways, sensitive sub-populations and the risks to smokers, risks from existing radon exposures, risks associated with co-occurring contaminants, risk increases associated with radon removal, the benefits of reduced radon exposures, the costs of radon treatment measures, the cost and benefit results, and the Multimedia Mitigation (MMM) program. The following discussion outlines the significant comments received on the HRRCA and the Agency's response to these comments.

1. Radon Occurrence

Several commenters had concerns related to EPA's analysis of radon occurrence. Two commenters felt that the radon levels in Table 3.1 of the HRRCA were too low and not representative of radon occurrence in their regions. A California water utility indicated that due to limitations of the NIRS, EPA should conduct a new national radon survey, with special emphasis on determining radon levels in the largest systems, before promulgating the rule. Two commenters from Massachusetts expressed concerns about radon occurrence. One suggested that additional analysis of radon variability in individual wells was required, and another indicated that the effects of storage and residence time on radon levels in supply systems needed to be taken into account. One commenter indicated that EPA should more strongly consider that most risk reductions predicted in the HRRCA come from reductions in radon levels in the small proportions of systems with initial very high radon levels.

EPA Response 1–1

As part of the regulatory development process, EPA updated and refined its analysis of radon occurrence patterns in ground water supplies in the United States. This new analysis incorporated information from the EPA 1995 National Inorganic and Radionuclides Survey (NIRS) of 1000 community ground water systems throughout the United States, along with supplemental data provided by States, water utilities, and academic researchers. EPA's current re-evaluation used data from 17 States to determine the differences between radon levels in ground water and radon levels in distribution systems in the same regions. The results of these comparisons were used to estimate national distributions of radon occurrence in ground water. EPA believes that the existing NIRS data, along with the Agency's updates to this data, currently provide the most comprehensive *national-level* analysis of radon occurrence patterns in ground water supplies. This analysis is not intended for the estimation of radon occurrence at the state-level.

Variability within the NIRS radon occurrence data was analyzed for several important contributing factors: within-well (temporal) variability, sampling and analytical (methods) variability, intra-system variability (variability between wells within a single system), and inter-system variability (variability between wells in different systems). Several important conclusions were drawn from this analysis. First and foremost is the conclusion that the NIRS data do capture the major sources of radon occurrence variability and thus can be used directly, without any additional correction for temporal or sampling and analytical variability, to provide reasonable national estimates of radon levels and variability levels in ground water drinking supplies. In addition, EPA analyzed the additional data sets provided from stakeholders (described previously) in conjunction with the NIRS radon data to estimate the magnitudes of the variability sources. Based on all of these analyses, EPA has concluded that the variability between systems dominates the over-all variability (it comprises approximately 70 percent of the over-all variability). Temporal variability (13–18 percent), sampling and analytical variability (less than 1 percent), and intra-system variability (12–17 percent) are relatively minor by comparison. These results are discussed in detail elsewhere (USEPA 1999b).

Note: These estimates of variability sources apply to national-level radon occurrence estimates: individual regions may have systems that show variability sources that deviate significantly from these values.

This analysis of variability was incorporated into EPA's estimates of nation-wide radon occurrence and was used in its estimates of the effects of uncertainty in occurrence information on total national costs of compliance.

In response to the comment that ''most risk reductions predicted in the HRRCA come from reductions in radon levels in the small proportions of systems with initial very high radon levels'', EPA agrees that a system with high radon levels would benefit more from water mitigation than a system with much lower initial radon levels, but the vast majority of the national water mitigation benefits come from systems that are above the MCL, but not that high above it (*e.g.*, 80 percent removal required for the system to be at the MCL). This is true since radon is approximately log-normally distributed (i.e., a much higher percentage of water systems can be expected to have relatively low radon levels than relatively high radon levels) and hence *most systems* fall into this category. For this reason, the summation of these smaller per system benefits enjoyed by the large number of systems nearer the MCL greatly outweigh summation of the larger per system benefits enjoyed by the minority of systems with very high radon levels. This is demonstrated in Table 6–2 of the HRRCA (''Estimated Monetized Benefits from Reducing Radon in Drinking Water''), in which the central tendency estimate of monetized benefits associated with an MCL of 500 pCi/L is 212 million dollars and the benefits associated with an MCL of 100 pCi/L is 673 million dollars. This means that, in the latter case, 461 million dollars of the benefits come just from the systems with radon levels between 100 and 500 pCi/L (80 percent removal required), while the remaining benefits (212 million dollars) come from the systems with radon levels from 500 pCi/L up to the highest radon levels.

Five commenters indicated that the estimates of the numbers of entry points per system used in the HRRCA were incorrect, in that large systems had far more entry points than the numbers given in Table 5.4 of the HRRCA. Several of these commenters cited data from the Community Water System Survey (CWSS), showing higher numbers of wells per system in each system size category than were used for cost calculations in the HRRCA.

EPA Response 1–2

The relevant distribution for costing out non-centralized treatment is the number of entry points, not the number of wells. A given entry point (the point at which treatment is applied) may be fed by several wells, and hence there is a discrepancy in numbers between the HRRCA, which reported a distribution of entry points, and Table 1–5 of the Community Water System Survey (CWSS), which reported the average number of wells per system. These numbers are related, but not directly comparable. In general, the average number of entry points for a class of ground water systems would be expected to be smaller than the average number of wells. In the HRRCA, the distribution of entry points per system was estimated from a statistical analysis (''bootstrap analysis'') of the well and entry point data from the CWSS. This statistically-calculated distribution was then used to estimate the percentage of systems within a system size category having a given number of entry points. However, as part of its uncertainty analysis, EPA has used the 95% confidence upper bound of the site distribution in the national cost estimates supporting this proposal. The average number of entry points per system is roughly 10% higher using this upper bound analysis. In addition, to test the effects of varying this distribution on the national costs of compliance, the per system costs, and the per household costs, EPA conducted an uncertainty analysis (Monte Carlo analysis including sensitivity) on the distribution by simultaneously varying both the percentages of systems estimated to have a particular number of sites and the estimated number of sites. The results of this analysis are reported both in this notice and in the Regulatory Impact Analysis. It should be noted that the treatment unit costs and total number of systems dominated the cost uncertainty and that the entry point distribution was a relatively minor contributor to the overall cost uncertainty.

2. Exposure Pathways

A number of issues related to radon exposure pathways were raised. Several commenters indicated that the risks associated with the build-up of radon in carbon filters needed to be addressed in HRRCA. Concerns were also expressed about general population exposures to radon in air released from aeration facilities and exposures to workers at water utilities. Another commenter said that EPA should discuss the persistence of radon in the body after ingestion.

EPA Response 2–1

The risks from radon build-up in carbon filters and radon off-gas emissions are discussed in some detail in this notice, including an evaluation of risks, a discussion of references, and responses from a survey of air permitting boards about the permitting of radon off-gas.

EPA Response 2–2

The persistence of radon in the body following ingestion has been investigated and the results have been presented in the Criteria Document for Radon (USEPA 1999b). In brief, radon ingested in water is well-absorbed from the stomach and small intestine into the bloodstream and transported throughout the body. Radon is rapidly (within approximately one hour) excreted from the body via the lungs, so only about 1 percent of ingested radon undergoes radioactive decay while in the body. The risks from the retained radon and its decay products in various organs are calculated by NAS and adopted by EPA in the proposed rule.

3. Nature of Health Impacts

No comments were made concerning the general nature of adverse effects associated with radon exposure. Comments concerning specific aspects of health impact evaluation are summarized in the following sections.

(a) Sensitive subpopulations, risks to smokers, non-smokers. Comments on these sections are addressed together because the majority of the comments had to do with the characterization of smokers as a sensitive population. Several commenters noted that most risk reduction from reducing radon exposure occurs among smokers, and took the position that EPA should not include risk reductions to smokers in its benefits assessment, because smoking can be viewed as a voluntary risk. One commenter suggested that the smokers' willingness to pay for cigarettes also indicated a willingness to face the risk of smoking.

EPA Response 3–1

The term, ''groups within the general population'' is addressed, but not comprehensively defined, in the 1996 amendments to the Safe Drinking Water Act (SDWA, §′1412(b)(3)(C)). The definition of sensitive subpopulations is an issue for discussion and debate, and EPA is interested in input from stakeholders. The National Academy of Sciences (NAS) Radon in Drinking Water Committee, as part of their assessment of the risks of radon in drinking water, has considered whether groups within the general population, including smokers, may be at increased risk. The NAS Committee has indicated, in their Risk Assessment of Radon in Drinking Water report, that smokers are the only group within the general population that is more susceptible to inhalation exposure to radon progeny, but did not specifically identify smokers as a sensitive subpopulation.

In this proposal, EPA is basing its risk management decision on risks to the general population. The general population includes smokers as well as former smokers. The risk assessments for radon in air and water are based on an average member of the population, which includes smokers, former smokers, and non-smokers. A more complete discussion on the risks of radon in drinking water and air is presented in the NAS's risk assessment report and in Section XII of this preamble.

(b) Risk reduction model, risks from existing radon exposures. Commenters raised only one concern associated with the risk model used to estimate radon reduction benefits. Three commenters suggested that EPA should consider adopting a threshold-based model for radon carcinogenesis, and that EPA's current (non-threshold) approach overestimates radon risks. In support, the commenters cited a recently published paper (Miller et al, 1999) as providing evidence that a single alpha particle ''hit'' typical in low-level radon may not be sufficient to cause cell transformation leading to cancer.

EPA Response 3–2

There are a number of papers that have recently examined the effects of a single alpha particle on a cell nucleus of mammalian cells in culture. The authors of this study concluded that cells were more likely to be transformed to cancer causing cells if there were multiple alpha particle hits to their nuclei. However, another study, *Hei et al.* (1997), using a similar methodology, found direct evidence that a single ''particle traversing a cell nucleus will have a high probability of resulting in a mutation'' and concluded that their work highlighted the need for radiation protection at low doses. Moreover, follow-up microbeam experiments described by Miller et al. at the 1999 International Congress of Radiation Research demonstrated that one alpha particle track through the nucleus was indeed sufficient to induce transformation under some experimental conditions. Epidemiological data relating to low radon exposures in mines also indicate that a single alpha track through the cell may lead to cancer. Finally, while not definitive by themselves, the results from residential case-control studies provide some direct support for the conclusion that environmental levels of radon pose a risk of lung cancer. EPA has based its current risk estimates for radon in drinking water on the findings of the National Academy of Sciences. Rather than focus on the results of any one study, the NAS committees based their conclusions on the totality of data on radon—a weight-of-evidence approach.

Both the BEIR VI Report (NAS 1999a) and their report on radon in drinking water (NAS 1998b) represent the most definitive accumulation of scientific data gathered on radon since the 1988 NAS BEIR IV (NAS 1988). These committees' support for the use of linear-non-threshold relationship for radon exposure and lung cancer risk came primarily from their review of the mechanistic information on alpha-particle-induced carcinogenesis, including studies of the effect of single versus multiple hits to cell nuclei.

In the BEIR VI report (NAS 1999a), the NAS concluded that there is good evidence that a single alpha particle (high-linear energy transfer radiation) can cause major genomic changes in a cell, including mutation and transformation that potentially could lead to cancer. They noted that even if substantial repair of the genomic damage were to occur , ''the passage of a single alpha particle has the potential to cause irreparable damage in cells that are not killed.'' Given the convincing evidence that most cancers originate from damage to a single cell, the committee went on to conclude that ''on the basis of these [molecular and cellular] mechanistic considerations, and in the absence of credible evidence to the contrary, the committee adopted a linear-nonthreshold model for the relationship between radon exposure and lung-cancer risk. However, the BEIR VI committee recognized that it could not exclude the possibility of a threshold relationship between exposure and lung cancer risk at very low levels of radon exposure.'' The NAS committee on radon in drinking water (NAS 1999b) reiterated the finding of the BEIR VI committee's comprehensive review of the issue, that a ''mechanistic interpretation is consistent with linear, non-threshold relationship between radon exposure and cancer risk''. The committee noted that the ''quantitative estimation of cancer risk requires assumptions about the probability of an exposed cell becoming transformed and the latent period before malignant transformation is complete. When these values are known for singly hit cells, the results might lead to reconsideration of the linear no-threshold assumption used at present.'' EPA recognizes that research in this area is on-going but is basing its regulatory decisions on the best currently available science and recommendations of the NAS that support use of a linear non-threshold relationship.

(c)Risk and risk reduction associated with co-occurring contaminants. Several commenters addressed the issue of risks associated with co-occurring contaminants. Other commenters indicated a need to include risks and risk reductions from co-occurring contaminants.

EPA Response 3–3

The contaminants that may co-occur with radon that are of main concern are those that can cause fouling of aeration units (or otherwise impede treatment) and those that are otherwise affected by the aeration process in such a way as to increase risks. Measures and costs to avoid aeration fouling are discussed in this notice and in the references cited. Arsenic co-occurrence may be relevant since some systems may have to treat for both, but the treatment processes are not incompatible. In fact, the only side-effect of the aeration process that may impact the removal of arsenic would be the potential oxidation of some fraction of less easily removed As(IV) form to the more easily removed As(VI) form. There would be no additional costs due to this effect, and in fact, there may be cost savings involved. The potential for increased risks due to potential disinfectant by-product formation after disinfection, is discussed next.

(d) Risk increases associated with radon removal. Five commenters said that EPA should include quantitative estimates of the risk increases associated with increased exposure to disinfection byproducts (DBPs) in the risk and cost-benefit analyses of the HRRCA. One commenter said that risks should be apportioned appropriately between the proposed radon rule and the Groundwater rule. Another commenter maintained that, contrary to the assertion in the HRRCA, there would be no reduction in microbial risks due to the increased disinfection associated with the radon rule because most groundwater sources currently present no microbial risks.

EPA Response 3–4

EPA would like to highlight that the AMCL/MMM option is the preferred option for all drinking water systems, which would result in very few water treatment systems adding disinfection. EPA expects the radon rule to result in a minority of ground water systems choosing the MCL option, and of those, many will be larger systems. Since very few small systems are expected to choose the MCL option , very few systems are above the AMCL of 4000 pCi/L, and most large ground water systems already disinfect their water, few systems are expected to add disinfection in response to the radon rule, i.e., increased risk due to disinfection by-product formation should not be a significant issue. However, EPA does evaluate this risk-risk trade-off in this notice for that minority of systems that will be expected to add disinfection with treatment for radon. For that minority of systems, the trade-off between decreased risks from radon and increased risks from disinfection-by-products is favorable.

4. Benefits of Reduced Radon Exposure

The majority of the comments related to the estimation of benefits focused on the methods used to monetize reductions in cancer risks. There were also a few comments on non-quantifiable benefits, and on several other topics. The previous comments pertaining to risk reductions to smokers and that benefits from these risk reductions should be excluded from the HRRCA apply here as well.

(a) Nature of regulatory benefits. There were few comments on this section, most of which pertained to non-quantifiable benefits. One commenter indicated that the peace-of-mind non-quantifiable benefit from radon reduction would be offset by the anxiety of those living near aeration plants. Another noted that peace-of-mind benefits were not easy to quantify for non-threshold pollutants like radon and, in fact, that the regulation of radon might actually increase anxiety by drawing attention to the risks associated with radon exposures. Commenters also noted that claiming arsenic reduction as a benefit from aeration is questionable because there is no demonstrated correlation between the levels of radon and arsenic in groundwater systems.

EPA Response 4–1

By definition, non-quantifiable benefits cannot be measured and have not been measured in the HRRCA analysis. Thus, comparisons of types of such benefits are not very meaningful. EPA attempts to note these potential benefits when the Agency believes they might occur, as in the case of peace-of-mind benefits from radon reduction. There may also be non-quantifiable costs that may offset any non-quantifiable benefits. These include anxiety on the part of residents near treatment plants and customers who may not have previously been aware of radon in their water. As noted elsewhere in this preamble, EPA believes it unlikely that accounting for these non-quantifiable benefits and costs quantitatively would significantly alter the overall assessment.

(b) Monetization of benefits. Comments related to risk reduction have been discussed in previous responses, so are not discussed further here. Commenters addressed all three approaches to monetizing benefits: the value of statistical life; the costs of illness; and willingness-to-pay. A number of commenters suggested the use of Quality-Adjusted Life Years (QALY) as an alternative approach to the valuation of health benefits. One commenter indicated that the use of QALYs was a good way to avoid having to monetize health outcomes. Two commenters indicated that QALYs had the advantage of being able to take into account the delayed onset of cancer, as well as reduced incidence. One organization suggested QALYs as a superior method for combining the benefits from fatal and non-fatal illness over different time periods; which would be particularly useful in the case of smokers, whose cancers are likely to be delayed, but not necessarily prevented, by reductions in radon exposure.

EPA Response 4–2

The use of QALYs has been extensively discussed within EPA and also before the Environmental Economics Advisory Committee of EPA's Science Advisory Board. At this time, current Agency policy is to use Value of Statistical Life (VSL) estimates for the monetization of risk reduction benefits. EPA believes QALY calculations to be experimental and not well established for the types of analyses performed by the Agency.

(c) Value of statistical life (VSL). Several commenters questioned the use of, or the value selected for, the value of statistical life as a measure of benefits. Other commenters indicated that the large range of uncertainty associated with the estimates of risk reduction called the VSL (and the willingness-to-pay) methods into question, and indicated that EPA needed to better justify the central-tendency VSL value selected for use in the HRRCA. They maintained that the VSL approach would only be appropriate if the VSL estimates were derived from ''similar scenarios'' to those being evaluated in the HRRCA. Another commenter suggested that using the VSL was inappropriate in that the VSL dollars did not represent (as do compliance costs) actual resource losses to society that could be spent on other programs (e.g. pollution reduction). Thus, the comparison of compliance costs to VSL costs is not valid. They strongly recommend the use of compliance cost per life saved as an appropriate measure for judging radon control options. One commenter indicated that the use of the VSL approach resulted in greatly over-estimated benefits of radon exposure reduction, particularly because the VSL for smokers is the same as for non-smokers and does not account for the age at which mortality is avoided. Another questioned the validity of the mean VSL value used in the HRRCA, and indicated that VSL estimates should only come from the peer-reviewed scientific literature or from Agency documents that had been subject to public comment.

EPA Response 4–3

The VSL value, currently recommended by Agency guidance, is derived from a statistical distribution of the values found in twenty-six VSL studies, which were chosen as the best such studies available from a larger body of studies. This examination of studies was undertaken by EPA's Office of Air and Radiation in the course of its Clean Air Act retrospective analysis. EPA believes the VSL estimate ($5.8 million, 1997 dollars) to be the best estimate at this time, and is recommending that this value be used by the various program offices within the Agency. This estimate may, however, be updated in the future as additional information becomes available to assist the Agency in refining its VSL estimate. The VSL estimate is consistent with current Agency economic analysis guidance, which was recently peer reviewed by EPA's Science Advisory Board.

d. Costs of illness (COI). Two commenters suggested that EPA should further review the literature on the costs of illness and develop better cost measures for the illnesses addressed in the HRRCA.

EPA Response 4–4

EPA believes that the COI data is the most complete analysis of this type currently underway. The cost of illness (COI) data shown in the HRRCA were presented as a comparison to Willingness to Pay (WTP) to avoid chronic bronchitis. The Agency did not use the COI data to estimate risk reduction valuations for non-fatal cancers because these estimates can be seen as underestimating the total WTP to avoid non-fatal cancers. COI may understate total WTP because of its failure to account for many effects of disease such as pain and suffering, defensive expenditures, lost leisure time, and any potential altruistic benefits. It is important to note that the proportion of benefits attributable to non-fatal cancer cases accounts for less than one percent of the total benefits in the HRRCA.

(e) Willingness-to-pay. Several commenters questioned EPA's use of the willingness-to-pay (WTP) approach for monetizing non-fatal cancer risk reductions. Another suggested that a WTP value for victims of non-fatal cancers should have been used, instead of the WTP estimates for chronic bronchitis. It was also suggested that WTP measures would vary within the general population, and that use of a constant value was inappropriate.

EPA Response 4–5

EPA believes that the WTP estimates to avoid chronic bronchitis are the best available surrogate for WTP estimates to avoid non-fatal cancers. WTP estimates were used in the HRRCA as opposed to COI to value non-fatal cancer cases. EPA believes that COI may understate total WTP because of its failure to account for many effects of disease such as pain and suffering, defensive expenditures, lost leisure time, and any potential altruistic benefits. It is important to note that the proportion of benefits attributable to non-fatal cancer cases accounts for less than one percent of the total benefits in the HRRCA.

(f) Treatment of benefits over time. Many commenters objected to EPA's assumption that cancer risk reduction, and hence benefits, would begin to accrue immediately upon the reduction of radon exposures. In addition, they felt that the failure to discount health benefits resulted in an overestimation of the benefits. One commenter suggested that a ''gradual phase-in'' of risk reduction should be incorporated into the HRRCA benefits calculation. It was also suggested that an alternative to immediate benefits accrual be used, and that the effects of the immediate benefits accrual assumption be discussed in detail with regard to the uncertainties it introduces into the benefits estimates. One commenter identified the assumption of immediate benefits as a major source of benefits overestimation. Another comment asked that EPA provide better justification for assuming immediate benefits accrual, and suggests instead that a linear phase-in of risk reduction over 70 years would be more appropriate. Three commenters also indicate that the failure to take latency of risk reduction into account and to discount benefits appropriately, greatly biases the benefits estimates in the upward direction. One commenter indicated that the failure to discount benefits resulted in a five- to ten-fold over-estimation.

EPA Response 4–6

These comments address the issue of latency, the difference between the time of initial exposure to environmental carcinogens and the onset of any resulting cancer. Qualitative language has been added to the preamble regarding adjustments, including latency, that could be made to benefits calculations. This qualitative discussion notes that latency is one of a number of adjustments related to an evaluation of potential benefits associated with this rule. EPA believes that such adjustments should be considered simultaneously. For further discussion, see section XIII.D of the preamble.

5. Costs of Radon Treatment Measures

(a) Drinking water treatment technologies and costs. All of the commenters had concerns related to EPA's assumptions and analyses of costs of radon treatment measures. In fact, one commenter suggested that the entire section was oversimplified by EPA. Most of the commenters, however, provided more specific comments which are outlined next.

EPA Response 5–1

Most, if not all, commenters assumed that EPA would propose that the risks from radon would be best addressed by drinking water systems attempting to meet the MCL. Under this scenario, many small systems would be in situations where they faced very difficult treatment issues, often with technically difficult and/or expensive solutions. However, EPA is suggesting that the risks from radon are best addressed by the combined use of the AMCL with a multi-media mitigation (MMM) program. Since the proposal also includes a regulatory expectation of adoption of the AMCL by small systems, EPA believes that many of the comments received are less applicable to this proposal than if the MCL were the preferred route of compliance.

(b) Aeration. Several commenters expressed concerns related to aeration costs. One major concern was EPA's failure to address worker safety issues, and the associated cost of occupational safety programs, at treatment plants. A reference to earlier studies of increased risk to neighbors is provided, but details are not included to evaluate these studies. Concern was expressed that costs for permitting and control of radon emissions from treatment plants were not included, and that the public might react strongly to the presence of a local treatment plant even if analysis showed the risk to be minimal. Three commenters noted that the HRRCA failed to consider quantifiable corrosion control costs associated with aeration. Installation of aeration for radon removal may also affect lead/copper levels in the water distribution system, resulting in additional treatment modifications and costs. Many systems will have to develop a different corrosion control strategy to comply with the lead and copper rule due to the radon regulation.

EPA Response 5–2

Worker safety issues for aeration treatment of radon in drinking water are discussed in today's notice (Section

VIII.A.3) and are discussed in more detail in other sources (USEPA 1994b, USEPA 1998h). Radon exposure to workers in drinking water treatment plants has been discussed in the literature (e.g., Fisher et al. 1996, Reichelt 1996). In fact, these discussions usually apply to situations where radon is NOT the contaminant being purposely removed, since there is currently no regulatory driver to do so. When ground water is exposed to air during treatment for any contaminant, radon may be released and may accumulate in the treatment facility. The National Research Council (NAS 1999b) suggests that the air in all groundwater facilities *treating for any contaminant* should be monitored for radon and that ventilation should be investigated as a means of reducing worker exposure. In support of this position, EPA would further strongly suggest that systems that attempt to meet the MCL (i.e., that are in States that do not adopt the AMCL or otherwise choose to meet the MCL) by installing aeration treatment should take the appropriate measures to monitor and ventilate the treatment facilities. For those small systems that choose GAC treatment, other precautions should be taken to monitor and control gamma exposure. GAC treatment issues are discussed later in this notice and are discussed in detail elsewhere (USEPA 1994b, AWWARF 1998 and 1999).

EPA has suggested that occupational exposures be limited to 100 mRem/year, a level well below the upper limit of 5000 mRem/year approved in by the President in 1987 (''Radiation Exposure Guidance to Federal Agencies for Occupational Exposure'', as cited in USEPA 1994b). Based on limited data, it appears that 100 mRem/year is a maintainable objective within water treatment plants treating for radon or other contaminants. Exposure level monitoring and mitigation through a combination of air monitoring and ventilation has been demonstrated to be feasible and relatively inexpensive (e.g., Reichelt 1996).

Regarding the effects on water corrosivity and the impacts of costs of corrosion control measures, this notice presents much more detail on EPA's assumptions. Corrosion control measures are included in national cost estimates and are discussed in this notice. Case study information on corrosion control costs associated with aeration are included in the Radon Technologies and Costs document (USEPA 1999h).

(c) GAC. Two commenters noted that the option for use of granular activated carbon (GAC) did not address potential problems with radioactivity buildup in the carbon. In consideration of treatment methods the two commenters saw no mention of the cost of disposal of GAC used for radon removal. If not replaced in time it will become a low level radioactive waste because of Lead 210 and will become difficult to dispose of. Other issues that need to be addressed include: will the unit require special shielding; may the charcoal bed be required to have a radioactive materials license from the State; and how may radioactive carbon be disposed of?

EPA Response 5–3

Special considerations regarding GAC operations, maintenance, and ultimate GAC unit disposal are discussed in some detail in Section VIII.A of this notice, including discussions of the radiation hazards involved and steps that can be taken to ameliorate these hazards. GAC disposal costs are included in the operations and maintenance costs in the model used for cost estimates. Comparisons of modeled GAC capital and operations & maintenance cost estimates to actual costs reported in case studies are included in Section VIII of this notice. EPA would like to strongly emphasize that carbon bed lifetimes (carbon bed replacement rates) should be designed to preclude situations where disposal becomes prohibitively expensive or technically infeasible.

Recently, the American Water Works Association Research Foundation has published a study on the use of GAC for radon removal, which includes discussions of the issues described previously, that concludes that GAC is a tenable treatment strategy for small systems when used properly under the appropriate circumstances (AWWARF 1998a). AWWARF also reviewed the proper use of GAC for radon removal in its recent review of general radon removal strategies (AWWARF 1998b). When the final radon rule is promulgated, a guidance manual will be published describing technical issues and solutions for small systems installing treatment.

One commenter suggested that the costs for GAC seemed to be too high. The figures used in the analysis could be two orders of magnitude above the costs actually seen by the systems.

EPA Response 5–4

EPA agrees that its GAC cost estimates seem to be very high, as compared to case studies (USEPA 1999h, AWWARF 1998b). EPA agrees with others (e.g., AWWARF 1998a and b) that GAC will probably be cost-effective for very small systems or in a point-of-entry mode. This issue is addressed in the preamble (Section VIII.A) and GAC will be included as a small systems compliance technology.

(d) Regionalization. Two commenters questioned a cost of $280,000 as the single cost for regionalization. Assuming $100/foot for an interconnection, these costs would equate to an interconnection of 2800 feet which seems low. Systems are usually separated by more than one-half mile. A range of costs may need to be considered rather than a single number. Smaller systems will have smaller costs, while large systems will have larger costs. Thus, the charge for regionalization should vary by systems size. Also, EPA should clarify whether or not regionalization charges include yearly operation and maintenance costs.

EPA Response 5–5

EPA agrees that the costs of regionalization would be expected to change with water system size, but, as indicated in the assumptions outlined in the February 26, 1999 HRRCA, EPA assumed that only very small systems (those serving fewer than 500) would resort to regionalization in response to the radon rule. Given that the proposed rule involves a multi-media approach that greatly encourages small systems to choose the AMCL of 4000 pCi/L in conjunction with a multi-media mitigation program, EPA expects that very few systems would choose regionalization as an option. EPA believes that the assumption that 1 out of 100 small systems that choose the MCL option would regionalize is conservative and would only be exercised if regionalization were cost-competitive with other options, except under very unusual circumstances. Since the estimate of $250,000 is much more expensive than any other option modeled for those size categories, this assumption supports the situation where small systems may be expected to entertain this option, i.e., where regionalization does not involve piping water over great distances. This figure is based on a simple estimate using the cost of installed cast iron pipe at $44 per linear foot (an average cost for several pipe relevant pipe diameters) from the 1998 Means Plumbing Cost Data and applying 20 percent for fittings, excavation, and other expenses to arrive at an estimate of $53 per linear foot, or $280,000 per linear mile. Purchased water costs ($/kgal) were assumed to equal the pre-regionalization costs of production ($/kgal), merely as a modeling convenience. In some cases, purchased water costs may be higher, in some cases lower. Although EPA does not have many case studies to support this assumption, it does have information on a Wisconsin case study in which a small water system (serving 375 persons) regionalized to connect to a near-by city water supply in 1995, partly in response to a radium violation. The capital costs for this regionalization case study was $225,000. There were no reported operations costs associated with the purchased water. EPA makes no claims that this case study is typical, but rather that this is the best assumption that it could make based on the available information. Since this is a minor part of the over-all national costs and since a more extensive modeling of the costs of regionalization would necessitate a much more detailed modeling of the additional benefits of regionalization (which were not included), this assumption is maintained in the Regulatory Impact Assessment for this proposed rule.

One commenter also questioned the feasibility of regionalization for many systems. There are very few locations where this is possible and just hooking up to a larger supplier is not practical. Many have systems that are not acceptable to a larger supplier and many larger suppliers won't accept the liability involved in taking over the small system.

EPA Response 5–6

Since most small systems are expected to adopt the AMCL/MMM option, EPA's regionalization assumption (1 percent of the minority of small systems that choose the MCL option) is consistent with this commenter's concern. Nevertheless, administrative regionalization is often feasible, in particular when this does not require new physical connections, and may be an important element of the long term compliance strategy for a number of systems.

(e) Pre-treatment to reduce iron/manganese levels. The majority of the commenters disagreed with EPA's assumptions on the removal of Fe/Mn. It was assumed that essentially all systems with high Fe/Mn levels are likely to already be treating to remove or sequester these metals. Therefore, costs of adding Fe/Mn treatment to radon removal were not included in the February, 1999 HRRCA (64 FR 9560). Commenters suggested that this is a poor cost assumption, in that there are many systems above the secondary MCL for Fe/Mn that do not treat. Of those that sequester, commenters suggested that existing treatment is ineffective once Fe/Mn has been oxidized. Therefore, filtration as well as disinfection would be required for that type of system at a significant additional cost that needs to be considered when reviewing the HRRCA.

If Fe/Mn is present in the source water, removal treatment will be necessary to prevent fouling of the radon removal system. Disposal for the Fe/Mn residuals also presents a special problem with its associated costs. One commenter noted that by not including the costs of Fe/Mn removal, EPA is making a poor assumption and may be underestimating costs.

EPA Response 5–7

EPA recognized that not quantifying the costs associated with the control of dissolved iron and manganese (Fe/Mn) was potentially a poor assumption, and indicated that this assumption would be revisited for the Regulatory Impact Analysis supporting this proposed rule. However, EPA also indicated that national costs and average per system costs would probably not be significantly affected in addressing this issue. While EPA's current modeling results support this conclusion, EPA has included the costs of adding chemical stabilizers (which minimize Fe/Mn precipitation and also provide for corrosion control in some cases) by 25 percent of small systems that treat and 15 percent of large systems that treat. A more detailed discussion on the inclusion of Fe/Mn treatment costs is provided in Section VIII of the preamble.

To further support its position on Fe/Mn control, EPA has also (1) analyzed case studies of systems aerating, which include Fe/Mn control measures for a small minority of the systems, (2) performed an analysis of the co-occurrence of radon with Fe/Mn in ground water, and (3) performed an uncertainty analysis on costs, which includes a simulation of more expensive control measures for Fe/Mn. All of these results are also discussed in Section VIII of the preamble.

(f) Post treatment-disinfection. Many commenters stated that EPA's assumption that the majority of groundwater systems already disinfect is false. Some commenters felt this is inconsistent with the Ground Water Rule estimates. Commenters suggested that analyses supporting the proposed groundwater rule estimate that only 50 percent of CWSs and only 25 percent of NTNCWSs disinfect, while Table 5–2 of the HRRCA suggests that the majority of water systems using groundwater already disinfect and that 20 percent of all water systems serving 3,300 or greater have aeration or disinfection in place.

EPA Response 5–8

The cited analyses supporting the Ground Water Rule (GWR) were conducted using occurrence estimates at the level of individual entry points at water systems. The February 1999 Radon HRRCA was conducted using occurrence estimates at the level of water systems. The GWR and radon analyses use the same data source for estimating their respective disinfection-in-place baselines, the 1997 Community Water System Survey (USEPA 1997a), the only source of information of this type that is based on a survey that was designed to be statistically representative of community water systems at the national level. The GWR used a disinfection-in-place baseline for entry points and the radon HRRCA used a disinfection-in-place baseline for water systems.

The most desirable level of analysis is at the entry point, but the only nationally representative data source for radon, the National Inorganics and Radionuclides Survey, was conducted at the water system level (samples were taken at the tap), which provides no information about radon occurrence at individual entry points within water systems. Radon intrasystem (within system) occurrence variability studies were not available for the analyses supporting the February 1999 radon HRRCA. In the interim between publishing the radon HRRCA and today's proposal, EPA has conducted radon intrasystem variability studies (based on studies other than NIRS) and has used the results of this study to estimate radon occurrence at the entry point level. The current Regulatory Impact Analysis supporting the Radon rule was conducted at the entry point level, consistent with the Ground Water Rule.

EPA Response 5–9

The additional costs to which this commenter is referring, namely the costs of storage for contact time, are included in the costs of the clearwell, which are included in the costs of the aeration process. In the scenarios in which disinfection is assumed, EPA does NOT assume that the systems have a clearwell in place and does include the costs of adding a clearwell for collection of water after aeration and for five minutes of disinfection contact time, which EPA believes to be sufficient for 4-log viral de-activation.

(g) Monitoring costs. One commenter expressed concerns regarding EPA's calculation of monitoring costs. The commenter suggested that EPA grossly underestimated the number of wells per

different water system size in Table 5.4 of the HRRCA (64 FR 9585), page 9585 and in Appendix D of the HRRCA. As a result, monitoring costs need to be recalculated by EPA.

EPA Response 5–10

See EPA Response 1–2 for EPA's approach to determining the number of wells per system.

(h) Choice of treatment responses. As noted previously in Section G, one commenter questioned whether chlorination would always be the disinfection technology of choice, as well as EPA's assumption that existing chlorination practices would not have to be augmented if aeration were installed. Other commenters on cost issues questioned the feasibility and practicability of some technologies on cost grounds.

EPA Response 5–11

EPA assumed that chlorination would be the ''typical'' disinfection technology chosen to model the ''average treatment costs'' (or ''central tendency costs''). There is no way to know beforehand exactly how the universe of water systems will behave in response to a given situation, so EPA believes that the best way to model national compliance costs is to estimate these central tendency costs, then to use statistical tools to capture the fact that ''real world costs'' will spread around the central tendency costs, rather than being equivalent to them. By estimating the central tendency costs and using statistical uncertainty to capture ''real world'' variability (including variability in disinfection costs), EPA believes that this modeling technique allows for the fact that real systems will behave in a variety of ways, including things like choosing different disinfection technologies.

(i) Site and system costs. A number of issues were raised concerning site and system cost estimates. Several commenters suggested that the HRRCA severely underestimated the number of sites per system, citing the difference between the CWSS data and HRRCA assumptions. Several commenters noted that the numbers of sources per system in Table 5–4 of the HRRCA for systems serving 10,001—50,000 were too low. One commenter maintained that the number of sources per system could have a significant impact on national treatment costs.

EPA Response 5–12

EPA agrees that the distribution of the number of sites per system was underestimated and *has revised its estimate to be consistent with the CWSS.* However, it should be noted that while the distribution of the sites per system actually does have an impact on national treatment costs, this impact is significantly mitigated by the fact that the flow per well being treated decreases proportionally as the estimated number of wells per system increases.

(j) Aggregated national costs. Several commenters agreed that the national average costs masked significant impacts on small systems. When small systems are considered, the financial impact is large; in some cases, water bills could double or triple. Providing individual system costs is critical so that utilities can explain to their customers the specific costs and benefits for that specific system.

EPA Response 5–13

EPA estimates household impacts for small systems that install treatment (per household costs) by estimating the costs that small systems would face (per system costs), then spreading these costs over the customer base (population served). As demonstrated in the HRRCA, household costs for small systems are expected to be many times higher for very small systems than for larger systems. In listing small systems compliance technologies for radon, EPA estimated the impacts on small systems by estimating the per system costs and the per household costs and comparing them to affordability criteria, as described in this notice and in the references cited. However, it should also be noted that the vast majority of small systems are expected to comply with the AMCL/MMM option, rather than the MCL option. Under these circumstances, less than 1 percent of small systems would have to take measures to reduce radon levels in their drinking water.

(k) Costs to CWSs. Small systems will bear a significant percentage of the costs for implementing a radon MCL, but will only accrue a small proportion of the benefits. At the 300 pCi/L, the two categories of smallest systems combined would receive 5.6 percent of the benefits at this level, but would pay 42 percent of the total costs. Several commenters indicated that the benefit-cost ratio for small systems was thus highly unfavorable.

EPA Response 5–14

EPA recognizes that small systems experience similar benefits per customer as large systems, but, due to economies of scale (higher treatment costs per gallon treated), experience much higher costs per customer compared to large systems. This, of course, leads to higher costs at the same level of benefits. However, EPA has also recognized that radon is a multi-media problem in which most of the risk is presented from sources other than drinking water and has addressed this fact by designating the AMCL/MMM option as the preferred option for small systems. This will greatly lower the per customer costs faced by small systems and may lead to greater total benefits that accrue to small systems.

(l) Costs to consumers/households. One commenter thought that the household consumption presented in the HRRCA (83,000 gal/year) is too low. This is an understatement because treatment would be required for all water produced, not just water consumed by households.

EPA Response 5–15

EPA does not assume that per system costs are based only on residential water use and so does not miscalculate water *prices* in the way described by the commenter. To determine the price of water, EPA calculates per system costs based on both residential and non-residential consumers (which is the main reason EPA calculates costs for privately-owned and publically-owned separately, i.e., because they have different ratios of residential to non-residential consumption). These per system costs determine the costs per gallon *treated* (not per gallon *consumed*) to determine the water price. The water price may then be used in conjunction with the household consumption to estimate the water bills faced by households, since they do pay by the gallon consumed (and not by the gallon treated).

(m) Application of radon related costs to other rules. Several commenters addressed the need to include the cumulative impact of regulations in the RIA. The incremental costs of the regulations for radon, arsenic, and groundwater systems could substantially change the affordability analysis for small systems. Thus, treatment decisions need to be made with an understanding of all the requirements that must be met so that treatment systems can be designed to meet all requirements. One commenter suggested a multi-rule cost and benefit analysis to capture the true costs incurred by these systems.

EPA Response 5–16

The cumulative effects of rules are captured in EPA's ''affordability criteria'', which are described in the publicly available 1998 EPA document, ''National-Level Affordability Criteria Under the 1996 Amendments to the Safe

Drinking Water Act'' (USEPA 1998e). These small system affordability criteria take into account how much consumers are currently paying for typical water bills. Since the upcoming regulations will affect these amounts, the cumulative effect of the costs of the rules will be explicitly considered in the affordability determinations for small systems as new rules are issued. EPA recognizes that its method of basing affordability determinations on average costs does not address the situation of systems that have significantly above average costs because they must treat for a number of contaminants simultaneously. EPA believes this approach is consistent with the requirements of SDWA for identifying affordable small system technologies and notes that other SDWA mechanisms may be used to address situations where systems incur considerably higher costs.

6. Cost and Benefit Results

The main concern of many of the comments regarding this section suggested that the costs of controlling radon in drinking water far outweighed possible benefits, especially for small systems. Controlling indoor air radon was identified as a better use of regulatory and economic resources by several commenters. Commenters also had concerns regarding how national total costs, benefits, and economic impacts were calculated, and regarding the uncertainties in costs and benefits estimates.

(a) Overview of analytical approach. Many commenters indicated that the cost-benefit analysis was skewed toward overestimating benefits, and/or omitted important cost elements. One concern shared by many of these commenters was that the cost-benefit calculations were biased because mitigation costs, but not health benefits, were discounted. A commenter also indicated that too many assumptions had been used to derive cost and benefit estimates.

EPA Response 6–1

The radon cost benefit analysis was performed according to EPA guidelines, in an attempt to fairly portray both costs and benefits, and not leave out important categories of either costs or benefits.

Annual mitigation costs are compared to annual benefits for the cost benefit comparisons. Annual mitigation costs consist of annualized capital costs plus yearly operating costs. Annualized costs are computed under the assumption that capital expenditure are made up front, with borrowed funds, and the payments are then annualized over a period of twenty years. Changes in the rate of interest used in the annualization process will change the annual cost, just like a mortgage will change with different rates of interest. Adding yearly operating costs for one year to annualized capital costs for one year gives the total annual cost for the year. The issue of discounting of benefits is discussed in Section XIII.D.

In any modeling process, assumptions must be made. To model costs and benefits, assumptions about those costs and benefits must be made. The number of assumptions needed depends on the complexity of the problem addressed, and the time and information available to address it. We would be interested in information that might inform our modeling, particularly addressing improvements that could be made to specific assumptions.

(b) MCL decision-making criteria. A commenter requested that EPA define explicit decision-making criteria for setting MCL levels, to assure that the net benefit to society is positive.

Another commenter indicated that, because drinking water radon accounts for a small portion of total risks, EPA should consider the relative costs and benefits of mitigation on a case-by-case basis at individual systems before making regulatory decisions. A commenter suggested that if the latency of cancer risk reduction and benefits were discounted properly, the national cost-benefit ratios for radon mitigation would be between 5:1 and 9:1. They stated that EPA should not promulgate a rule with net negative benefits, especially in light of the large economic impacts on small systems.

A commenter indicated that the cost-benefit ratios in Table 6–13 of the HRRCA imply that regulation of radon in ground water is not justified. They point out that systems serving 25–3,300 people incur at least 56 percent of the costs and generate at most 21 percent of the total benefits at all MCLs. They say that justifying radon control in drinking water by adding in the benefits of MMM programs is not justified. Another commenter also maintained that the small, localized benefits of controlling radon exposures do not come near to justifying the costs of mitigation.

One commenter said that the decision to set an MCL must take into account the level of uncertainty in cost and benefit estimates. Another commenter suggested that the Agency undertake a quantitative uncertainty analysis of the cost and benefit estimates. Two commenters said that the closeness of the cost and benefit estimates should be considered in setting a regulatory level; if uncertainty is large, a less stringent MCL would be justified.

EPA Response 6–2

EPA has included a detailed discussion on its decision-making criteria for setting the MCL for radon in drinking water in the preamble for the proposed rulemaking (see Section VII.D).

(c) National costs of radon mitigation. Two commenters indicated that the national cost estimates obscured the high costs that would be borne by individual systems. One commenter indicated that radon variability in individual wells increases the uncertainty in the cost estimates. Another commenter said that cost estimates should include the costs of more frequent lead and copper exceedences brought about by increased aeration. Other comments on specific cost elements were summarized in Section 5. One commenter requested that EPA regionally disaggregate cost and benefit estimates because of structural and operational differences among water systems. Another commenter suggested that EPA should conduct a more comprehensive analysis of costs and benefits, including cost elements not currently addressed, such as waste management.

EPA Response 6–3

The national costs include an uncertainty analysis which captures the regional spread in treatment costs. In addition, EPA has estimated total national costs by assuming that most systems will face ''typical costs'', but that some will face ''high side'' and some ''low side'' treatment costs. These ''high side'' and ''low side'' cost differences are largely based on regional considerations, like the costs of land, structure, and permitting.

(d) Incremental costs and benefits. One commenter indicated that the incremental costs and benefits of the various MCL options should be presented in the HRRCA. They question the affordability of radon mitigation for small systems.

EPA Response 6–4

EPA has provided an analysis of the incremental costs and benefits of each MCL option in the HRRCA. See Table 6–7, Estimates of the Annual Incremental Costs and Benefits of Reducing Radon in Drinking Water, in the February 1999 HRRCA.

(e) Costs to community water systems. One commenter said that a more accurate picture of costs and impacts (inclusive of State and local costs) would be needed to make a reasonable

risk management decision. Another commenter suggested that EPA should consider the cumulative costs of all drinking water regulations on drinking water systems.

EPA Response 6–5

See EPA Response 5–14 for EPA's approach to determining the costs to CWSs. Administrative costs to States were not included in the February 1999 HRRCA, but have been added in the RIA for the proposed rule.

(f) Costs and impacts on households. One commenter asked that EPA explain how it determined what was an ''acceptable'' percentage of household income that would go to radon mitigation. Another commenter indicated that household costs should be compared to benefits at the local, rather than national, level, because benefits and costs are realized locally. A commenter indicated the median household incomes for households served by different system sizes are not shown; they also suggested that household costs as a percentage of income were underestimated in Table 6–11 of the HRRCA. One commenter said that expressing household impacts as a proportion of annual income trivializes it and that costs could more meaningfully be compared to other types of household expenses (i.e., food, rent). Several commenters also noted the significant impact the costs could have on customer water bills for small systems.

EPA Response 6–6

See EPA Response 5–15 for EPA's approach to determining the costs to households.

(g) Summary of costs and benefits. Comments from one organization regarding the cost-benefit comparison for radon mitigation were typical of those received from other sources. They cited the NRC/NAS report as indicating that only two percent of population risk came from drinking water and questioned whether the high costs of the rule could justify the small benefits obtained. They said that the cost-benefit comparison did not justify regulating radon in ground water, especially in small systems, where costs were highest and benefits lowest. Another commenter also pointed out that it would be more cost-effective to regulate radon in indoor air than in drinking water and further maintained that spending resources to mitigate radon in water could actually result in reduced public health protection. They point out that the cost-benefit ratios for the smallest systems range from 20:1 to 50:1, and suggest that these ratios, rather than the greater aggregate costs to large systems, should be persuasive in regulatory decision making. Other commenters suggested the high cost-benefit ratios did not justify the regulation of small systems.

EPA Response 6–7

The 1996 Safe Drinking Water Act Amendments require EPA to propose a regulation for radon in drinking water by August 1999. The options for small systems, proposed for public comment in this rulemaking, represents EPA's efforts to address stakeholder comments concerning small systems.

7. Multimedia Mitigation Programs

(a) Multimedia programs. Two commenters indicated that setting the AMCL at 4,000 pCi/L was justifiable. They suggested that EPA should utilize on MMM approach as the primary tool for reducing radon risks, and not use the SDWA to force the States to develop MMM programs.

Several commenters noted that the MCL EPA selects should be justifiable on cost-benefit grounds, with the MMM program serving as a supplemental program to allow States to achieve greater risk reduction at less cost. Another commenter suggested the multimedia approach allowed under the 1996 amendments to the SDWA should not be used with regard to radon–222 in water.

EPA Response 7–1

The requirement for implementation of an EPA-approved MMM program in conjunction with State adoption of the AMCL is consistent with the statutory framework outlined by Congress in the SDWA provision on radon. As proposed, States may choose either to adopt the MCL or the AMCL and an MMM program. EPA recommends that small systems comply with an AMCL of 4,000 pCi/L and implement a MMM program. See section VII.D for background on the selection of the MCL and AMCL.

Two commenters believe the radon regulation may result in litigation against water utilities, local, and State governments if systems comply with the AMCL rather than the MCL. As a result, some water utilities could choose to comply with the more stringent MCL rather than face potential litigation for meeting a ''less stringent standard,'' regardless of the increased public health protection. According to one commenter, problems will arise when both the AMCL and the MCL are required to appear on the annual Consumer Confidence Report. The public will view the AMCL as an attempt by the water industry to get around the MCL. This will leave the water utility vulnerable to toxic tort lawsuits. Because of these problems, the concept of an MMM program/AMCL is not as attractive as it once appeared.

EPA Response 7–2

EPA is aware of this concern and the risk communication challenges of two regulatory limits for radon in drinking water. However, the SDWA framework requires EPA to set an alternative maximum contaminant limit for radon if the proposed MCL is more stringent than the level of radon in outdoor air. It is important to recognize that in State primacy applications for oversight and enforcement of the drinking water program, States choosing the MMM approach will be adopting 4,000 pCi/L as their MCL. In addition, as part of the proposed rule, EPA will be amending the Consumer Confidence Reporting Rule to reflect the proposed regulation for radon. Under § 141.153 of the proposed radon rule, a system operating under an approved multimedia mitigation program and subject to an Alternative MCL (AMCL) for radon must report the AMCL instead of the MCL whenever reporting on the MCL is required.

Another commenter questioned the need for regulating radon in water below 3,000 pCi/L, and maintained that there is no conceivable reason to regulate it at 100 pCi/L, with or without an MMM program.

EPA Response 7–3

See EPA Response 6–2 for EPA's decision criteria for setting an MCL.

(b) Implementation scenarios evaluated. One commenter feels that a ''desk top review'' of States likely to adopt an MMM program would give more useful estimates of MMM acceptance than the HRRCA assumptions of zero, 50 percent, and 100 percent adoption of MMM programs. This commenter felt that for an MMM program to be productive, two things are necessary: (1) relatively high radon concentration in water and (2) relatively high radon in indoor air.

EPA Response 7–4

For the purposes of the HRRCA, EPA made these assumptions as a straight forward approach for assessing overall cost implications of MMM. States are not required to make their determinations on whether to adopt the MMM approach until after the rule is final in August 2000. Therefore, EPA did not have this information available when developing the HRRCA, nor does EPA have this information at this time. However, discussions with many State drinking water and radon program staff suggest that many States are seriously considering the MMM approach.

EPA expects that MMM programs will be able to achieve indoor radon risk reduction even in areas of low radon potential. It is important to keep in mind that the only way to know if a house has elevated indoor radon levels is to test it. Many homes in low radon potential areas have been found with levels well above EPA's action level of 4 pCi/L, often next door to houses with very low levels. EPA estimates that about 6 million homes in the U.S. of the 83 million homes that should test are at or above 4 pCi/L. To date only about 11 million homes have been tested. In addition, EPA is not requiring State MMM program plans to precisely quantify equivalency in risk reduction between radon in drinking water and radon in indoor air.

(c) Multimedia mitigation cost and benefit assumptions. Two commenters indicated that, even if it is not known how the MMM programs will be funded, the costs of administering such programs should be included in the HRRCA. Several commenters expressed concerns regarding the estimated cost of $700,000 per fatal cancer averted. One commenter felt that using this value is far too optimistic, indicating that the cost of radon risk reduction under State-mandated MMM programs will significantly exceed present costs under the voluntary system. To get the greatest risk reductions at the lowest costs, MMM program should focus on the houses with the highest radon concentrations. Another commenter recommended that EPA develop an MMM program that is better than the existing voluntary programs and further reduces the cost per fatal cancer avoided. The commenter also requested that EPA supply background information supporting use of this single MMM program cost estimate.

EPA Response 7–5

EPA is required under the UMRA to assess the costs to States of implementing and administering both the MCL and the MMM/AMCL. EPA has addressed these costs in the preamble of the rule.

EPA believes that the criteria for EPA approval of State MMM program plans will augment and build on existing State indoor radon programs and will result in an increased level of risk reduction.

As part of developing the 1992 ''A Citizen's Guide to Radon,'' EPA analyzed the risk reductions and costs of various radon testing and mitigation options (USEPA 1992b). Based on these analyses, a point estimate of the average cost per life saved of the current national voluntary radon program was used as the basis for the cost estimate of risk reduction for the MMM option. EPA had previously estimated that the average cost per fatal lung cancer avoided from testing all existing homes in the U.S. and mitigation of all those homes at or above EPA's voluntary action level of 4 pCi./L is approximately $700,000. This value was originally estimated by EPA in 1991. Since that time there has been an equivalent offset between a decrease in testing and mitigation costs since 1992 and the expected increase due to inflation in the years 1992–1997.

One commenter stated that experiences in Massachusetts showed that the costs of incorporating passive radon resistant construction techniques is about the same as current prices for marginal quality (active) radon mitigation in existing buildings, and disputed the HRRCA statement that passive techniques are much less expensive. The commenter supported the NAS findings that the effectiveness of these techniques in normal construction practice is uncertain.

EPA Response 7–6

Builders have reported costs as low as $100 to install radon resistant new construction features which is significantly less than the $350—$500 that was derived in EPA's cost-effectiveness analysis of the radon model standards. The cost of materials alone for the passive system will always be less than the cost for an active system which includes the cost of a fan. In many areas, the majority of the features for radon-resistant new construction are already required by code or are common building practice, such as an aggregate layer, ''poly'' sheeting, and sealing and other weatherization techniques. The only additional cost is associated with the vent stack consisting of PVC pipe and fittings. In those areas where gravel is not commonly used, builders can use a drain tile loop or other alternative less costly than gravel to facilitate communication under the slab. EPA estimates that the cost to mitigate an existing home ranges from $800 to $2,500 with an average cost of $1,200.

(d) Annual costs and benefits of MMM program implementation. Several concerns were raised regarding the costs and benefits associated with MMM program implementation. One commenter suggested that the MMM program description in the HRRCA provides essentially no guidance on the point from which additional risk reduction due to MMM will be measured.

EPA Response 7–7

The HRRCA was not intended to include a discussion and description of the criteria for EPA approval of State MMM programs. Rather, proposed criteria are presented in this proposed rule. EPA's proposed criteria do not entail a determination by the State of the level of indoor radon risk reduction that has already occurred (''baseline'') as the basis for determining how much more risk reduction needs to take place. Rather States, with public participation, are required to set goals that reflect State and local needs and concerns.

Another commenter states that EPA has underestimated the benefits of an MMM program. The HRRCA registers only the benefits gained in relation to water being treated to the MCL. However, according to EPA's figures, MMM benefits are expected to be much higher than those achieved by mitigating water alone.

EPA Response 7–8

EPA anticipates that MMM programs will result in sufficient risk reduction to achieve ''equal or greater'' risk reduction. A complete discussion on why MMM is expected to achieve equal or greater risk reduction is shown in Section VI.B of today's preamble. For the purposes of the HRRCA analyses, EPA made the conservative assumption that the level of risk reduction would at least be ''equal'' to that achieved by universal compliance with the MCL.

8. Other Key Comments

(a) Omission of non-transient non-community water systems (NTNCWSs). Eleven commenters criticized EPA's failure to include NTNCWSs in the HRRCA. Three commenters indicate that failure to include NTNCWSs grossly underestimates costs of radon mitigation. Another commenter also suggests that NTNCWSs should be included in the HRRCA, to provide a better picture of both costs and benefits. Two commenters would also like NTNCWSs included because impacts on these systems are likely to be high. Other commenters maintain that excluding NTNCWSs skews benefit-cost analyses in favor of regulation. Another commenter indicates that NTNCWSs, because of the type of wells and aquifers that they draw from, will be most affected by a radon rule.

EPA Response 8–1

Partly as a result of concerns raised by commenters, and partly as a result of its own preliminary analysis of exposure and risk, EPA is not proposing that NTNCWSs be covered by this rule. A more complete discussion of this issue is included in the preamble for the proposed rule. EPA has conducted a preliminary analysis on exposure and risks to NTNCWSs and is asking for public comment on this preliminary analysis and on the proposed exclusion of NTNCWSs. An analysis of the potential benefits and costs of radon in drinking water for NTNCWSs is included in the docket for this proposed rulemaking. (USEPA 1999m)

XIV. Administrative Requirements

A. Executive Order 12866: Regulatory Planning and Review

Under Executive Order 12866, ''Regulatory Planning and Review'' (58 FR 51,735 (October 4, 1993)), the Agency must determine whether the regulatory action is ''significant'' and therefore subject to OMB review and the requirements of the Executive Order. The Order defines ''significant regulatory action'' as one that is likely to result in a rule that may:

(1) have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or tribal governments or communities;

(2) create a serious inconsistency or otherwise interfere with an action taken or planned by another agency;

(3) materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or

(4) raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order.

Pursuant to the terms of E.O. 12866, it has been determined that this rule is a ''significant regulatory action''. As such, this action was submitted to OMB for review. Changes made in the proposal in response to OMB suggestions or recommendations will be documented in the public record.

B. Regulatory Flexibility Act (RFA)

1. Today's Proposed Rule

Under the Regulatory Flexibility Act (RFA), 5 U.S.C. 601 *et seq.*, as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA), EPA generally is required to conduct a regulatory flexibility analysis describing the impact of the regulatory action on small entities as part of rulemaking. Today's proposed rule may have significant economic impact on a substantial number of small entities and EPA has prepared an Initial Regulatory Flexibility Analysis (IRFA). In addition, when preparing an IRFA, EPA must convene a Small Business Advocacy Review (SBAR) Panel. A discussion of the Panel's recommendations and EPA's response to their recommendations is shown in Section 6.

2. Use of Alternative Small Entity Definition

The EPA is proposing that small CWS serving 10,000 people or less must comply with the AMCL, and implement a MMM program (if there is no state MMM program). This is the cut-off level specified by Congress in the 1996 amendments to the Safe Drinking Water Act for small system flexibility provisions. Because this definition does not correspond to the definitions of ''small'' for small businesses, governments, and non-profit organizations previously established under the RFA, EPA requested comment on an alternative definition of ''small entity'' in the Preamble to the proposed Consumer Confidence Report (CCR) regulation (63 FR 7620, February 13, 1998). Comments showed that stakeholders support the proposed alternative definition. EPA also consulted with the SBA Office of Advocacy on the definition as it relates to small business analysis. In the preamble to the final CCR regulation (63 FR 4511, August 19, 1998), EPA stated its intent to establish this alternative definition for regulatory flexibility assessments under the RFA for all drinking water regulations and has thus used it for this radon in drinking water rulemaking. Further information supporting this certification is available in the public docket for this rule.

3. Background and Analysis

The RFA requires EPA to address the following when completing an IRFA: (1) describe the reasons why action by the Agency is being considered; (2) state succinctly the objectives of, and legal basis for, the proposed rule; (3) describe, and where feasible, estimate the number of small entities to which the proposed rule will apply; (4) describe the projected reporting, record keeping, and other compliance requirements of the rule, including an estimate of the classes of small entities that will be subject to the requirements and the type of professional skills necessary for preparation of reports or records; (5) identify, to the extent practicable, all relevant Federal rules that may duplicate, overlap, or conflict with the proposed rule; and (6) describe any significant alternatives to the proposed rule that accomplish the stated objectives of applicable statutes while minimizing any significant economic impact of the proposed rule on small entities. EPA has considered and addressed all of the previously described requirements. The following is a summary of the IRFA.

The first and second requirements are discussed in Section II of this Preamble. The third, fourth, and sixth requirements are summarized as follows. The fifth requirement is discussed under Section VIII.A.2 of this Preamble in a subsection addressing potential interactions between the radon rule and upcoming and existing rules affecting ground water systems.

4. Number of Small Entities Affected

EPA estimates that 40,863 ground water systems are potentially affected by the proposed radon rule, with 96 percent of these systems serving less than 10,000 persons. Of the 39,420 small systems potentially affected, EPA estimates that 1,761 (4.4 percent) small systems will have to modify treatment (install treatment technology) to comply with the AMCL. The proposed rule recommends that small systems meet the 4,000 pCi/L AMCL and implement a multimedia mitigation (MMM) program if their State does not implement a MMM program. Small systems may also choose to comply with the MCL rather than implement an MMM program. As Table XIV.1 indicates, water mitigation administration costs for small systems remain the same under any State MMM program adoption scenario. However, small systems located in States that do not implement a MMM program must develop and implement their own MMM program for the population they serve (unless they choose to comply with the MCL), thus increasing their costs. Additional MMM implementation scenarios have been analyzed in the RIA (USEPA 1999f) which is included in the docket for this proposed rulemaking.

TABLE XIV.1.—ANNUAL WATER MITIGATION AND MMM PROGRAM COSTS TO SMALL SYSTEMS
[$Millions, 1997]

Cost description	100% of states adopt MMM	50% of states adopt MMM
Water Mitigation Costs[1]		
Total Capital Costs	118.5	194.1
Total Annual Costs[2]	31.3	43.2
Water Mitigation Administration Costs	5.8	5.8
Multimedia Mitigation Program Costs[3]	0	43.3
Total Small System Costs per Year	37.1	92.4

Notes:
[1] Costs to small systems to mitigate water to the AMCL of 4,000 pCi/L.
[2] Includes annual capital costs, monitoring costs, and operation and maintenance costs.
[3] Does not include the costs of testing and mitigating homes.

5. Proposed Rule Reporting Requirements for Small Systems

The proposed radon rule requires small systems to maintain records and to report radon concentration levels at point-of-entry to the water system's distribution system. Small systems are also required to provide radon information in the Consumer Confidence Report, and if the system is implementing its own MMM program, reports on progress to the goals outlined in the system's MMM program plan. Radon monitoring and reporting for water mitigation will be required on a quarterly basis for at least one year, but thereafter the frequency may be reduced to annually or once every three years depending on the level of radon present (see Section VIII.E). Other existing information and reporting requirements, such as Consumer Confidence Reports and (proposed) public notification requirements, will be marginally expanded to encompass radon along with other contaminants (see Section X). As is the case for other contaminants, required information on system radon levels must be provided by affected systems and is not considered to be confidential. The professional skills necessary for preparing the reports are the same skill level required by small systems for current reporting and monitoring requirements.

The classes of small entities that are subject to the proposed radon rule include public groundwater systems serving less than 10,000 people. Small systems are further classified into very very small systems (serving 25–500 persons), very small systems (serving 501–3,300 persons, and small systems (serving 3,301–10,000 persons).

6. Significant Regulatory Alternatives and SBAR Panel Recommendations

In response to the SBAR Panel's recommendations and other small entity concerns, EPA has included several requirements to help reduce the impacts of the proposed radon rule on small entities. These requirements include: (1) Recommendation of small system compliance with the MMM/AMCL option; (2) less routine monitoring; (3) State granting of waivers to ground water systems to reduce monitoring frequency; and (4) encouraging and providing information about the use of low maintenance treatment technologies. A more complete discussion of the SBAR Panel recommendations and EPA's responses follow here. EPA also believes small systems can in some cases reduce their economic burden by a variety of means, including using the State revolving fund loans to offset compliance costs. In the development of this proposed rulemaking, EPA considered several regulatory alternatives to the proposed requirements for small systems. The proposal includes the regulatory expectation that they comply with the AMCL of 4,000 pCi/L and be associated with either a state or local MM program. EPA believes that this option will provide equivalent or greater health protection while reducing economic burdens to small systems. For a more detailed description of the alternatives considered in the development of the proposed rule see the RIA (USEPA 1999f) or the discussion of regulatory alternatives in Section XIV.C (Unfunded Mandates Reform Act).

In addition to being summarized here, the public docket for this proposed rulemaking includes the SBAR Panel's report on the proposed radon regulation, which outlines background information on the proposed radon rule and the types of small entities that may be subject to the proposed rule; a summary of EPA's outreach activities; and the comments and recommendations of the small entity representatives (SERs) and the Panel.

(a) *Consultations.* Consistent with the requirements of the RFA as amended by SBREFA, EPA has conducted outreach directly to representatives of small entities that may be affected by the proposed rule. Anticipating the need to convene a SBAR Panel under Section 609 of the RFA/SBREFA, in consultation with the Small Business Administration (SBA), EPA identified 23 representatives of small entities that were most likely to be subject to the proposal. In April, 1998, EPA prepared an outreach document on the radon rule titled ''Information for Small Entity Representatives Regarding the Radon in Drinking Water Rule'' (USEPA 1998b). EPA distributed this document to the small entity representatives (SERs), as well as stakeholder meeting discussion documents and the executive summary of the February 1994 document ''Report to the United States Congress on Radon in Drinking Water: Multimedia Risk and Cost Assessment of Radon'' (EPA 1994a).

On May 11, 1998, EPA held a small entity conference call from Washington DC to provide a forum for small entity input on key issues related to the planned proposal of the radon in drinking water rule. These issues included: (1) Issues related to the rule development, such as radon health risks, occurrence of radon in drinking water, treatment technologies, analytical methods, and monitoring; and (2) issues related to the development and implementation of the multimedia mitigation program guidelines. Thirty people participated in the conference call, including 13 SERs from small water systems from Arizona, California, Nebraska, New Hampshire, Utah, Washington, Alabama, Michigan, Wyoming, and New Jersey.

Efforts to identify and incorporate small entity concerns into this rulemaking culminated with the convening of a SBAR Panel on July 9, 1998, pursuant to Section 609 of RFA/SBREFA. The four person Panel was headed by EPA's Small Business Advocacy Chairperson and included the Director of the Standards and Risk Management Division within EPA's

Office of Ground Water and Drinking Water, the Administrator of the Office of Information and Regulatory Affairs with the Office of Management and Budget, and the Chief Counsel for Advocacy of the SBA. For a 60-day period starting on the convening date, the Panel reviewed technical background information related to this rulemaking, reviewed comments provided by the SERs, and met on several occasions. The Panel also conducted its own outreach to the SERs and held a conference call on August 10, 1998 with the SERs to identify issues and explore alternative approaches for accomplishing environmental protection goals while minimizing impacts to small entities. Details of the Panel process, along with summaries of the conference calls with the SERs and the Panel's findings and recommendations, are presented in the September 1998 document ''Final Report of the SBREFA Small Business Advocacy Review Panel on EPA's Planned Proposed Rule for National Primary Drinking Regulation: Radon'' (USEPA 1998c).

(b) Recommendations and Actions.— Today's notice incorporates all of the recommendations on which the Panel reached consensus. In particular, the Panel made a number of recommendations regarding the MMM program guidelines, including that the guidelines be user-friendly and flexible and provide a viable and realistic alternative to meeting the MCL, for both States and CWSs. The Panel also agreed that provision of information to the public and equity are important considerations in the design of an MMM program.

In response to the Panel's recommendations and concerns heard from other stakeholders, EPA has developed specific criteria that MMM programs must meet to be approved by EPA. EPA believes these criteria are simple and straightforward and provide the flexibility States and public water systems need to develop programs to meet their different needs and concerns. The criteria permit States, with public participation and input, to determine their own prospective indoor radon risk reduction goals and to design the program strategies they determine are needed to achieve these goals. The criteria build on the existing framework of State indoor radon programs that are already working to get indoor radon risk reduction. EPA also believes that equity issues can be most effectively discussed and resolved with the public's participation and involvement in development of goals and strategies for an MMM program. Providing customers of public water systems with information about the health risks of radon and on the AMCL and MMM program option will help to promote understanding of the significant public health risks from radon in indoor air and help the public to make informed choices. Section VI of this Preamble discusses the MMM program in greater detail.

Following is a summary of the other Panel recommendations and EPA's response to these recommendations, by subject area:

Occurrence: The Panel recommended that EPA continue to refine its estimates of the number of affected wells. The occurrence section of the preamble contains an expanded description in regard to how EPA refined the estimates of the number of affected water supply wells (See Section XI.C ''EPA's Most Recent Studies of Radon Levels in Ground Water'').

Water Treatment: The Panel recommended the following: provide clear guidance for when granular activated carbon (GAC) treatment may be appropriate as a central or point-of-entry unit treatment technology; consider and include in its regulatory cost estimates, to the extent possible, the complete burden and benefits; and carefully consider effects of radon-off-gassing from aeration towers and potential permitting requirements in developing regulations or guidance related to aeration.

In response to these recommendations, the treatment section of the preamble contains an expanded description regarding conditions under which granular activated carbon (GAC) treatment may be appropriate as a central or point-of-entry unit treatment technology (See Section VIII.A.3 ''Centralized GAC and Point-of-entry GAC''); the RIA and the treatment sections of the preamble describe the components which contribute to the regulatory economic analysis (See Section VIII.A.2 ''Treatment Costs: BAT, Small Systems Compliance Technologies, and Other Treatment''); high-end treatment cost estimates have been revised to include scenarios where air-permitting costs are much higher than typical cases (see Sections VIII.A.2 ''Treatment Cost Assumptions and Methodology'' and ''Comparison of Modeled Costs with Real Costs from Case Studies''); and information and rationale has been added to support EPA's belief that permitting requirements from off-gassing from aeration towers will not preclude installation of aeration treatment (see Section VIII.A.3 ''Evaluation of Radon Off-Gas Emissions Risks'').

In addition, the Panel recommended that EPA fully consider the relationship of the Radon in Drinking Water Rule with other rules affecting the same small entities. In response, the treatment section of the preamble, the Treatment and Cost Document, and the RIA have been expanded to discuss the relationship of treatment for radon with other drinking water rules including the Ground Water Rule, Lead and Copper Rule, and the Disinfection By-Products Rules (see Section VIII.A.2 ''Potential Interactions Between the Radon Rule and Upcoming and Existing Rules Affecting Ground Water Systems'').

Analytical Methods and Monitoring: The Panel recommended the following: fully consider the availability and capacity of certified laboratories for radon analysis and consider the costs of monitoring; consider applying the VOCs sampling method to radon to reduce the need for additional training; reduce the frequency of monitoring after initial determination of compliance and consider providing waivers from monitoring requirements when a system is not at risk of exceeding the MCL; and develop monitoring requirements that are simple and easy to interpret to facilitate compliance by small systems.

In response, the analytical methods section of the preamble includes discussion of the availability and capacity of certified laboratories for radon analysis (see Section VIII.C ''Laboratory Capacity—Practical Availability of the Methods''); and a clarification that the radon sampling method is the same as for the volatile organic carbons sampling method (see Section VIII.B.2 ''Sampling Collection, Handling and Preservation''). The RIA and the preamble include more detailed discussion of regulatory costs estimates including the monitoring costs estimated (see Section VIII.B.2 ''Cost of Performing Analysis''). The monitoring section proposed rule provides for a reduced monitoring frequency to once every three years if the average of four quarterly samples is less than 1/2 MCL/AMCL, provided that no sample exceeds the MCL/AMCL (see Section VIII.E.4 ''Increased/decreased monitoring requirements'' and Section 141.28(b) of the proposed rule). Section VIII.E.5 ''Grandfathering of Data'' and Section 141.28(b) of the proposed rule describes the allowance of grandfathered data, i.e., data collected after proposal of the rule, that meet specified requirements. Section VIII.E.4 ''Increased/decreased monitoring requirements'' of this Preamble discusses the allowance for States to grant waivers to ground water systems to reduce the frequency of monitoring, i.e., up to a 9 year frequency. Section VIII.E, Table VIII.E.1 of this Preamble also describes monitoring requirements to facilitate interpretation of the requirements.

General: The Panel recommended that EPA explore options for providing technical assistance to small entities to clearly communicate the risks from radon in drinking water and indoor air, the rationale supporting the regulation, and actions consumers can take to reduce their risks. Therefore, this Preamble has been written to clarify to the public the risks from radon in drinking water and radon in indoor air, and the rationale supporting the proposed regulation (see Sections I through V of this Preamble).

Areas in which Panel did not reach consensus: There were also a number of issues discussed by the Panel on which consensus was not reached. These included the appropriateness of the Agency's affordability criteria for determining if affordable small system compliance technologies are available, the appropriate level at which to set the MCL, whether EPA should provide a ''model'' MMM program for use by small systems in states that do not adopt state-wide MMM programs, and whether information on the risks of radon and options for reducing it provides ''health risk reduction benefits'' (as referenced in the SDWA) independent of whether homes are actually mitigated or built radon resistant. A detailed discussion of these issues is included in the Panel report. EPA is requesting comment on some of these issues in other parts of the preamble. To read the full discussion of the issues on which EPA is requesting comment, see Sections VII.A ''Requirements for Small Systems Serving 10,000 People or Less'', VII.D ''Background on Selection of MCL and AMCL'', and VI.F ''Local CWS MMM Programs in Non-MMM States and State Role in Approval of CWS MMM Program Plans.''

C. Unfunded Mandates Reform Act (UMRA)

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA), P.L. 104–4, establishes requirements for Federal agencies to assess the effects of their regulatory actions on State, local, and tribal governments and the private sector. Under UMRA Section 202, EPA generally must prepare a written statement, including a cost-benefit analysis, for proposed and final rules with ''Federal mandates'' that may result in expenditures to State, local, and tribal governments, in the aggregate, or to the private sector, of $100 million or more in any one year. Before promulgating an EPA rule, for which a written statement is needed, Section 205 of the UMRA generally requires EPA to identify and consider a reasonable number of regulatory alternatives and adopt the least costly, most cost-effective or least burdensome alternative that achieves the objectives of the rule. The provisions of Section 205 do not apply when they are inconsistent with applicable law. Moreover, Section 205 allows EPA to adopt an alternative other than the least costly, most cost-effective or least burdensome alternative if the Administrator publishes with the final rule an explanation on why that alternative was not adopted.

Before EPA establishes any regulatory requirements that may significantly or uniquely affect small governments, including tribal governments, it must have developed, under Section 203 of the UMRA, a small government agency plan. The plan must provide for notification to potentially affected small governments, enabling officials of affected small governments to have meaningful and timely input in the development of EPA regulatory proposals with significant Federal intergovernmental mandates and informing, educating, and advising small governments on compliance with the regulatory requirements.

1. Summary of UMRA Requirements

EPA has determined that this rule contains a Federal mandate that may result in expenditures of $100 million or more for State, local, and tribal governments, in the aggregate, or the private sector in any one year. Accordingly, EPA has prepared, under Section 202 of the UMRA, a written statement addressing the following areas: (1) Authorizing legislation; (2) cost-benefit analysis including an analysis of the extent to which the costs to State, local, and tribal governments will be paid for by the Federal government; (3) estimates of future compliance costs; (4) macro-economic effects; and (5) a summary of EPA's consultation with State, local, and tribal governments, a summary of their concerns, and a summary of EPA's evaluation of their concerns. A summary of this analysis follows and a more detailed description is presented in EPA's Regulatory Impact Analysis (RIA) of the Radon Rule (USEPA 1999f) which is included in the docket for this proposed rulemaking.

(a) Authorizing legislation. Today's proposed rule is proposed pursuant to Section 1412(b)(13) of the 1996 amendments to the SDWA which requires EPA to propose and promulgate a national primary drinking water regulation for radon, establishes a statutory deadline of August 1999 to propose this rule, and establishes a statutory deadline of August 2000 to promulgate this rule.

(b) Cost-benefit analysis. Section XIII.B of this preamble, describing the Regulatory Impact Analysis (RIA) and Revised Health Risk Reduction and Cost Analysis (HRRCA) for radon, contains a detailed cost-benefit analysis in support of the radon rule. Today's proposed rule is expected to have a total annualized cost of approximately $121 million with a range of potential impacts from $60.4 to $407.6 million, depending on how many States and local PWSs adopt MMM programs and comply with the AMCL. This total annualized cost consists of total annual impacts on State, local, and tribal governments, in aggregate, of approximately $53.5 million and total annual impacts on private entities of approximately $67.6 million (Note: these estimates are based on Scenario A which assumes 50 percent of States implement MMM programs with the remaining 50 percent of States implementing system-level MMM programs or complying with the MCL. Under Scenario E, total costs are approximately $60.4 million. Total national costs of full compliance with an MCL are approximately $407.6 million. Detailed descriptions of the national costs and MMM scenarios are shown in Section XIII of this preamble and Sections 9 and 10 of the RIA (USEPA 1999f).

The RIA includes both qualitative and monetized benefits for improvements in health and safety. EPA estimates the proposed radon rule will have annual monetized benefits of approximately $17.0 million if the MCL were to be set at 4,000 pCi/L and $362 million if set at 300 pCi/L. The monetized health benefits of reducing radon exposures in drinking water are attributable to the reduced incidence of fatal and non-fatal cancers, primarily of the lung and stomach. Under baseline assumptions (no control of radon exposure), 168 fatal cancers and 9.7 non-fatal cancers per year are associated with radon exposures through CWSs. At a radon level of 4,000 pCi/L, an estimated 2.9 fatal cancers and 0.2 non-fatal cancers per year are prevented. At a level 300 pCi/L, 62.0 fatal and 3.6 non-fatal cancers per year are prevented. The Agency believes that compliance with an AMCL of 4,000 pCi/L and implementation of a MMM program would result in health benefits equal to or greater than those achieved by complying with the proposed MCL (300 pCi/L).

In addition to quantifiable benefits, EPA has identified several potential non-quantifiable benefits associated with reducing radon exposures in drinking water. These potential benefits are difficult to quantify because of the uncertainty surrounding their estimation. Non-quantifiable benefits may include any peace-of-mind benefits specific to reduction of radon risks that may not be adequately captured in the Value of Statistical Life (VSL) estimate. In addition, if chlorination is added to the process of treating radon via aeration, arsenic pre-oxidization will be facilitated. Neither chlorination nor aeration will remove arsenic, but chlorination will facilitate conversion of Arsenic (III) to Arsenic (V). Arsenic (V) is a less soluble form that can be better removed by arsenic removal technologies. In terms of reducing radon exposures in indoor air, provision of information to households on the risks of radon in indoor air and the availability of options to reduce exposure may be a non-quantifiable benefit that can be attributed to some components of a MMM program. Providing such information might allow households to make more informed choices about the need for risk reduction given their specific circumstances and concerns than they would have in the absence of a MMM program.

(i) State and Local Administrative Costs. States will incur a range of administrative costs with the MCL and MMM/AMCL options in complying with the radon rule. Administrative costs associated with water mitigation can include costs associated with program management, inspections, and enforcement activities. EPA estimates the total annual costs of administrative activities for compliance with the MCL to be approximately $2.5 million.

Additional administrative costs will be incurred by those States who comply with the AMCL and develop an MMM program plan. In this case, States will need to satisfy the four criteria for an acceptable MMM program which include: (1) Involve the public in developing the MMM program plan; (2) set quantitative State-wide goals for reducing radon levels in indoor air; (3) submit and implement plans on existing and new homes; and (4) develop and implement plans for tracking and reporting results. The administrative costs will consist of the various activities necessary to satisfy these four criteria. Because EPA is unable to specify the number of States that will implement an MMM program, administrative costs were estimated under two assumptions: (1) 50 percent of States (all water systems in those States) implement an MMM program; and (2) 100 percent of States implement an MMM program, since we expect that most States will choose this option.

If a State does not develop an MMM program plan, any local water system may chose to meet the AMCL and prepare an MMM program plan for State approval. Administrative costs to the State would consist primarily of reviewing local program plans and overseeing compliance. However, local water systems would bear administrative costs that resemble the State costs to administer an MMM program. To estimate costs for local water systems in these States, EPA assumed that all local systems that exceeded 300 pCi/L but were less than 4,000 pCi/L would choose to administer an MMM program rather than achieve the 300 pCi/L level through water mitigation. It is assumed that, on average, water mitigation costs will exceed MMM program administrative costs for local water systems.

EPA estimates that total annual costs of approximately $13.2 million are expected if half the States elect to administer an MMM program and all local water systems in the remaining States undertake MMM programs. In this case, costs to 50 percent of the States to administer the MMM program ($2.9 million), and costs to 50 percent of the States to approve MMM programs developed by local water systems ($7.8 million) are added to water mitigation costs ($2.5 million). In this latter case there would also be costs to local water systems of $45 million to develop and implement local MMM programs. This is the total cost per year across all system sizes to develop and implement system-level MMM programs and assumes approximately 45 percent of CWSs will do a system-level MMM plan. The total costs across all system sizes under Scenario E for system-level MMM programs is approximately $5 million.

Various Federal financial assistance programs exist to help State, local, and tribal governments comply with this rule. To fund development and implementation of a MMM program, States have the option of using Public Water Systems Supervision (PWSS) Program Assistance Grant funds [SDWA Section 1443(a)(1)] and Program Management Set-Aside funds from the Drinking Water State Revolving Fund (DWSRF) program. Infrastructure funding to provide the equipment needed to ensure compliance is available from the DWSRF program and may be available from other Federal agencies, including the Housing and Urban Development's Community Development Block Grant Program or the Department of Agriculture's Rural Utilities Service.

EPA provides funding to States that have a primary enforcement responsibility for their drinking water programs through the PWSS grants program. States may use PWSS grant funds to establish and administer new requirements under their primacy programs, including MMM programs. PWSS grant funds may be used by a State to set-up and administer a State MMM program.

States may also ''contract'' to other State agencies to assist in the development or implementation of their primacy program, including an MMM program for radon. However, States may not use grant funds to contract to regulated entities (i.e., water systems) for MMM program implementation.

An additional source of EPA funding to develop and implement a MMM program is through the DWSRF program. The program awards capitalization grants to States, which in turn use funds to provide low cost loans and other types of assistance to eligible public water systems to assist in financing the costs of infrastructure needed to achieve or maintain compliance with SDWA requirements. The DWSRF program also allows a State to set aside a portion of its capitalization grant to support other activities that result in protection of public health and compliance with the SDWA. The State Program Management set-aside (SDWA Section 1452(g)(2)) allows a State to reserve up to ten percent of its DWSRF allotment to assist in implementation of the drinking water program. States must match expenditures under this set-aside dollar for dollar. DWSRF State Program Management set-aside funds can be used to fund activities to develop and run an MMM program, similar to those eligible for funding from PWSS grant funds.

States may also use State Indoor Radon Grant (SIRG) funds to assist States in funding their MMM programs. The Agency has determined that activities that implement MMM activities and that meet current SIRG eligibility requirements can be carried out with SIRG funds because the goals of the MMM program reinforce and enhance the goals, strategies, and priorities of the existing State indoor radon programs that rely on funding through the SIRG program. However, expenditure of SIRG will not be permitted to fund strictly water-related activities, such as testing or monitoring of water by CWSs.

(c) Estimates of future compliance costs. To meet the requirement in Section 202 of the UMRA, EPA analyzed future compliance costs and possible disproportionate budgetary effects of both the MCL and MMM/AMCL options. The Agency believes that the cost estimates, indicated previously and discussed in more detail in Section XIII.B of today's preamble accurately characterize future compliance costs of the proposed rule.

(d) Macroeconomic effects. As required under UMRA Section 202, EPA is required to estimate the potential macro-economic effects of the regulation. These types of effects include those on productivity, economic growth, full employment, creation of productive jobs, and international competitiveness. Macro-economic effects tend to be measurable in nationwide econometric models only if the economic impact of the regulation reaches 0.25 percent to 0.5 percent of Gross Domestic Product (GDP). In 1998, real GDP was $7,552 billion so a rule would have to cost at least $18 billion annually to have a measurable effect. A regulation with a smaller aggregate effect is unlikely to have any measurable impact unless it is highly focused on a particular geographic region or economic sector. The macro-economic effects on the national economy from the radon rule should be negligible based on the fact that, assuming full compliance with an MCL, the total annual costs are approximately $43.1 million at the 4,000 pCi/L level and about $407.6 million at the 300 pCi/L level (at a 7 percent discount rate) and the costs are not expected to be highly focused on a particular geographic region or industry sector.

(e) Summary of EPA's consultation with State, local, and tribal governments and their concerns. Consistent with the intergovernmental consultation provisions of section 204 of the UMRA and Executive Order 12875 "Enhancing Intergovernmental Partnership," EPA has already initiated consultations with the governmental entities affected by this rule. EPA initiated consultations with governmental entities and the private sector affected by this rulemaking through various means. This included four stakeholder meetings, and presentations at meetings of the American Water Works Association, the Association of State Drinking Water Administrators, the Association of State and Territorial Health Officials, and the Conference of Radiation Control Program Directors. Participants in EPA's stakeholder meetings also included representatives from National Rural Water Association, National Association of Water Companies, Association of Metropolitan Water Agencies, State department of environmental protection representatives, State health department representatives, State water utility representatives, the Inter Tribal Council of Arizona, and representatives of other tribes. EPA also made presentations at tribal meetings in Nevada, Alaska, and California. To address the proposed rule's impact on small entities, the Agency convened a Small Business Advocacy Review Panel in accordance with the Regulatory Flexibility Act (RFA) as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA). EPA also held two series of three conference calls with representatives of State drinking water and State radon programs. In addition to these consultations, EPA made presentations on the proposed Radon Rule to the Association of California Water Agencies, the National Association of Towns and Townships, the National League of Cities, and the National Association of Counties. Several State drinking water representatives also participated in AWWA's Technical Workgroup for Radon.

The Agency also notified governmental entities and the private sector of opportunities to provide input on the Health Risk Reduction and Cost Analysis (HRRCA) for radon in drinking water in the **Federal Register** on February 26, 1999 (64 FR 9559). The HRRCA was published six months in advance of this proposal and illustrated preliminary cost and benefit estimates for various MCL options under consideration for the proposed rule. The comment period on the HRRCA ended on April 12, 1999, and EPA received approximately 26 written comments. Of the 26 comments received concerning the HRRCA, 42 percent were from States and 4 percent were from local governments.

The public docket for this proposed rulemaking contains meeting summaries for EPA's four stakeholder meetings on radon in drinking water, all comments received by the Agency, and provides details about the nature of State, local, and tribal governments' concerns. A summary of State, local, and tribal government concerns on this proposed rulemaking is provided in the following section.

In order to inform and involve tribal governments in the rulemaking process, EPA staff attended the 16th Annual Consumer Conference of the National Indian Health Board on October 6–8, 1998, in Anchorage, Alaska. Over nine hundred persons representing Tribes from across the country were in attendance. During the conference, EPA conducted two workshops for meeting participants. The objectives of the workshops were to present an overview of EPA's drinking water program, solicit comments on key issues of potential interest in upcoming drinking water regulations, and to solicit advice in identifying an effective consultative process with tribes for the future.

EPA, in conjunction with the Inter Tribal Council of Arizona (ITCA), also convened a tribal consultation meeting on February 24–25, 1999, in Las Vegas, Nevada to discuss ways to involve tribal representatives, both tribal council members and tribal water utility operators, in the stakeholder process. Approximately twenty-five representatives from a diverse group of tribes attended the two-day meeting. Meeting participants included representatives from the following tribes: Cherokee Nation, Nezperce Tribe, Jicarilla Apache Tribe, Blackfeet Tribe, Seminole Tribe of Florida, Hopi Tribe, Cheyenne River Sioux Tribe, Menominee Indian Tribe, Tulalip Tribes, Mississippi Band of Choctaw Indians, Narragansett Indian Tribe, and Yakama Nation.

The major meeting objectives were to: (1) Identify key issues of concern to tribal representatives; (2) solicit input on issues concerning current OGWDW regulatory efforts; (3) solicit input and information that should be included in support of future drinking water regulations; and (4) provide an effective format for tribal involvement in EPA's regulatory development process. EPA staff also provided a brief overview on the forthcoming radon rule at the meeting. The presentation included the health concerns associated with radon, EPA's current position on radon in drinking water, the distinction between an MCL and AMCL, the multimedia mitigation (MMM) program, and specific issues for tribes. The following questions were posed to the tribal representatives to begin discussion on radon in drinking water: (1) Will tribal governments be interested in substituting MMM for drinking water control; (2) what types of MMM could tribes reasonably implement; and (3) what resources are available to fund MMM? The summary for the February 24–25, 1999, meeting was sent to all 565 Federally recognized tribes in the United States.

EPA also conducted a series of workshops at the Annual Conference of the National Tribal Environmental Council which was held on May 18–20, 1999, in Eureka, California. Representatives from over 50 tribes attended all, or part, of these sessions.

The objectives of the workshops were to provide an overview of forthcoming EPA regulations affecting water systems; discuss changes to operator certification requirements; discuss funding for tribal water systems; and to discuss innovative approaches to regulatory cost reduction. Tribal representatives were generally supportive of regulations which would ensure a high level of water quality, but raised concerns over funding for regulations. With regard to the forthcoming proposed radon rule, many tribal representatives saw the multimedia mitigation option as highly desirable, but felt that this option may not be adapted unless funds were made available for home mitigation. Meeting summaries for EPA's tribal consultations are available in the public docket for this proposed rulemaking.

(f) Nature of state, local, and tribal government concerns and how EPA addressed these concerns. State and local governments raised several concerns, including the high costs of the rule to small systems; the high degree of uncertainty associated with the benefits; the high costs of including Non-Transient Non-Community Water Systems (NTNCWSs); and the inclusion of risks to both smokers and non-smokers in the proposed regulation. Tribal governments raised several concerns with the MMM program, including where the funding to mitigate homes would come from; the number of homes that would require testing; and the frequency of home testing.

EPA understands the State, local, and tribal government concerns with the issues described previously. The Agency believes that the options for small systems, proposed for public comment in this rulemaking, will address stakeholder concerns pertaining to small systems and will help to reduce the financial burden to these systems.

Non-Transient Non-Community Water Systems (NTNCWSs) are not subject to this proposed rulemaking. A detailed discussion of the exposure to radon in NTNCWSs is shown in Section XII.D of this preamble. EPA has conducted a preliminary analysis on exposure and risks to NTNCWSs and is soliciting public comment on this preliminary analysis. An analysis of the potential benefits and costs of radon in drinking water for NTNCWSs is included in the docket for this proposed rulemaking. (USEPA 1999m)

EPA has included the risks to both ever-smokers and never-smokers in this proposed rulemaking. The Agency is basing this regulation on the risks to the general population and is not excluding any particular segments of the population. For a more complete discussion on the risks of radon in drinking water and air, see Section XII of this preamble.

EPA understands tribal governments' concerns with funding for the MMM program. To assist State, local, and tribal governments with the implementation of an MMM program, EPA is making available Public Water Supply Supervision (PWSS) Program Assistance Grant Funds, Drinking Water State Revolving Fund (DWSRF) funds, and State Indoor Air Grant (SIRG) funds. A more complete discussion of the funding available to State, local, and tribal governments for MMM program implementation is shown in Section XIV.C.1(b) of this preamble.

(g) Regulatory Alternatives Considered. As required under Section 205 of the UMRA, EPA considered several regulatory alternatives in developing an MCL for radon in drinking water. In preparation for this consideration, the Regulatory Impact Analysis and Health Risk Reduction and Cost Analysis (HRRCA) for Radon evaluated radon levels of 100, 300, 500, 700, 1,000, 2,000, and 4,000 pCi/L.

The Regulatory Impact Analysis and HRRCA also evaluated national costs and benefits of MMM implementation, with States choosing to reduce radon exposure in drinking water through an Alternative Maximum Contaminant Level (AMCL) and radon risks in indoor air through MMM programs. Based on the National Academy of Sciences recommendations, the AMCL level that was evaluated is 4,000 pCi/L. For further discussion on the regulatory alternatives considered in this proposed rulemaking, see Section XIII.B of this preamble.

EPA believes that the regulatory approaches proposed in today's notice are the most cost-effective options for radon that achieve the objectives of the rule, including strong public health protection. For a complete discussion of this issue, see EPA's Regulatory Impact Analysis and Revised HRRCA for Radon (USEPA 1999f).

2. Impacts on Small Governments

In preparation for the proposed radon rule, EPA conducted analysis on small government impacts. This rule may significantly impact small governments. EPA included small government officials or their designated representatives in the rule making process. EPA conducted four stakeholder meetings on the development of the radon rule which gave a variety of stakeholders, including small governments, the opportunity for timely and meaningful participation in the regulatory development process. Groups such as the National Association of Towns and Townships, the National League of Cities, and the National Association of Counties participated in the proposed rulemaking process. Through such participation and exchange, EPA notified potentially affected small governments of requirements under consideration and provided officials of affected small governments with an opportunity to have meaningful and timely input into the development of the regulatory proposal.

EPA also held a conference call on May 11, 1998, to consult directly with representatives of small entities that may be affected by the proposed rule. This conference call provided a forum for Small Entity Representative (SER) input on key issues related to the proposed radon rule. These issues included: (1) Issues related to the rule development, such as radon health risks, occurrence of radon in drinking water, treatment technologies, analytical methods, and monitoring; and (2) issues related to the development and implementation of the MMM program guidelines.

As required by SBREFA, EPA also convened a Small Business Advocacy Review (SBAR) Panel to help further identify and incorporate small entity concerns into this proposed rulemaking. For a sixty-day period starting in July 1998, the Panel reviewed technical background information related to this rulemaking, reviewed comments provided by the SERs, and met on several occasions with EPA and on one occasion with the SERs to identify issues and explore alternative approaches for accomplishing environmental goals while minimizing impacts to small entities. The SBAR final report on the proposed radon rule, which includes a description of the SBAR Panel process and the Panel's findings and recommendations, is available in the public docket for this proposed rulemaking. For a more detailed discussion of the Panel report, see Section XIV.B of this preamble.

In addition, EPA will educate, inform, and advise small systems, including those run by small governments, about the radon rule requirements. One of the most important components of this process is the Small Entity Compliance Guide, required by the Small Business Regulatory Enforcement Fairness Act of 1996 after the rule is promulgated. This plain-English guide will explain what actions a small entity must take to comply with the rule. Also, the Agency is developing fact sheets that concisely describe various aspects and requirements of the radon rule.

D. Paperwork Reduction Act (PRA)

The information collection requirements in this proposed rule have been submitted for approval to the Office of Management and Budget (OMB) under the Paperwork Reduction Act, 44 U.S.C. 3501 *et seq.* An Information Collection Request (ICR) document has been prepared by EPA (ICR, No. 1923.01) and a copy may be obtained from Sandy Farmer by mail at OP Regulatory Information Division, U.S. Environmental Protection Agency (2137), 401 M St., SW, Washington, DC 20460; by email at farmer.sandy@epa.gov; or by calling (202) 260–2740. A copy may also be downloaded off the Internet at http://www.epa.gov/icr.

Two types of information will be collected under the proposed radon rule. First, information on individual water systems and their radon levels will enable the States and EPA to evaluate compliance with the applicable MCL or AMCL. This information, most of which consists of monitoring results, corresponds to information routinely collected from water systems for other types of drinking water contaminants. Radon monitoring and reporting will initially be required on a quarterly basis for at least one year, but thereafter the frequency may be reduced to annually or once every three years depending on the level of radon present (see Section VIII.E). Other existing information and reporting requirements, such as Consumer Confidence Reports and (proposed) public notification requirements, will be marginally expanded to encompass radon along with other contaminants. As is the case for other contaminants, required information on system radon levels must be provided by affected systems and is not considered to be confidential.

The second type of information relates to the MMM program, which is EPA's recommended approach for small systems under the proposed radon rule. Information of this type includes MMM plans prepared by States as well as MMM plans prepared by community ground water systems in States that do not develop a MMM plan. The proposed rule allows States to prepare MMM plans regardless of whether they are primacy States with respect to drinking water programs. EPA will review the MMM plans developed by States, and States will review system-level MMM plans. These reviews will help ensure that MMM programs are likely to achieve meaningful reductions in human health risks from radon exposure. Acceptable MMM plans will include a plan for the collection of data to track the progress of the MMM program relative to goals established in the plans (*e.g.*, data on the number or rate of mitigated homes and the number or rate of new homes built radon resistant). EPA will review State-level MMM programs at least every five years, and States will review system-level programs at least every five years. Information related to MMM programs (i.e., the MMM plans and tracking data) is mandatory for States that choose to implement an EPA-approved MMM program and enforce the AMCL for radon rather than the MCL. Similarly, information related to system-level MMM programs is required only from systems that comply with the AMCL rather than the MCL and are in States that do not have a MMM program in place.

EPA believes the information discussed previously, on compliance with the MCL or AMCL and on MMM programs, is essential to achieving the radon-related health risk reductions anticipated by EPA under the proposed rule.

EPA has estimated the burden associated with the specific record keeping and reporting requirements of the proposed rule in an accompanying Information Collection Request (ICR), which is available in the public docket for this proposed rulemaking. Burden means the total time, effort, or financial resources expended by persons to generate, maintain, retain, or disclose or provide information to or for a Federal agency. This includes the time needed to review instructions; develop, acquire, install, and utilize technology and systems for the purposes of collecting, validating, and verifying information, processing and maintaining information, and disclosing and providing information; adjust the existing ways to comply with any previously applicable instructions and requirements; train personnel to be able to respond to a collection of information; search data sources; complete and review the collection of information; and transmit or otherwise disclose the information.

EPA has estimated a range of administrative costs for the proposed rule. These costs do not include testing and mitigating water or testing and mitigating households in the MMM program. The PRA requires that average annual cost and labor for administrative costs be calculated over a three-year period. These costs are presented next. However, because the full implementation of the proposed rule does not occur until later years, average annual cost and labor for a 20-year period are also presented. These 20-year average annual costs are presented by scenarios defined by the proportions of systems that elect to develop system-level MMM programs and the proportions of states that elect to implement state-wide MMM programs. These scenarios are described in detail in Section XIII.G and Section 9 of the RIA (USEPA 1999f). Based on these analyses, EPA's burden estimates for the proposed rule, in both costs and hours, are as follows:

- Administrative costs to community groundwater systems for mitigation-related activities are estimated to be $14.6 million per year ($357 per system) or 267,625 hours, distributed by system size as shown in Table XIV.2. All 40,863 community groundwater systems will bear these costs under all scenarios evaluated.
- In the first three years of the rule, there are no administrative costs to community groundwater systems for MMM program activities.

TABLE XIV.2.—ADMINISTRATIVE COSTS TO COMMUNITY WATER SYSTEMS ASSOCIATED WITH WATER MITIGATION AND SYSTEM-LEVEL MMM PROGRAMS (EXCLUDING MMM TESTING AND MITIGATION)

System size (customers served)	Administrative costs of water mitigation ($ per year)	Administrative costs of system-level MMM programs ($ per year)
VVS (25–100)	4,485,485	0
VVS (101–500)	4,958,735	0
VS (501–3,300)	3,430,387	0
S (3,301–10,000)	848,487	0
M (10,001–100K)	491,944	0

TABLE XIV.2.—ADMINISTRATIVE COSTS TO COMMUNITY WATER SYSTEMS ASSOCIATED WITH WATER MITIGATION AND SYSTEM-LEVEL MMM PROGRAMS (EXCLUDING MMM TESTING AND MITIGATION)—Continued

System size (customers served)	Administrative costs of water mitigation ($ per year)	Administrative costs of system-level MMM programs ($ per year)
L (>100K)	23,579	0
Total For All Systems	14,598,617	0

• Administrative costs to States for water mitigation-related activities are to be approximately $3 million per year (Table XIV.3) and 119,625 hours, or approximately $65,400 per year per state and 2,600 hours per year per state. Forty-six states bear these costs under all scenarios.

Table XIV.3 presents the costs if 100 percent of all states were to incur the specific administrative costs listed. However, no state will bear 100 percent of state-wide MMM program costs and 100 percent of system-level MMM program costs. These costs will be borne in an inverse relationship; e.g., 95 percent of the states will bear administrative costs associated with state-wide MMM programs and 5 percent of states will bear administrative costs associated with system-level MMM programs.

TABLE XIV.3.—STATE ADMINISTRATIVE COSTS FOR WATER MITIGATION AND MMM PROGRAMS

	($ per year)
Water Mitigation	3,009,713
State-Wide MMM Programs	6,346
System-Level MMM Programs	5,909
Total State Administrative Costs	3,021,968

• State administrative costs associated with state-wide MMM programs are estimated up to $6,300 per year and up to 140 hours per year for the first three years of the rule.

• State administrative costs to review system-level MMM programs and related activities are estimated up to $5,900 per year and up to 123 hours per year for the first three years of the rule.

• The total State administrative costs (water mitigation, state-wide, and system-level MMM programs) are estimated up to approximately $3 million per year and 119,887 hours per year.

Because much of the activity required under the proposed rule occurs in later years, this analysis presents average administrative costs borne by systems and states over a 20 year period. Again, these costs do not include water testing and mitigation or testing and mitigating households in MMM programs. In addition, these costs are presented by scenarios that are defined by the proportions of systems that elect to develop system-level MMM programs and the proportions of states that elect to implement state-wide MMM programs.

• Administrative costs to community groundwater systems for mitigation-related activities are estimated to be $8.6 million per year ($211 per system) or 145,547 hours per year, distributed by system size as shown in Table XIV.4. All 40,863 community groundwater systems will bear these costs under all scenarios evaluated.

• Under Scenario A, administrative costs to community groundwater systems for MMM program activities are approximately $45.1 million per year ($2,452 per system) or 174,000 hours per year for the 18,388 systems (45 percent of all community groundwater systems) that develop and file an MMM plan. The costs are distributed across the system size categories as shown in Table XIV.4. Under Scenario E, administrative costs to systems are $5.0 million per year or 19,333 hours per year. The per-system cost is the same as Scenario A, but only five percent of systems (2,042) bear these costs.

TABLE XIV.4.—ADMINISTRATIVE COSTS TO COMMUNITY WATER SYSTEMS ASSOCIATED WITH WATER MITIGATION AND SYSTEM-LEVEL MMM PROGRAMS

[Excluding MMM Testing and Mitigation]

System size (customers served)	Administrative costs of water mitigation ($ per year)	Administrative costs of system-level MMM programs under scenario A ($ per year	Administrative costs of system-level MMM programs under scenario E ($ per year
VVS (25–100)	2,857,190	14,978,142	1,664,238
VVS (101–500)	2,923,970	15,328,217	1,703,135
VS (501–3,300)	2,022,764	10,603,857	1,178,206
S (3,301–10,000)	500,319	2,622,804	291,423
M (10,001–100K)	290,080	1,520,674	168,964
L (>100K)	13,904	72,886	8,097
Total for All Systems	8,608,226	45,126,581	5,014,065

• Total administrative costs to community water systems (water mitigation plus MMM programs) range from $11 million per year under Scenario E to $51.2 million under Scenario A or 165,000 hours under Scenario E to 320,000 hours under Scenario A. The costs are distributed across the various system sizes as shown in Table XIV.5.

TABLE XIV.5.—TOTAL ADMINISTRATIVE COSTS WATER MITIGATION AND MMM PROGRAMS TO COMMUNITY GROUNDWATER SYSTEMS

System size (customers served)	Total administrative costs under scenario A ($ per year)	Total administrative costs under scenario E ($ per year)
VVS (25–100)	16,990,791	3,676,887
VVS (101–500)	17,387,906	3,762,824
VS (501–3,300)	11,238,829	1,813,178
S (3,001–10,000)	3,412,697	1,081,316
M (10,001–100,000)	1,873,106	521,396
L (100,000)	256,893	192,105
Total for All Systems	51,160,223	11,047,707

• Administrative costs to States for water mitigation-related activities are estimated to be approximately $2.5 million per year (Table XIV.6) or approximately $53,900 per year per state. Total state burden is approximately 100,000 hours per year. Forty-six states bear these costs under all scenarios.

TABLE XIV.6.—STATE ADMINISTRATIVE COSTS FOR WATER MITIGATION AND MMM PROGRAMS
[$ per year]

	Scenario A	Scenario E
Water Mitigation	2,477,299	2,477,299
State-Wide MMM Programs	2,926,691	5,560,713
System-Level MMM Programs	7,830,995	870,111
Total State Administrative Costs	13,234,985	8,908,123

• State administrative costs associated with state-wide MMM programs are estimated to be $2.9 million dollars ($127,200 per state across 23 states) or 123,000 hours per year under Scenario A. Under Scenario E, estimated state administrative costs of state-level MMM programs are estimated to be $5.6 million (again $126,400 per state, but under this scenario, 44 states bear the costs) or 233,000 hours per year for all 44 states.

• State administrative costs to review system-level MMM programs and related activities are estimated to be $7.8 million per year or 316,410 hours per year under Scenario A and approximately $870,000 per year or 35,157 hours per year under Scenario E. In both cases the cost per state is approximately $371,000 per year, with 21 states affected under Scenario A and two states affected under Scenario E.

• The total State administrative costs (water mitigation, state-wide, and system-level MMM programs) are estimated to be $13.2 million per year or 538,845 hours per year under Scenario A and $8.9 million per year or 367,878 hours per year under Scenario E.

An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. The OMB control numbers for EPA's regulations are listed in 40 CFR Part 9 and 48 CFR Chapter 15.

Comments are requested on the Agency's need for this information, the accuracy of the provided burden estimates, and any suggested methods for minimizing respondent burden, including through the use of automated collection techniques. Send comments on the ICR to the Director, OP Regulatory Information Division, U.S. Environmental Protection Agency (2137), 401 M St., SW., Washington, DC 20460 and to the Office of Management and Budget, 725 17th St., NW., Washington, DC 20503, marked ''Attention: Desk Officer for EPA''. Include the ICR number (1923.01) in any correspondence. Since OMB is required to make a decision concerning the ICR between 30 and 60 days after November 2, 1999, a comment to OMB is best assured of having its full effect if OMB receives it by December 2, 1999. The final rule will respond to any OMB or public comments on the information collection requirements contained in this proposal.

E. National Technology Transfer and Advancement Act (NTTAA)

Section 12(d) of the National Technology Transfer and Advancement Act of 1995 (''NTTAA''), Public Law 104–113, § 12(d) (15 U.S.C. 272 note) directs EPA to use voluntary consensus standards in its regulatory activities unless to do so would be inconsistent with applicable law or otherwise impractical. Voluntary consensus standards are technical standards (*e.g.*, materials specifications, test methods, sampling procedures, and business practices) that are developed or adopted by voluntary consensus standard bodies. The NTTAA directs EPA to provide Congress, through OMB, explanations when the Agency decides not to use available and applicable voluntary consensus standards.

EPA's process for selecting the analytical test methods is consistent with Section 12(d) of the NTTAA. EPA performed literature searches to identify analytical methods from industry, academia, voluntary consensus standard bodies, and other parties that could be used to measure radon in drinking water.

This proposed rulemaking involves technical standards. EPA proposes to use Standard Method 7500–Rn, which is specific for radon 222 (radon) in drinking water, for both the MCL and AMCL for radon in drinking water. This method meets the objectives of the rule because it accurately and reliably detects radon in drinking water below 100 pCi/L. Standard Method 7500–Rn was approved by the Standard Methods Committee in 1996 and is described in the ''Standard Methods for the Examination of Water and Wastewater (19th Edition Supplement)'' which was prepared and published jointly by the American Public Health Association, American Water Works Association, and Water Environment Federation. Additional information on this method is shown in Section VIII.B.2 of today's preamble.

EPA is also proposing the use of the American Society for Testing and Materials (ASTM) Standard Test Method for Radon in Drinking Water (designation: D5072–92) for the AMCL for radon in drinking water. This method is specific for radon in drinking water, but has been shown to accurately and reliably detect radon only at concentrations above 1,500 pCi/L and thus is only useful for the AMCL. ASTM's Standard Test Method for Radon in Drinking Water was adopted by ASTM in 1992 and is described in the Annual Book of ASTM Standards. Additional information on this method is shown in Section VIII.B.2 of this preamble.

As discussed in Section VIII.B (Analytical Methods) of this preamble, EPA is in the process of adopting the Performance-Based Measurement System (PBMS) to allow greater flexibility in compliance monitoring for this proposed rule and for future rules. For further information on PBMS, see Section VIII.D.

EPA welcomes comments on this aspect of the proposed rulemaking and, specifically, invites the public to identify potentially-applicable voluntary consensus standards and to explain why such standards should be used in this regulation.

F. Executive Order 12898: Environmental Justice

Executive Order 12898 ''Federal Actions To Address EnviroPopulations and Low-Income Populations,'' 59 FR 7629 (February 16, 1994) establishes a Federal policy for incorporating environmental justice into Federal agency missions by directing agencies to identify and address disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations. The Agency has considered environmental justice related issues concerning the potential impacts of this action and has consulted with minority and low-income stakeholders by convening a stakeholder meeting via video conference specifically to address environmental justice issues.

As part of EPA's responsibilities to comply with E.O. 12898, the Agency held a stakeholder meeting via video conference on March 12, 1998, to address various components of pending drinking water regulations; and how they may impact sensitive sub-populations, minority populations, and low-income populations. Topics discussed included treatment techniques, costs and benefits, data quality, health effects, and the regulatory process. Participants included national, State, tribal, municipal, and individual stakeholders. EPA conducted the meeting by video conference call between eleven cities. This meeting was a continuation of stakeholder meetings that started in 1995 to obtain input on the Agency's Drinking Water programs. The major objectives for the March 12, 1998, meeting were: (1) Solicit ideas from Environmental Justice (EJ) stakeholders on known issues concerning current drinking water regulatory efforts; (2) identify key issues of concern to EJ stakeholders; and (3) receive suggestions from EJ stakeholders concerning ways to increase representation of EJ communities in OGWDW regulatory efforts. In addition, EPA developed a plain-English guide specifically for this meeting to assist stakeholders in understanding the multiple and sometimes complex issues surrounding drinking water regulation. A meeting summary for the March 12, 1998, stakeholder meeting is available in the public docket for this proposed rulemaking.

Stakeholders have raised concerns that this action may have a disproportionate impact on low-income and minority populations. The rule framework and in particular, the MMM program coupled with a 4,000 pCi/L AMCL, were discussed with EJ stakeholders at the March 12, 1998, meeting. Key issues of concern with the MMM/AMCL approach included: (1) The potential for an uneven distribution of benefits across water systems and society; (2) the cost of air remediation to apartment dwellers; and (3) the concern that the approach could provide water systems and State governments a ''loophole'' through which they could escape the responsibility of providing appropriate protection from radon exposures.

The Agency considered equity-related issues concerning the potential impacts of MMM program implementation. There is no factual basis to indicate that minority and low income or other communities are more or less exposed to radon in drinking water than the general public. However, some stakeholders expressed more general concerns about equity in radon risk reduction that could arise from the MMM/AMCL framework outlined in SDWA. One concern is the potential for an uneven distribution of risk reduction benefits across water systems and society. Under the proposed framework for the rule, customers of CWSs complying with the AMCL could be exposed to a higher level of radon in drinking water than if the MCL were implemented, though this level would not be higher than the background concentration of radon in ambient air. However, these CWS customers could also save the cost, through lower water rates, of installing treatment technology to comply with the MCL. Under the proposed regulation, CWSs and their customers have the option of complying with either the AMCL (associated with a State or local MMM program) or the MCL.

EPA believes it is important that these issues and choices be considered in an open public process as part of the development of MMM program plans. Therefore, EPA has incorporated requirements into the proposed rule that provide a framework for consideration of equity concerns with the MMM/AMCL. The proposed rule includes requirements for public participation in the development of MMM program plans, as well as for notice and opportunity for public comment. EPA believes that the requirement for public participation will result in State and CWS program plans that reflect and meet their different constituents needs and concerns and that equity issues can be most effectively dealt with at the State and local levels with the participation of the public. In developing their MMM program plans, States and CWSs are required to document and consider all significant issues and concerns raised by the public. EPA expects and strongly recommends that States and CWSs pay particular attention to addressing any equity concerns that may be raised during the public participation process. In addition, EPA believes that providing CWS customers with information about the health risks of radon and on the

AMCL and MMM program option will help to promote understanding of the health risks of radon in indoor air, as well as in drinking water, and help the public to make informed choices. To this end, EPA is requiring CWSs to alert consumers to the MMM approach in their State in consumer confidence reports issued between publication of the final radon rule and the compliance dates for implementation of MMM programs. This will include information about radon in indoor air and drinking water and where consumers can get additional information.

The proposed requirements include the following: (1) A description of processes the State used to provide for public participation in the development of its MMM program plan; (2) a description of the nature and extent of public participation that occurred, including a list of groups and organizations that participated; (3) a summary describing the recommendations, issues, and concerns arising from the public participation process and how these were considered in developing the State's MMM program plan; (4) a description of how the State made information available to the public to support informed public participation, including information on the State's existing indoor radon program activities and radon risk reductions achieved, and on options considered for the MMM program plan along with any analyses supporting the development of such options; and (5) the State must provide notice and opportunity for public comment on the plan prior to submitting it to EPA.

The public is invited to comment on this aspect of the proposed rulemaking and, specifically, to recommend additional methods to address EJ concerns with the MMM/AMCL approach for treating radon in drinking water.

G. Executive Order 13045: Protection of Children From Environmental Health Risks and Safety Risks

Executive Order 13045, ''Protection of Children from Environmental Health Risks and Safety Risks,'' 62 FR 19885 (April 23, 1997) applies to any rule that: (1) Is determined to be ''economically significant'' as defined under E.O. 12866, and (2) concerns an environmental health or safety risk that EPA has reason to believe may have a disproportionate effect on children. If the regulatory action meets both criteria, the Agency must evaluate the environmental health or safety effects of the planned rule on children, and explain why the planned regulation is preferable to other potentially effective and reasonably feasible alternatives considered by the Agency.

This proposed rule is not subject to the Executive Order because the Agency does not have reason to believe the environmental health risks or safety risks addressed by this action present a disproportionate risk to children. Based on the risk assessment for radon in drinking water developed by the NAS, children were not identified as being disproportionately impacted by radon. The Committee on Risk Assessment of Exposure to Radon in Drinking Water that conducted the National Research Council Risk Assessment of Radon in Drinking Water Study (NAS 1999b) concluded, except for the lung cancer risk to smokers, there is insufficient scientific information to permit quantitative evaluation of radon risks to susceptible subpopulations such as infants, children, pregnant women, elderly, and seriously ill persons.

The National Academy of Sciences Committee on the Biological Effects of Ionizing Radiation (BEIR VI) (NAS 1999a) noted that there is only one study (tin miners in China) that provides data on whether risks from radon progeny are different for children, adolescents, and adults. Based on this study, the committee concluded that there was no clear indication of an effect of age at exposure, and the committee made no adjustments in the model for exposures received at early ages (NAS 1999a). Nonetheless, we evaluated the environmental health or safety effects of radon in drinking water on children. The results of this evaluation are contained in Section XII of this preamble. Copies of the documents used to evaluate the environmental health or safety effects of radon in drinking water on children, including the NAS Reports, have been placed in the public docket for this proposed rulemaking.

The public is invited to submit or identify peer-reviewed studies and data, of which EPA may not be aware, that assessed results of early life exposure to radon in drinking water.

H. Executive Orders on Federalism

Under Executive Order 12875, ''Enhancing the Intergovernmental Partnership,'' 58 FR 58093 (October 28, 1993) EPA may not issue a regulation that is not required by statute and that creates a mandate upon State, local, or tribal government, unless the Federal government provides the funds necessary to pay the direct compliance costs incurred by those governments, or EPA consults with those governments. If EPA complies by consulting, E.O. 12875 requires EPA to provide to the Office of Management and Budget a description of the extent of EPA's prior consultation with representatives of affected State, local, and tribal governments, the nature of their concerns, any written communications from the governments, and a statement supporting the need to issue the regulation. In addition, E.O. 12875 requires EPA to develop an effective process permitting elected officials and other representatives of State, local, and tribal governments ''to provide meaningful and timely input in the development of regulatory proposals containing significant unfunded mandates.''

EPA has concluded that this rule will create a mandate on State, local, and tribal governments and the Federal government will not provide the funds necessary to pay the direct costs incurred by State, local, and tribal governments in complying with the mandate. In developing this rule, EPA consulted with State, local, and tribal governments to enable them to provide meaningful and timely input in the development of this rule.

As described in Section XIV.C.1.e, EPA held extensive meetings with a variety of State and local representatives, who provided meaningful and timely input in the development of the proposed rule. Summaries of the meetings have been included in the public docket for this proposed rulemaking. See Sections XIV.C.1.e and XIV.C.1.f for summaries of the extent of EPA's consultation with State, local, and tribal governments; the nature of the governments' concerns; and EPA's position supporting the need to issue this rule.

On August 4, 1999, President Clinton issued a new executive order on federalism, Executive Order 13132 [64 FR 43255 (August 10, 1999)], which will take effect on November 2, 1999. In the interim, the current Executive Order 12612 [52 FR 41685 (October 30, 1987)], on federalism still applies. This rule will not have a substantial direct effect on States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among various levels of government, as specified in Executive Order 12612. ''This proposed rule establishes a National Primary Drinking Water Regulation (NPDWR) for the control of radon. This regulation is required by section 1412(b)(13) of the Safe Drinking Water Act, as amended. EPA conducted extensive discussions with States and local governments in developing this proposal, and significant flexibility is provided in implementing these regulations.''

I. Executive Order 13084: Consultation and Coordination With Indian Tribal Governments

Under Executive Order 13084, ''Consultation and Coordination with Indian Tribal Governments,'' 63 FR 27655 (May 19, 1998) EPA may not issue a regulation that is not required by statute, that significantly or uniquely affects the communities of Indian tribal governments, and that imposes substantial direct compliance costs on those communities, unless the Federal government provides the funds necessary to pay the direct compliance costs incurred by the tribal governments, or EPA consults with those governments. If EPA complies by consulting, E.O. 13084 requires EPA to provide the Office of Management and Budget, in a separately identified section of the preamble to the rule, a description of the extent of EPA's prior consultation with representatives of affected tribal governments, a summary of the nature of their concerns, and a statement supporting the need to issue the regulation. In addition, E.O. 13084 requires EPA to develop an effective process permitting elected officials and other representatives of Indian tribal governments ''to provide meaningful and timely input in the development of regulatory policies on matters that significantly or uniquely affect their communities.''

EPA has concluded that this rule will significantly or uniquely affect communities of Indian tribal governments. It will impose substantial direct compliance costs on such communities, and the Federal government will not provide the funds necessary to pay the direct costs incurred by the tribal governments in complying with the rule. In developing this rule, EPA consulted with representatives of tribal governments pursuant to both E.O. 12875 and E.O. 13084. Summaries of the meetings have been included in the public docket for this proposed rulemaking. EPA's consultation, the nature of the governments' concerns, and EPA's position supporting the need for this rule are discussed in Section XIV.C.2 of this preamble.

J. Request for Comments on Use of Plain Language

Executive Order 12866 and the President's memorandum of June 1, 1998, require each agency to write all rules in plain language. We invite your comments on how to make this proposed rule easier to understand. For example:

- Have we organized the material to suit your needs?
- Are the requirements in the rule clearly stated?
- Does the rule contain technical language or jargon that isn't clear?
- Would a different format (grouping and order of sections, use of headings, paragraphing) make the rule easier to understand?
- Would more (but shorter) sections be better?
- Could we improve clarity by adding tables, lists, or diagrams?
- What else could we do to make the rule easier to understand?

Stakeholder Involvement

XV. How Has the EPA Provided Information to Stakeholders in Development of This NPRM?

A. Office of Ground Water and Drinking Water Website

EPA's Office of Ground Water and Drinking Water maintains a website on radon at the following address: *http://www.epa.gov/safewater/radon.html.* Documents are placed on the website for public access.

B. Public Meetings

EPA has consulted with a broad range of stakeholders and technical experts. Participants in a series of stakeholder meetings held in 1997 and 1998 included representatives of public water systems, State drinking water and indoor air programs, tribal water utilities and governments, environmental and public health groups, and other Federal agencies. EPA convened an expert panel in Denver in November, 1997, to review treatment technology costing approaches. The panel made a number of recommendations for modification to EPA cost estimating protocols that have been incorporated into the radon cost estimates. EPA also consulted with a subgroup of the National Drinking Water Advisory Council (NDWAC) on evaluating the benefits of drinking water regulations. The NDWAC was formed in accordance with the Federal Advisory Committee Act (FACA) to assist and advise EPA. A variety of stakeholders participated in the NDWAC benefits working group, including utility company staff, environmentalists, health professionals, State water program staff, a local elected official, economists, and members of the general public.

EPA conducted one-day public meetings in Washington, D.C. on June 26, 1997; in San Francisco, California on September 2, 1997; and in Boston, Massachusetts on October 30, 1997, to discuss its plans for developing a proposed NPDWR for radon–222. EPA presented information on issues related to developing the proposed NPDWR and solicited stakeholder comments at each meeting. EPA also held a series of conference calls in 1998 and 1999 with State drinking water and indoor air programs, to discuss issues related to developing guidelines for multiedia mitigation programs. EPA also held a public meeting in Washington, DC. on March 16, 1999, to discuss the HRRCA published on February 26, 1999, and the multimedia mitigation framework.

C. Small Entity Outreach

EPA has conducted outreach directly to representatives of small entities that may be affected by the proposed rule, as part of SBREFA. A full discussion of the small entity outreach is in Section XIV.B.6 ''Significant Regulatory Alternatives and SBAR Panel Recommendations.''

D. Environmental Justice Initiatives

In order to uphold Executive Order 12898, ''Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,'' EPA's Office of Ground Water and Drinking Water convened a public meeting in Washington, DC in March 1998 to discuss ways to involve minority, low-income, and other sensitive subgroups in the stakeholder process and to obtain input on the proposed radon rule. The meeting was held in a video-conference format linking EPA Regions I through IX to involve as many stakeholders as possible. EPA has taken the concerns and issues raised by the environmental justice community into account while setting the MCL, MCLG, and AMCL for radon. For more information on the March 1998 environmental justice meeting, and on EPA proposals to address concerns of stakeholders, see Section XIV.F of this Preamble.

E. AWWA Radon Technical Work Group

The American Water Works Association (AWWA) convened a ''Radon Technical Work Group,'' in 1998 that provided technical input on EPA's update of technical analyses (occurrence, analytical methods, and treatment technology), and discussed conceptual issues related to developing guidelines for multimedia mitigation programs. Members of the Radon Technical Work Group included representatives from State drinking water and indoor air programs, public water systems, drinking water testing laboratories, environmental groups and the U.S. Geological Survey.

Background

XVI. How Does EPA Develop Regulations to Protect Drinking Water?

A. Setting Maximum Contaminant Level Goal and Maximum Contaminant Level

EPA sets an MCLG and MCL or treatment technology for each regulated contaminant. The MCLG is based on analysis of health effects of the contaminant. Based on the carcinogenicity of ionizing radiation, and the NAS' current recommendation for a linear, non-threshold relationship between exposure to radon and cancer in humans (NAS 1999a), the Agency is proposing an MCLG of zero for radon in drinking water.

A drinking water MCL applies to finished (treated) drinking water as supplied to customers. The SDWA generally requires that EPA set the MCL for each contaminant as close as feasible to the corresponding MCLG, based on available technology and taking costs into account. For example, if the analytical methods will only allow a relatively confident measure of a contaminant at a certain level, then the MCL cannot practically be set below that level. In addition, the cost of water treatment technologies is considered. If treatment capabilities are limited then the MCL must be set at a level that is found to be feasible. The MCL set by EPA must be protective of public health.

The 1996 amendments to SDWA require the Administrator to do a cost-benefit analysis of the MCLs under consideration and to make a determination as to whether the benefits of an MCL under consideration justify the costs (1412(b)(3)(C)). The Administrator may set an MCL at a level less stringent than the feasible level if he/she finds that the benefits of the feasible MCL do not justify the costs (1412(b)(6)(A)). There are certain exceptions to the use of this authority (1412(b)(6)(B) and (C)).

B. Identifying Best Available Treatment Technology

As discussed also in Section VIII of this preamble, EPA identifies one or more water treatment technologies (i.e., best available treatment (BAT)) found to be effective in removing the contaminant from drinking water and capable of meeting the MCL. There are a number of physical, chemical, and other means used by such treatment technologies for removing the contaminant, or in some cases destroying the contaminant or otherwise changing the contaminant's composition. In assessing potential BATs, EPA examines removal efficiency, cost to purchase and maintain, compatibility with other processes, and other factors. Most of the information cited by EPA in this context is gleaned from technical literature, including research studies covering pilot or full scale treatments. If some of the treatments identified are found to be most efficient, practical and economical, EPA places these on the BAT list and on occasion may provide guidance on other treatments that may have certain limitations.

C. Identifying Affordable Treatment Technologies for Small Systems

The 1996 Amendments to the SDWA directed EPA to identify treatment technologies that are affordable for small water systems. EPA is charged with identifying affordable treatments for three small system population categories: systems serving from 25 to 500, 501 to 3,300, and 3,301 to 10,000 persons. A designated ''compliance technology'' for these small systems may be a technology that is affordable and that achieves compliance with the MCL or a treatment technique requirement. Possible compliance technologies may include packaged or modular systems, and point-of-entry (POE) or point-of-use (POU) type treatment units. As with BAT designations, the compliance technology(ies) selected by EPA must be based upon available information from technical journals and/or qualified research studies.

EPA must also identify affordable ''variance technologies'' which are to be installed by a public water system after the system has applied to the responsible primacy agency for a variance, i.e., a ''small system variance.'' This variance applies only to systems serving fewer than 10,000 people. It also applies only in cases where an affordable technology is not available to achieve compliance with an MCL (or treatment technique requirement) yet still will be protective of public health. One of the requirements for systems that have obtained a variance is to install and maintain the variance technology in accordance with the listing by EPA, which may be specific to system size and/or dependent upon source water quality. A small system variance may only be obtained if compliance with the MCL through alternate source, treatment, or restructuring options are deemed not to be affordable for that system.

Small system variances are not available to meet MCL or treatment technique requirements promulgated prior to 1986, nor for regulations addressing microbiological contamination of water.

D. Requirements for Monitoring, Quality Control, and Record Keeping

Water systems are responsible for conducting monitoring of drinking water to ensure that it meets all drinking water standards. To do this, water systems and States use analytical methods set out in EPA regulations.

EPA is responsible for evaluating analytical methods developed for drinking water and approves those methods that it determines meet Agency requirements. Laboratories analyzing drinking water compliance samples must be certified by the EPA or the State.

Whether addressing regulated or unregulated contaminants, EPA establishes requirements as to how often water systems must monitor for the presence of the subject contaminant. Water systems serving larger populations generally must conduct more monitoring (temporally and spatially) because there is a greater potential human health impact of any violation, and because of the physical extent of larger water systems (e.g., miles of pipeline carrying water). Small water systems can receive variances or exemptions from monitoring in limited circumstances. In addition, under certain conditions, a State may have the option to modify monitoring requirements on an interim or a permanent basis for regulated contaminants, with a few exceptions. States may use this flexibility to reduce monitoring requirements for systems with low risk of incurring a violation.

E. Requirements for Water Systems to Notify Customers of Test Results if Not in Compliance

Each owner or operator of a public water system must notify customers if the system has failed to comply with an MCL or treatment technique requirement, or a testing procedure required by EPA regulation. A system must notify its customers if the system is subject to a variance (due to an inability to comply with an MCL).

The form of this notification must be readily understood and delivered via mail or direct delivery, through an annual report, or in the first water billing cycle following such a drinking water violation. The notification must also contain important information about the contaminant so that consumers will be aware of any particular hazards involved; the notification may indicate whether water can/cannot be consumed or used for bathing, whether boiling drinking water will make it safe; or whether storing water before use may be advisable.

F. Approval of State Drinking Water Programs to Enforce Federal Regulations

Section 1413 of the SDWA sets requirements that a State or eligible Indian tribe must meet in order to maintain primary enforcement responsibility (primacy) for its public water systems. These include (1) adopting drinking water regulations that are no less stringent than Federal NPDWRs; (2) adopting and implementing adequate procedures for enforcement; (3) keeping records and making reports available on activities that EPA requires by regulation; (4) issuing variances and exemptions (if allowed by the State) under conditions no less stringent than allowed by Sections 1415 and 1416; (5) adopting and being capable of implementing an adequate plan for the provision of safe drinking water under emergency situations, and (6) adopting authority for administrative penalties.

In addition to adopting the basic primacy requirements, States may be required to adopt special primacy provisions pertaining to a specific regulation. These regulation-specific provisions may be necessary where implementation of the NPDWR involves activities beyond those in the generic rule. States are required by 40 CFR 142.12 to include these regulation-specific provisions in an application for approval of their program revisions.

XVII. Important Technical Terms

Adsorption: In the case of the water/solid interface, the accumulation of a dissolved chemical species at the interface between a solid material (e.g., granular activated carbon) and water.

Alpha particle: A radioactivity decay product consisting of the charged helium-4 nucleus (two protons and two neutrons with a positive ionic charge of two, +2). Alpha particles are relatively heavy (8000 times as heavy as the beta particle) and are quickly absorbed by surrounding matter. The properties of alpha particles are such that they are only a health hazard if the emitter is in contact with living tissue. When outside the body, they do not penetrate the skin and are stopped by a few centimeters of air. However, when inside the body (breathed in or ingested), the alpha particle may ionize molecules within cells or may form ''free radicals'' (an atom or chemical group that contains an unpaired electron and which is very chemically reactive), either of which may result in the disruption of normal cellular metabolism and produce changes that affect cell replication which may induce cancerous cellular growth.

Bq (becquerel): An alternative unit of radioactivity is the Bq, which is equal to 1 disintegration per second. One pCi is equal to 0.037 Bq, and one Bq is equal to 27 pCi.

cpm/dpm: Counts per minute divided by radioactive disintegrations per minute; counting efficiency as determined by the counts per minute detected relative to the predicted disintegrations per minute in a well-characterized standard.

Half-life: The time required for one-half of a population of radioactive isotopes to decay; in the case of radioactive contaminants dissolved in water, it is the time for the concentration of the radioactive contaminant to decrease by a factor of two due to radioactive decay.

Heterotrophic Plate Count: A laboratory procedure for estimating the total bacterial count in a water sample (or ''bacterial density'').

Individual Risk: The risk to a person from exposure to radon in water is calculated by multiplying the concentration of radon in the water (pCi/L) by the unit risk factor (risk per pCi/L) for the exposure pathway of concern (ingestion, inhalation).

Isotopes: Two or more forms of an atomic element having the same number of protons, but differing in the number of neutrons. Some isotopes are stable (not radioactive) and some are radioactive, depending upon the ratio of neutrons and protons.

Monte Carlo Analysis:: Method of approximating a distribution of model solutions by sampling from simulated ''random picks'' from distributions of model input values.

pCi (picocurie):: a unit of radioactivity equal to 0.037 radioactive disintegrations per second.

Percentile: For any set of observations, the ''pth percentile value'' is the value such that p% of the observations fall below the pth percentile value and (100-p)% fall above it.

pH: Numerical scale for measuring the relative acidity or basicity of an aqueous solution; values less than 7 are acidic (becoming increasingly so as they decrease) and above 7 are basic (becoming increasing so as they increase).

Radioactivity: The spontaneous disintegration of unstable atomic nuclei (central core of an atom), resulting in the formation of new atomic elements (daughter products), which may or may not themselves be radioactive, and the discharge of alpha particles, beta particles, or photons (other decay particles are known, but their parent isotopes do not occur in drinking water).

Removal efficiency: A measure of the ability of a particular water treatment process to remove a contaminant of interest; defined as the concentration of the contaminant in the treated water (effluent) divided by the concentration of the contaminant in the source water (influent).

WL (working level): Any combination of radioactive chemicals that result in an emission of 1.3×10^5 MeV of alpha particle energy. One WL is approximately the total amount of energy released by the short-lived progeny in equilibrium with 100 pCi of radon.

Working Level Month (WLM): 170 hours of exposure to one Working Level (WL) of radon progeny.

Unit Risk: The risk from lifetime exposure, via the inhalation and ingestion exposure routes, to water containing an unit concentration (1 pCi/L) of radon.

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Appendix 1 to the Preamble: What Were the Major Public Comments on the 1991 NPRM and How Has EPA Addressed Them in This Proposal?

EPA received more than 600 comments on the Notice of Proposed Rulemaking (NPRM) of July 18, 1991 (56 FR 33050). Of the comments received, 289 were from public water suppliers, 89 were from individuals, 76 were from local governments, 52 were from States, 48 were from companies, 43 were from trade/professional organizations, 12 were from Federal agencies, 10 were from health/environmental organizations, 3 were from Members of Congress, and 2 were from universities. EPA received additional comments at public hearings on September 6, 1991, in Washington, DC and on September 12, 1991, in Chicago, Illinois.

Those commenting raised several concerns, including cost of rule implementation, especially for small public water systems, and the larger risk to public health from radon in indoor air from soil under buildings. The next sections summarize major public comments on the 1991 NPRM and provide brief responses in the following areas of most concern: (1) General issues; (2) statutory authority and requirements; (3) radon occurrence; (4) radon exposure and health effects; (5) maximum contaminant level; (6) analytical methods; (7) treatment technologies and costs; and (8) compliance monitoring. In many instances the following sections refer the reader to applicable sections in today's preamble where many of the issues have been fully discussed.

A. General Issues

Additional regulation: Some public comments opposed additional regulation in general, and additional drinking water regulation in particular. Some comments also suggested EPA proceed with a more integrated approach to environmental regulation, i.e., that mitigation programs be designed to provide control over major exposure routes, which in the case of radon must take the soil gas source into account.

EPA Response: At the time of the 1991 proposal, EPA did not have authority under SDWA for a broader radon rule. However, the SDWA as amended in 1996 provides such authority. In addition to requiring EPA to promulgate a regulation for radon in drinking water, the SDWA radon provision also includes a less stringent alternative maximum contaminant level (AMCL) and a multimedia approach to address radon in indoor air. Much of the health threat is associated with radon emanating from soil gas into indoor air. Risk from drinking water particularly through the inhalation pathway is also a significant and preventable risk. Today's proposal addresses all major routes of exposure and is intended to promote multimedia mitigation (MMM) programs and implementation of the AMCL. Thus, the Agency expects to provide more cost-effective reductions in the health risks associated with radon.

Federal funding for compliance and phased implementation: Commenters asked the Agency for increased flexibility in complying with the proposed regulation through phased compliance; cheaper removal technologies; and/or additional Federal funding. Industry and other groups also recommended a phased implementation of radon removal, focusing first on priority water sources with the highest radon levels.

EPA Response: Today's proposal provides different compliance dates for compliance with the MCL and with the AMCL/MMM program, such that there will be sufficient time to implement the MMM program.

The Agency recognizes that the SDWA regulations will continue to place a significant burden on some small communities with limited tax bases and resources with which to attain compliance. The EPA drinking water State Revolving Fund provides support to the States and public and private water suppliers, in particular to small public water suppliers. This fund offers capitalization grants to the States for low-interest loans to help water systems comply with the SDWA (For more information refer to Section XIV.C.1 of today's preamble.)

In addition, EPA surveys of public and private water suppliers have been initiated to understand more clearly their needs in particular in terms of funding to support capital improvements in the context of implementing SDWA-related plans.

B. Statutory Authority and Requirements

Applicability to non-transient, non-community (NTNC) systems: Ten commenters stated that EPA must provide better justification for regulating non-transient, non-community water systems along with community water systems. The indoor occupancy factors and exposure rates are different for persons in the workplace (i.e., school and hospital) than in the home. EPA should state clearly how the final rule will apply to this group.

EPA Response: About one-third of the systems estimated in 1991 as being affected by the final regulation were NTNC water systems. The Agency requested data in 1991 on NTNC system exposure patterns but received none; subsequently, the Agency conducted analysis on limited data on NTNC occurrence and exposure patterns and found the attendant exposures and risks to be relatively small in comparison to those estimated for community water supplies. (For more information refer to Section XI.D of today's preamble.)

In keeping with the flexibility accorded the Agency by SDWA to focus on areas of cognizable public health risk, EPA proposes that NTNC water systems not be required to comply with the proposed radon regulation. At the same time, EPA is soliciting comment and data related to this issue and has left open its options in terms of the final radon regulation.

State authority: Commenters felt that the Federal drinking water regulations should not be uniform across the nation's drinking water supply. Many drinking water issues, including those which involve unique circumstances in the State and the necessary resources to implement programs, remain unresolved and perhaps are not resolvable by the Federal government. As a result, States will need to carry more of the responsibility in regulating drinking water given their familiarity with local circumstances.

EPA Response: The Agency acknowledges the unique circumstances faced by State primacy programs and public water systems. According to the framework set forth in the SDWA Amendments, States will have the option of adopting the MCL or the higher AMCL and the MMM program to address radon in indoor air. State programs in this area are expected to vary, in part due to radon occurrence patterns locally and in part due to State resources as they apply to monitoring public water systems; also States will have flexibility in MMM program implementation, and through consideration of variances and exemptions as allowed under SWDA.

C. Radon Occurrence

Radon in PWS (Nationwide): The American Water Works Association (AWWA) suggested that EPA's 1991 national occurrence estimates for radon were low compared to actual levels, i.e., greater than 20 percent low, resulting in an inaccurate EPA cost impact estimate. The Association suggested EPA consider the following changes to the radon occurrence analysis:

- Disaggregation of the National Inorganics and Radionuclides Survey (NIRS) occurrence data for the smallest public systems, i.e., those serving fewer than 500 persons, into two subsets of systems;
- An accounting in the radon occurrence analysis for geologic conditions in various regions by applying NIRS data in an area-specific manner;
- Updating and increasing the inventory (including NTNCs) based upon FRDS data;
- Inclusion of State radon data in the national occurrence analysis;
- EPA analyses may have underestimated radon in water levels because the location of sampling in NIRS was in the distribution systems (where natural decay of radon-222 may have been significant, thereby lowering occurrence estimates).

EPA Response: EPA analyses of these issues addressed the concerns described previously to the extent feasible (USEPA 1999c). The EPA analyses have incorporated the referenced issues as data allowed; the analyses also addressed newer data collected and/or submitted to EPA.

The Agency used State radon in drinking water data to refine the previous analysis that were based solely on the NIRS data. The Agency identified and obtained data from a number of States that supplement the geographic coverage, representativeness, and utility of the NIRS data in predicting the occurrence of radon in drinking water in the U.S. Additional data sets were obtained that, while not addressing radon distributions in States or regions, provided significant data related to the sampling, analytical, temporal and intra-system variability of radon measurements. The data from the NIRS and from the supplementary data sources were subjected to extensive statistical analysis to characterize their distribution and compare data sets.

These analyses are discussed and referenced in today's preamble Section XI.C. The results indicate that: radon levels seen in the NIRS data sets were generally slightly lower than those seen in the wellhead and point-of-entry data provided by the same States (with radon levels being more comparable in the very small systems due to short residence times); previous results were verified that radon levels in the U.S. are the highest in New England, the Appalachian uplands and other Western and Midwest regions; the levels of radon seen in the supplemental State data sets were similar to those seen in the NIRS data for the same regions; and, due to procedures used to adjust the NIRS data, the proportions of systems exceeding the various levels in the current study are greater than those seen in previous analyses.

However, best estimates of the numbers of systems exceeding regulatory levels in EPA's 1993 estimate for the 1994 EPA Report to Congress (USEPA 1994) and the central tendency estimates in the current analysis are quite similar. This is because the total estimated number of community and non-community non-transient systems that are believed to be active in the U.S. has decreased approximately 17 percent between 1993 and the Agency's current estimates. Part of this difference is due to system consolidation, and part may be due to improved methods for differentiating active from inactive systems, although the relative importance of these two factors is not known.

Occurrence of radon in California: A California drinking water industry association provided a number of resources including the following: a survey of its member agencies; a California Department of Health Services (DHS) Groundwater Study; and the Metropolitan Water District's (MWD) Southern California Radon Survey. The commenter produced estimated radon occurrence figures which far exceeded EPA's California and national occurrence profiles. The commenter's estimate predicted 75 percent to 97 percent of California public water systems out of compliance with a radon standard of 300 pCi/L. The commenter submitted to EPA additional methods and source data necessary for a complete EPA evaluation of this comment.

EPA Response: EPA studied the commenter's methodology for determining radon occurrence in California, proposed water system categorization scheme, and the sources of radon data (surveys mentioned previously), and has concluded the following:

- That sampling in the California surveys biased the results towards higher radon levels since data were apparently collected at the wellhead;
- The methods used in combining data sources (and in substitutions within data sets) resulted in substantial overestimation of radon occurrence in California ground water supplies.
- The commenter assumed 23 percent more public water supplies in California than indicated in then-current EPA FRDS records;
- The use of commenter's GIS-predicted radon levels for California systems was also problematic (USEPA 1999c).

EPA believes that EPA NIRS survey did not under represent the levels of radon in California. A comparison by EPA of the NIRS-California data and other California data reveals a similarity in results. Furthermore, EPA results are more in accord with California State predictions submitted to EPA during the same comment period.

Variability of radon levels in water: The American Water Works Service Company (AWWSC) provided technical information on the issue of radon variability in well water. AWWSC said that the variability of radon levels in well water is a phenomenon that could affect the compliance status of systems. AWWA and the Association of California Water Agencies also echoed concerns about the seasonal and diurnal variability in groundwater.

EPA Response: EPA analyzed this issue to determine if radon variability may or may not have any influence on national occurrence profiles. EPA reviewed the two available sources of information on radon variability (Kinner et al. 1990), and data supplied by the American Water Works Service Co. (AWWSC). The Kinner report was limited to four sites in New Hampshire that exhibited short-term and long-term variability of radon. The AWWSC data were drawn from 400 wells, nationwide, in 1986 and 1987. Kinner's data appear to indicate a radon fluctuation of 20 to 50 percent in well water over long-term intervals, weekly or biweekly. The short-term variability (15 to 180 minute intervals during a three month test at one site) showed a fluctuation of 50 percent as observed in the long-term test. These studies did not try to correlate any of the variability observed with well yield and water table level to account for the inconsistent patterns. The data provided were too limited to independently analyze factors that may have influenced radon level fluctuations. However, EPA notes that the short-term and long-term variabilities of radon observed at a single site were similar. This suggests that the long-term variability may be a reflection of random sampling where short-term influences are influencing radon levels.

The AWWSC analysis of radon in well water included sampling in the fall of 1986 and January 1987. A decrease of 29 percent on average was found over the two-month period. A change in analytical procedure accounted for about 10 percent of that difference. The remaining 19 percent difference was not explained. AWWSC also conducted a test of the effect of pumping time on radon levels over a short period (five days then two days), beginning with an idle period. AWWSC inferred that an observed initial increase in radon level (about 25 percent) was due to radon decay in water that had been sitting near the well casing. According to AWWSC, a subsequent decrease (much smaller) over two days was due to the drawing of less enriched water from beyond a potential geologic radon source yet within the cone of depression.

EPA believes that local geologic and operating conditions may produce temporal variations in radon levels in ground water sources. However, data are too limited to permit drawing of any conclusions. Also, since the Kinner and AWWSC reports cited water that generally contained radon in the high levels, 2,500 to 200,000 pCi/L, and 1,200 to 1,700 pCi/L, respectively, EPA cannot draw any conclusions on the effect(s) of short or long-term variability on radon in water at 300 pCi/L. Because EPA NIRS data represents single, one-time values for systems sampled, it produces no basis for a bias conclusion (*i.e.*, over- or under-estimates). On the contrary, the random nature of the NIRS survey would cancel any differences between the NIRS level and the ''true average'' radon level in public supplies.

Radon Emanation from Pipe Scale Deposits: Data received after the comment period, and subsequently reviewed by EPA, suggested that due to an existing radon source (radium-226) in some systems, levels of radon-222 may in some instances increase as water passes through water distribution systems.

EPA Response: A paper by Valentine et al. (Valentine 1992) contained data on the phenomenon of radon levels increasing in water distribution pipelines. In three of five distribution systems studied in Iowa, the paper's authors found what they refer to as radon ''hot spots.'' These systems have more radon in delivered water than at the entry to distribution. However, more geographically diverse data generally show that natural radon decay is a more influential factor as water is distributed. In other words, without nationally-relevant data to the contrary, it would be expected that within-distribution system radon decay supercedes radon production, except in very specific circumstances.

A more recent article by Field et al. (1995) reported that a case study of an Iowa water system with an average of 2.2 mg/L dissolved iron and 2.5 pCi/L of radium-226. The finished water entering the distribution system had a mean radon level of 432 ± 54 pCi/L (one standard deviation). Field et al. measured radon levels at the taps of 25 homes and measured radon levels ranging from 81 pCi/L to 2,675 pCi/L, with a mean of $1,108 \pm 648$ pCi/L. The authors concluded that iron scale deposits were sorbing radium-226, the parent of radon-222. In the case study reported, greater than 80% of the surface pipe-scale was comprised by iron oxides, with traces of scales containing calcium and silicon. Since iron oxides have been shown to selectively scavenge radium, it is plausible that a co-occurrence of high iron and radium levels may result in the production of significant levels of radon within the distribution system. Other factors that would determine the level of radon produced include concentration of radium-226 sorbed to the pipe scale, the quantity, distribution, and surface area of the scale, the composition of the scale, all of which are determined by the average finished water quality, and the length of time the water is in contact with the scale. All case studies were confined to the state of Iowa.

It remains to be shown that the confluence of conditions that result in significant radon production within distribution systems exists commonly at the national level or is confined to specific locales (e.g., areas with high average levels of iron, radium-226, and other site-specific factors).

Regarding this issue, information available at the present time does not support a determination as to the extent to which this phenomenon may occur in the U.S. The Agency is, however, soliciting comments in today's proposal on the advisability of requiring additional monitoring for radon as a source of consumer exposure from the distribution system, and on other radon occurrence issues.

D. Radon Exposure and Health Effects

Approximately 400 public comments were submitted on the assessments of exposure to and health effects of radon in the 1991 NPRM. The major issues raised in these comments, including comments regarding the proposed MCLG, are addressed next.

Linear no-threshold dose response model: Many commenters were concerned that EPA only used a linear no-threshold dose-response model in projecting cancer risk associated with low level exposure to radon in the domestic environment.

EPA Response: The shape of the dose-response curve for radon has been evaluated in detail by the NAS (1999a, 1999b), who concluded that essentially all available data are consistent with a linear non-threshold mechanism. This includes data on the effects of a wide range of ionizing radiation, as well as direct dose-response relationships observed for radon in animals studies and in studies of cohorts of underground miners. The EPA concurs with the NAS evaluation and conclusion.

Age dependence on risk from radon exposure: A few commenters stated that EPA should consider the effect of exposure at young ages. According to these commenters, the additional risks in children were not well addressed.

EPA Response: Data on the relative sensitivity of children to radon are sparse. In general, the NAS Radon in Drinking Water Committee concluded that there is insufficient scientific information to permit quantitative evaluation of the risks of lung cancer death from inhalation exposure to radon progeny in susceptible sub-populations such as infants, children, pregnant women, and elderly and seriously ill persons. However, the BEIR VI committee (NAS 1999a) noted that there is one study (tin miners in China) that provides data on whether risks from radon progeny are different for children, adolescents, and adults. Based on this study, the committee concluded that there was no clear indication of an effect of age at exposure, and the committee made no adjustments in the model for exposures received at early ages. This indicates that children are not an especially susceptible sub-group. With respect to cancer risk from ingestion of radon, NAS (1999b) performed an analysis to investigate the relative contribution of radon ingestion as a child to the total risk. This analysis considered the age dependence of water consumption, of the behavior of radon and its decay products in the body, of organ size, and of risk. The results indicated that dose coefficients are somewhat higher in younger people than adults. NAS (1999b) estimated that about 30 percent of a lifetime risk was due to exposures occurring during the first 10 years of life.

Uncertainty of radon risk estimates: Several commenters said EPA needs to provide a more in-depth discussion of the uncertainty associated with the risk estimates for radon.

EPA Response: EPA has performed a very detailed two-dimensional Monte Carlo evaluation of variability and uncertainty in exposure and risk from water-borne radon (USEPA 1993, 1995). The methods and inputs used by EPA were reviewed by the SAB and by NAS, and the results were judged to be appropriate and sound, subject to some refinements in the uncertainty bounds on some of the inputs. Based on the most recent recommendations from the NAS regarding the uncertainty in the risk coefficient for ingestion and inhalation exposure, EPA (1999d) has recalculated the uncertainty bounds around each risk estimate. In brief, the credible interval around the best estimate of individual and population risks from inhalation and ingestion exposure pathways are about four-fold and fourteen-fold, respectively.

Extrapolation of high dose in mines to lower dose in homes: Many commenters stated that the differences in dose between the mines and homes in the 1991 NAS report *Comparative Dosimetry of Radon in Mines and Homes* needs to be incorporated into the Agency's radon progeny inhalation risk calculation.

EPA Response: EPA and NAS both recognize the importance of potential differences between dose and risk per unit exposure in mines and in homes. The ratio of the dose to lung cells per WLM in the home compared to that in a mine is described by the K factor. Based on the best data available at the time, NAS (1991) had previously concluded that the dose to target cells in the lung was typically about 30 percent lower for a residential exposure compared to an equal WLM exposure in mines (i.e., K=0.7). The BEIR VI committee re-examined the issue of the relative dosimetry in homes and mines. In light of new information regarding exposure conditions in home and mine environments, the committee concluded that, when all factors are taken into account, the dose per WLM is nearly the same in the two environments (i.e., a best estimate for the K-factor is about 1) (NAS 1999a). The major factor contributing to the change was a downward revision in breathing rates for miners. Thus, NAS has concluded that the risk coefficient based on miners is appropriate for use in residences without adjustment.

Possible confounding factors in mine studies: Some commenters raised questions about the possible confounding factors in the miner epidemiological studies EPA used to project lung cancer risks. Commenters stated that, besides radon, exposure to other contaminants not found at home can produce synergistic effects. Such other contaminants could include diesel fumes, excessive dust (which may be a problem in poorly constructed mines without adequate ventilation), and other radionuclides like uranium in the mine air.

EPA Response: The effects on radon risk estimates from potentially toxic exposures to substances such as silica, uranium dust, blasting fumes, and engine exhaust to underground miner cohorts were carefully examined in the NAS reports on radon risks (NAS 1988, 1999a) and other studies. For example, in the Malmberget iron miner study, Radford and St. Clair Renard (1984) investigated and determined that the risk from confounders such as tuberculosis, dust, silica, diesel exhaust, metals and asbestos is negligible. Edling and Axelson (1983) found the Grangeberg mine atmosphere clean of arsenic, asbestos and carcinogenic metals. In the Eldorado miner cohort (NAS 1988), potential confounders were investigated and exposures to silica and diesel exhaust were very low. In the Czechoslovakian uranium miners' study, Sevc et al. (1984, 1988) found that cigarette smoking was the only risk factor other than radon that was a significant exogenic carcinogenic agent. Two of the studies (China and Ontario) have quantitative data on arsenic, and there was no significant variation in excess relative risk per unit radon exposure across different levels of arsenic exposure (NAS 1999a). Despite the variety of exposures to potentially toxic agents other than radon, the dose-response between radon and lung cancer death was approximately consistent across the mining cohorts. NAS (1988) also noted that animal studies show no evidence of a synergistic effect of these agents on lung cancer risk from radon. Taken together, these findings indicate that the effect of confounding factors on observed lung cancer rates in miners is likely to be small.

Radon-smoking interaction: Several commenters stated that EPA's analysis shows that smoking acts synergistically with radon to induce lung cancer. The risk from radon is, on average, ten times higher for smokers than for the rest of the population, and over 20 times higher for heavy smokers. Several commenters asked why they should spend resources to remove a natural contaminant from water while more than ⅔ of the related cancer risk is attributable to the subpopulation who smoke.

EPA Response: Because of the strong influence of smoking on the risk from radon, the BEIR VI committee (NAS 1999a) evaluated risk to ever-smokers and never-smokers separately. The BEIR VI committee had smoking information on five of the miner cohorts, from which they concluded that there was a submultiplicative interaction between radon and smoking in causing lung cancer. Based on current smoking prevalence rates, it is estimated that about 84 percent of all radon-induced lung cancers will occur in ever-smokers, with only 16 percent in never-smokers. Thus, it is true that a reduction in radon exposure will save more cancer cases in the cohort of smokers than nonsmokers, but the relative amount of risk reduction is actually greater for nonsmokers than smokers.

Epidemiological studies of lung cancer in the home environment. Some commenters stated that in estimating risk associated with exposure to radon, EPA should consider health risk data associated with the exposure to low levels of radon in the domestic environment.

EPA Response: The NAS (1999a) has recently performed a careful analysis of epidemiological data on the risk of cancer in residents from radon. The NAS committee concluded that because of numerous design and experimental limitations, these studies do not constitute an adequate data base from which quantitative risk estimates can be derived. However, the data from studies in residents are considered to be generally consistent with the predictions based on the miner data.

Lack of experimental or epidemiological data link exposure via ingestion to increased cancer rates: Several commenters stated that no experimental or epidemiologic data link exposure via ingestion to increased cancer rates. The basis for ingestion risk data was a surrogate gas, xenon-133, that behaves similarly to radon.

EPA Response: Although no human or animal data directly demonstrate cancer risk from ingestion of radon, it is certain that ingested radon is absorbed from the gastrointestinal tract into the body, that this absorbed radon is distributed to internal tissues which are then irradiated with alpha particles as the radon and its progeny undergo decay. That alpha irradiation increases cancer risk is well established (UNSCEAR 1988; NAS 1990).

EPA's ingestion risk estimate is based on the conclusions from the NAS Radon in Drinking Water committee (NAS 1999b). The NAS committee performed a re-evaluation of the risks from ingestion of radon in direct tap water using the basic approach described in Federal Guidance Document 13 (USEPA 1998). This involved developing a new pharmacokinetic model of the behavior of ingested radon, based primarily on observations of the behavior of ingested radon in humans, as well as studies using xenon and other noble gases. NAS also addressed the uncertainties (within an order of magnitude) of the risk estimates for oral exposure associated with dose estimate to the stomach and in the epidemiologic data used to estimate the risk (NAS 1999b). Because the magnitude of the risk posed by ingestion is about 10 percent of the risk from inhalation of radon progeny, these uncertainties are not most critical in evaluating the overall hazards from water-borne radon.

Air-water transfer factor and episodic exposure: As for inhalation exposure, most commenters supported EPA's proposed radon water-to-air transfer ratio of 10,000:1. Two commenters regarded this transfer factor as too conservative.

EPA Response: EPA has performed a detailed evaluation of radon gas transfer from water to air (USEPA 1993, 1995). Values are highly variable between buildings, with an average value of about 1E–04. The NAS has recently performed an independent review of both measured and modeled values, and the NAS committee also concluded that a value of 1E–04 is the best point estimate available (NAS 1999b).

Outdoor versus indoor radon concentrations: Some commenters asserted that the concentration of radon in outdoor air is higher than the indoor air concentration resulting from the proposed MCL of 300 pCi/L.

EPA Response: EPA agrees. The NAS committee reviewed all the ambient radon concentration data that are available, and based on these data concluded that the best estimate of the average ambient (outdoor) radon concentration in the United States is 0.4 pCi/L of air. In contrast, based on a transfer factor of 1×10^{-4}, the contribution to indoor air from an average radon concentration in water (about 213 pCi/L) is only about 0.021 pCi/L. However, some groundwater systems have much higher radon concentrations, and increments in indoor air from water-borne radon may be much higher in those cases. As required by the Congress. EPA is implementing the MMM program to address the issue of relative radon risk from water and air.

Direct tap water ingestion rate: Concerning ingestion intake, few commenters expressed an opinion on the direct tap water ingestion rate of 1 L/day. One commenter suggested that the intake assumption should be 0.7 L/day, and another, 0.25 L/day.

EPA Response: EPA has based its current assessment of this issue on reports by the National Academy of Sciences and others. The reader is referred to a fuller discussion in the preamble to today's proposed radon in drinking water regulation and to references cited therein (see Section XII).

Radon loss via volatilization prior to ingestion: Two commenters felt that the 20 percent radon loss from direct tap water before ingestion is conservative.

EPA Response: Data are limited on the amount of radon lost from direct tap water before ingestion. Several studies (von Doblin and Lindell 1964; Hursh 1965; Suomela and Kahlos 1972; Gesell and Prichard 1980; Horton 1982) suggest a value of about 20 percent as the central estimate of radon lost before direct ingestion. Because of the lack of data, the NAS (1999b) recommended that a value of 0 percent (i.e., no loss) be assumed. It is important to note that this applies only to ''direct tap water'', and that radon loss is assumed to be nearly complete from other types of water (coffee, juice, that in foods, etc.).

Concerning the potential additional loss from the stomach prior to absorption, EPA believes that radon does not escape from the esophagus. An available study (Correia et al. 1987) conducted by the Massachusetts General Hospital specifically measured exhaled air following ingestion of radioactive xenon in drinking water. Gas did not immediately escape through the mouth. However, the absorption through the stomach and small intestine transferred xenon to the bloodstream and lungs. The pharmacokinetic model used to evaluate risk from ingested radon utilizes this absorption mechanism.

New studies indicating reduced lung cancer risk: Some commenters asserted that the lung cancer risk estimates will be reduced based on new studies.

EPA Response: The risk coefficients for lung cancer derived by NAS (1999a, 1999b) are based on a detailed analysis of all of the currently available studies.

Relative risk of radon from soil versus radon from drinking water: Many commenters stated that the risks posed by radon in water are small compared to the risk of radon from soil, and that regulation of radon in water will have very little effect in reducing the total risk of cancer from radon exposure.

EPA Response: EPA recognizes that the risk to residents contributed by radon in household water is a relatively small fraction of the risk contributed by radon released into indoor air from soil. Based on the most recent quantitative analysis, NAS estimates that this fraction is only about 1 percent. Nevertheless, it is still true that radon in water is one of the most hazardous substances in public water systems, contributing a total of about 160–170 cancer deaths per year. Thus, regulation of radon in water is appropriate.

Cancer risk posed by radon in drinking water: Radon in drinking water is one of the water contaminants with the highest estimated cancer risk.

EPA Response: EPA agrees, and it is for this reason that EPA believes that regulation of radon in water is necessary and appropriate. By definition, because radon is a known human carcinogen, the MCLG is zero.

E. Maximum Contaminant Level

Opposition to a radon MCL of 300 pCi/L: More than 300 commenters representing trade associations, Federal and State agencies, and regional and community water suppliers disagreed with a standard of 300 pCi/L for radon in drinking water. The strongest opposition came from California, Nebraska, and the northeastern region of the United States. Other commenters suggested the MCL be set at 1,000 pCi/L or at 2,000 pCi/L.

EPA Response: As referenced in Section A of this Appendix, the SDWA as amended in 1996 provides EPA authority to utilize an alternative approach (AMCL with MMM programs), which is expected to significantly allay concerns of stakeholders and commenters on the 1991 proposal.

Use of cost-effectiveness in standard setting: Local water agencies throughout California and elsewhere in the United States insisted that water rates would double, resulting in economic problems. State and local water agencies were in almost unanimous agreement that the proposed standard may not be cost-effective, posing significant financial and administrative burdens on agencies and customers.

EPA Response: In the past, EPA generally limited consideration of economic costs under the SDWA to whether a treatment technology was affordable for large public water systems. Under the SDWA as amended in 1996, the Agency has conducted considerable analysis in the areas of cost and technologies for small systems implementing the radon MCL and on small system compliance technologies. (For more information on related EPA analyses refer to today's proposal.)

The MCL as proposed in 1991 and in today's action was set within the EPA regulatory target range of approximately 10^{-4} to 10^{-6} individual lifetime fatal cancer risk level, to ensure the health and safety of the country's drinking water supply. Although this level will prevent numerous fatal cancer cases per year, the Agency recognizes that this benefit would affect only radon in ground water or 5 percent of the total radon exposure. The Agency expects the proposed AMCL/ multimedia approach will result in greater radon risk reduction at lower cost. (The multimedia mitigation program and the projected costs and benefits are described in greater detail in today's proposal.)

Impact on private wells: Several commenters expressed concern over the potential impact of the proposed standards on private wells.

EPA Response: The Agency cannot comment on the impact of an NPDWR (radon standard) on private wells. EPA currently possesses some data from State surveys that indicate relatively high levels of radon in private wells. However, the data are distinct from Public Water System data collected by EPA and others. The statute regulates public water systems that provide piped water for human consumption to at least 15 service connections or that serve an average of at least 25 people for at least 60 days each year. Public water systems can be community; non-transient, non-community; or transient non-community systems. As a supplement to Federal coverage, some States extend their authority by regulating systems serving 10 people or fewer.

F. Analytical Methods

Availability of qualified laboratories and personnel: Commenters stressed the impact the proposed regulation may have on requirements for analytical laboratory certification and training of laboratory technicians. For example, one State wrote that it has no certification process through which laboratories can receive State certification for radionuclide analyses. Another commenter stressed the need for a strategy to work with individual States to ensure sufficient certified analytical laboratory capacity.

EPA Response: The current situation and expected changes in the processes governing laboratory approval and certification are discussed in some detail in today's preamble (Section VIII.B). One of the changes since 1991 is the formation of the National Environmental Laboratory Accreditation Conference (NELAC) in 1995. NELAC serves as a voluntary national standards-setting body for environmental laboratory accreditation, and includes members from both state and Federal regulatory and non-regulatory programs having environmental laboratory oversight, certification, or accreditation functions. The members of NELAC meet bi-annually to develop consensus standards through its committee structure. These consensus standards are adopted by participants for use in their own programs in order to achieve a uniform national program in which environmental testing laboratories will be able to receive one annual accreditation that is accepted nationwide. The intent of the NELAC standards setting process is to ensure that the needs of EPA and State regulatory programs are satisfied in the context of a uniform national laboratory accreditation program. EPA shares NELAC's goal of encouraging uniformity in standards between primacy States regarding laboratory proficiency testing and accreditation.

Four-day holding period between sampling and analysis: Several commenters contended that for laboratories to cope with the increased number of samples, the holding period should increase to eight days. A State agency suggested a holding period of seven days. Another commenter stated that the proposed four-day holding period was not possible because many ground water systems have sources distributed over large areas that may need sampling. Certified personnel will collect, record, package, and send the samples to analytical laboratories within four days. Also, with a 100-minute counting time requirement, commercial laboratories may be ill-equipped to analyze samples from 28,000 systems. Another State commented that the four-day holding period was not compatible with a standard work week.

Response: Standard Method 7500–Rn reports a 50 minute counting time (not 100 minutes) and a four day sample holding time. This combination of counting time and holding time has been determined to be a good trade-off, given the limitation of the 3.8 day half-life of radon. Doubling the sample holding time (i.e., eight days) would approximately triple the counting time (i.e., to 150 minutes) necessary to achieve the same level of certainty in the analytical results, which would probably result in much higher analytical costs. Since the sample counting procedure is capable of being highly automated, EPA believes that certified laboratories will be able to process the required samples with a four-day holding time. As an example, one laboratory contacted by EPA currently analyzes radon in 12,000 water samples per year as part of a ground water monitoring study, providing evidence that a demand for radon analytical capacity will result in the required laboratory capacity. Based on an evaluation of the potential for laboratory certification, performance testing, and analytical procedures, which included input from stakeholders, the four day holding time has been determined to be feasible, and should result in lower analytical costs than a longer holding time and a longer counting time.

Proposed analytical techniques: A commenter representing a group of utilities approved of direct, low-volume liquid scintillation for measurement of radon as proposed, but recommended the use of Lucas Cell de-emanation for measurement of Ra–226 (not also for radon, as proposed). According to this commenter, the liquid scintillation method for radon measurement is straightforward and efficient compared with the Lucas Cell method that requires a high degree of specialized skill. Also, equipment cost for the Lucas Cell method may be prohibitive. The Conference of Radiation Control Program Directors stated that liquid scintillation, while able to detect radon in water at low levels, may provide laboratory results that are not reliable.

EPA Response: EPA agrees that LSC has the stated advantages relative to de-emanation. EPA also expects that the vast majority of nationwide radon analysis will be done using LSC. However, some laboratories are already equipped to perform the de-emanation method. Since the de-emanation method performs acceptably well, there is no reason to refuse the possibility of the added laboratory capacity afforded by the approval of this method.

Precision variability: A local water agency and an engineering company representative stated that the 30% precision variability is inadequate for determining compliance because of the extensive natural variability in radon levels over time. The combination of counting error, sampling error, and holding time variability demands a precision of ±20%, which would lead to more consistent data.

EPA Response: EPA agrees that the 1991 proposal of an acceptance level of ± 30%, based on a radon ''practical quantitation level'' (PQL) of 300 pCi/L is not supportable. This conclusion is based on an extensive collaborative study of the liquid scintillation method and the de-emanation method for radon published by EPA in 1993, as described in the methods section (VIII.b) of the preamble to this proposal. Today's proposal contains several options for ensuring that compliance monitoring is performed using radon methods with acceptable accuracy and precision. Based on other comments to the 1991 radionuclides proposal, EPA's preferred option is that the method detection limit (MDL) be used as the measure of sensitivity for radon, and not a PQL, consistent with the use of the MDL as the basis for sensitivity in the current radionuclides rule. EPA is proposing a value of 12 ± 12 pCi/L as the MDL for radon.

Based on the collaborative study data, EPA's best recommendation for acceptance limits for performance evaluations is ± 5% for single measurements, and for triplicate measurements, ± 6% at the 95% confidence level, and ± 9% at the 99% confidence level.

G. Treatment Technologies and Cost

Water Treatment Costs: Industry groups and several utilities provided detailed analyses of unit treatment costs for removal of radon in water. Water treatment cost estimates prepared by a consultant were up to five times the costs estimated by EPA. An analysis produced by a consultant showed that among the different factors influencing annual compliance costs estimated by them, unit treatment costs have the largest impact.

EPA Response: EPA disagrees that its radon aeration treatment estimates supporting the 1991 radionuclides proposal were under-estimates. EPA analyzed the aeration cost model and the cost elements put forward by the industry commenters and summarized the major differences between the EPA and industry models. This summary may be obtained from the docket supporting today's proposal (USEPA 1992). While this summary accounts for the differences in cost estimates between EPA and the industry and utility estimates, it is not necessary to go into detail regarding these differences since overwhelming evidence suggests that EPA's 1992 cost estimates were much closer to actual unit costs, based on costs reported in case studies collected since 1991 (USEPA 1999a, AWWARF 1998a) than the commenter's estimates. A comparison of EPA's current unit capital cost estimates to actual capital costs reported in published case studies can be found in Figure VIII.A.1 of this preamble. The consultant's 1991 estimates are compared against case studies and against EPA's current estimates in an EPA memorandum dated July 28, 1999 (USEPA 1999b). In summary, the consultant's estimates over-estimated the small systems case studies by factors ranging from three for small systems with design flows of around 1 MGD down to around 0.3 MGD. For the smallest systems case studies (systems serving around 0.015 MGD), the consultant's estimates were high by a factor of more than twenty. For large systems, the consultant's estimates were two to three times higher than the best fit for the large system case studies. As can be seen in Figure VIII.A.1 (''Total Capital Costs: Aeration Cost Case Studies''), EPA's current unit capital cost estimates appear to be very conservative compared to small systems case studies (systems with design flows less than 1 MGD) and are typical of case studies for larger flows (design flows greater than 1 MGD). It should be noted the costs reported for these case studies are total capital costs and include all process costs, as well as pre- and post-treatment capital costs, land, buildings, and permits. Figures VIII.A.1 through VIII.A.3 shown in the preamble provide strong evidence that EPA's assumptions affecting its unit cost estimates are realistic for large systems and are conservative for small systems.

Additional Treatment—Disinfection: Commenters asserted that some systems may need to add disinfection treatment to protect aerated water supplies from biological contamination. It was also stated that about 58 percent of small systems and 12 percent of large systems may need to add disinfection technology.

EPA Response: The current cost analysis assumes that all systems adding aeration and GAC will disinfect. For those systems not already disinfecting (proportions estimated from the EPA 1997 Community Water System Survey), it was assumed that systems adding treatment would also add disinfection.

Pretreatment for Iron and Manganese: A commenter also challenged EPA's position on the minimal pretreatment of a ground water supply before air stripping of radon. The commenter presumed that iron and manganese fouling will require additional treatment. While the comment did not address the costs to pre-treat water for iron and manganese removal, it was mentioned this pretreatment would result in high potential costs to water systems.

EPA Response: EPA has re-evaluated its assumptions regarding iron and manganese (Fe/Mn) fouling and has included costs for chemical stabilization (sequestration) of Fe/Mn for 25% of small systems and 15% of large systems. Based on an analysis of the occurrence of Fe/Mn in raw and finished ground water, EPA believes that this is adequate to account for Fe/Mn control. Data sources for this evaluation were: ''National Inorganics and Radionuclides Survey'' (NIRS); American Water Works Association, ''Water:/Stats, 1996 Survey: Water Quality''. and U.S. Geological Survey, ''National Water Information System''). This analysis is more fully discussed in Section VIII of the preamble. EPA reiterates that if its Fe/Mn cost assumptions were invalid, this fact would be demonstrated in comparisons of its estimates of capital and O&M costs against those reported in the case studies cited in the preamble. As described previously, EPA's unit cost estimates are apparently conservative for small systems and seem to be typical of large systems.

Aeration as BAT and Use of Carbon Treatment: A major commenter and a city in California asserted that aeration treatment for radon could potentially create a problem in air emissions permitting. Also, a major commenter commented that systems with high radon levels in water could produce high levels of radon in off-gas, potentially creating a shift among utilities to activated carbon treatment and waste (radioactive) disposal problems.

EPA Response: EPA discusses this concern in some detail in Section VIII of the preamble, including an evaluation of the estimates of the potential risks. Results from a survey of nine California air permitting agencies regarding permitting requirements and costs for radon treatment is also described in the preamble. The full text of this survey is reported in EPA 1999a.

Centralized Treatment Assumption: Commenters from the regulated community challenged EPA's cost analysis assumption involving centralized water treatment for radon. These associations cited the then-current EPA Community Water Supply Survey of 1986 and the then-current Water Industry Database. They suggested centralized treatment facilities were unrealistic and under predicts the costs to public water systems. The industry asserted that the number of wells and well groupings per system (with numbers increasing with increasing system size) will likely determine the number of treatment sites. An industry group produced estimated distributions of the percent of systems that would require treatment sites.

EPA Response: Centralized treatment was not assumed in the current radon cost analysis. EPA's current estimate of national compliance costs for the proposed radon rule uses the distribution of wells (treatment sites) per ground water system as a function of water system size from the 1997 Community Water System Survey (USEPA 1997). EPA assumed that a given system's total flow would be evenly distributed between the total number of wells at the system. To estimate the radon occurrence at a particular well within a system with multiple wells, EPA used its evaluation of intra-system occurrence variability (the variability of radon occurrence between wells within a given system) to estimate individual well radon levels. If multiple wells were predicted to be impacted at a given system, the cost model assumes that treatment is installed at each well requiring treatment.

Integrated approach to waste management: Three commenters declared that compliance with the radionuclides rule will create radioactive waste that may or may not be disposable. They recommended an integrated environmental management approach in addressing this waste issue.

EPA Response: The Agency used an integrated environmental management approach to determine BAT in removing contaminants from drinking water. While Packed Tower Aeration (PTA), the BAT for radon, does not generate waste requiring disposal, granular activated carbon is of concern. While not BAT, granular activated carbon may be used by very small systems to remove radon. Waste disposal issues regarding GAC treatment for radon are discussed in some detail in Section VIII of this preamble. For more information, see NAS 1999b and AWWARF 1998a and AWWARF 1998b.

H. Compliance Monitoring

Sampling location: Four State environmental/health agencies, one private non-environmental firm, eight public water suppliers, and one water association suggested that radon sampling of the distribution system at the point of entry does not allow systems to account for decay and aeration of radon during distribution. According to these commenters, sampling is more effective closer to the point of use.

EPA Response: EPA's proposal requires sampling at the entry points to the distribution system to assure compliance with the MCL for the water delivered to every customer. All samples will be required to be finished water, as it enters the distribution system after any treatment and storage. This approach allows systems to account for the decay and aeration of radon during treatment and storage before it enters the distribution system and at the same time offers maximum protection to the consumer. It is expected that radon levels would progressively decrease within the distribution system, downstream from the point of entry. Therefore, consumers who are located closest to the point of entry are exposed to higher levels of radon that those further downstream. In order to assure maximum protection to all of the consumers, EPA requires sampling at the entry points to the distribution system.

Compliance period: Clarification concerning the frequency of compliance periods, specifically in regards to the specific timing for the commencement of water systems monitoring is warranted.

EPA Response: The proposed monitoring requirements for radon are consistent with the monitoring requirements for regulated drinking water contaminants, as described in the Standardized Monitoring Framework (SMF) promulgated by EPA under the Phase II Rule of the National Primary Drinking Water Regulations (NPDWR) and revised under Phases IIB and V. The goal of the SMF is to streamline the drinking water monitoring requirements by standardizing them within contaminant groups and by synchronizing monitoring schedules across contaminant groups.

Systems already on-line must begin initial monitoring for compliance with the MCL/AMCL by the compliance dates specified in the rule (i.e., 3 years after the date of promulgation or 4.5 years after the date of promulgation). New sources connected on-line must satisfy initial monitoring requirements.

Initial compliance with the MCL/AMCL will be determined based on an average of 4 quarterly samples taken at individual sampling points in the initial year of monitoring. Systems with averages exceeding the MCL/AMCL at any well or sampling point will be deemed to be out of compliance. Systems exceeding the MCL/AMCL will be required to monitor quarterly until the average of 4 consecutive samples are less than the MCL/AMCL. Systems will then be allowed to collect one sample annually if the average from four consecutive quarterly samples is less than the MCL/AMCL and if the State determines that the system is reliably and consistently below MCL/AMCL.

Systems that primarily use surface water, supplemented with ground water: One water association suggested that public water systems supplementing their surface water supply with ground water are not in violation. Since the actual lifetime risk involved is significantly lower than those systems using 100 percent ground water supply, an equitable method of compliance for this type of combined systems should be administered.

EPA Response: In today's proposal, systems relying exclusively on surface water as their water source are not required to sample for radon. Systems that rely in part on ground water during low-flow periods about one quarter of the year are considered public ground water systems. According to the ground water monitoring requirements, systems are subject to monitor finished water at each entry point to the distribution system for radon during periods of ground water use. For the purpose of determining compliance, systems supplementing their surface water during part of the year will use a value of ½ the detection limit for radon for averaging purposes for the quarters when the water system is not supplemented by ground water. The water system having ground water samples supplementing surface water with a radon detection level above the MCL would not be out of compliance provided that these samples do not cause the average to exceed the MCL when averaged with the value of ½ the detection limit during the quarters the ground water source is not in use.

Averaging quarterly samples: Commenters recommended clarifying the discussion concerning the averaging of initial measurements to determine compliance. They stated that averaging the first year quarterly samples with the annual second and third compliance years will defeat the purpose of quarterly samples detecting signs of seasonal variability.

EPA Response: EPA is retaining the quarterly monitoring requirement for radon as proposed initially in the 1991 proposal to account for variations such as sampling, analytical and temporal variability in radon levels. Results of analysis of data obtained since 1991, estimating contributions of individual sources of variability to overall variance in the radon data sets evaluated, indicated that sampling and analytical variance contributes less than 1 percent to the overall variance. Temporal variability within single wells accounts for between 13 and 18 percent of the variance in the data sets evaluated, and a similar proportion (12–17 percent) accounts for variation in radon levels among wells within systems (USEPA 1999c).

For today's proposal, the Agency performed additional analyses to determine whether the requirement of initial quarterly monitoring for radon was adequate to account for seasonal variations in radon levels and to identify non-compliance with the MCL/AMCL. Results of analysis based on radon levels modeled for radon distribution for ground water sources and systems (USEPA 1999c) in the U.S. show that the average of the first four quarterly samples provides a good indication of the probability that the long-term average radon level in a given source would exceed an MCL or AMCL. Tables A.1 and A.2 show the probability of the long-term average radon level exceeding the MCL and AMCL at various averages obtained from the first four quarterly samples from a source.

TABLE A.1.—THE RELATIONSHIP BETWEEN THE FIRST-YEAR AVERAGE RADON LEVEL AND THE PROBABILITY OF THE LONG-TERM RADON AVERAGE RADON LEVELS EXCEEDING THE MCL

If the average of the first four quarterly samples from a source is:	Then the probability that the long-term average radon level in that source exceeds 300 pCi/L is:
Less than 50 pCi/L	0 percent
Between 50 and 100 pCi/L	0.5 percent
Between 100 and 150 pCi/L	0.4 percent
Between 150 and 200 pCi/L	7.2 percent
Between 200 and 300 pCi/L	26.8 percent

TABLE A.2.—THE RELATIONSHIP BETWEEN THE FIRST-YEAR AVERAGE RADON LEVEL AND THE PROBABILITY OF THE LONG-TERM RADON AVERAGE RADON LEVELS EXCEEDING THE AMCL

If the average of the first four quarterly samples from a source is:	Then the probability that the long-term average radon level in that source exceeds 4000 pCi/L is:
Less than 2,000 pCi/L	Less than 0.1 percent
Between 2,000 and 2,500 pCi/L.	9.9 percent
Between 2,500 and 3,000 pCi/L.	15.1 percent
Between 3,000 and 4,000 pCi/L.	32.9 percent

Water systems with a history of compliance: EPA has provided for the grandfathering of prior monitoring data for granting waivers. Monitoring data collected after January 1, 1985, that are generally consistent with the requirements of the section, and includes at least one sample taken on or after January 1, 1993, may be accepted by the State to satisfy the initial monitoring requirements. Many systems meeting the current monitoring requirements should qualify for this grandfathering provision because each sampling point or source water intake will be monitored within the preceding four-year period. New sampling points, or sampling points with new sources, must take an initial sample within the year the new source or sampling point begins operation.

EPA Response: Today's proposal provides that at a State's discretion, sampling data collected after the proposal could be used to satisfy the initial sampling requirements for radon, provided that the system has conducted a monitoring program not less stringent than that specified in the regulation and used analytical methods specified in the proposed regulation. The Agency wants to provide water suppliers with the opportunity to synchronize their monitoring program with other contaminants and to get an early start on their monitoring program if they wish to do so.

The proposed regulation provides for the States to grant monitoring waiver reducing monitoring frequency to once every nine years (once per compliance cycle) provided the system demonstrates that it is unlikely that radon levels in drinking water will occur above the MCL/AMCL. In granting the waiver, the State must take into consideration factors such as the geological area where the water source is located, and previous analytical results which demonstrate that radon levels do not occur above the MCL/AMCL. The waiver will be granted for up to a nine year period. (Given that all previous samples are less than ½ the MCL/AMCL, then it is highly unlikely that the long-term average radon levels would exceed the MCL/AMCL.)

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List of Subjects

40 CFR Part 141

Environmental protection, Chemicals, Indians—lands, Intergovernmental relations, Radiation protection, Reporting and recordkeeping requirements, Water supply.

40 CFR Part 142

Environmental protection, Administrative practice and procedure, Chemicals, Indians—lands, Radiation protection, Reporting and recordkeeping requirements, Water supply.

Dated: October 19, 1999.

Carol M. Browner,

Administrator.

For the reasons set out in the preamble, the Environmental Protection Agency proposes to amend 40 CFR parts 141 and 142 as follows:

PART 141—NATIONAL PRIMARY DRINKING WATER REGULATIONS

1. The authority citation for part 141 continues to read as follows:

Authority: 42 U.S.C. 300f, 300g–1, 300g–2, 300g–3, 300g–4, 300g–5, 300g–6, 300j–4, 300j–9, and 300j–11.

2. Section 141.2 is amended by adding definitions of ''Alternative Maximum Contaminant Level (AMCL)'' and ''Multimedia Mitigation (MMM) Program Plan'' in alphabetical order, to read as follows:

§ 141.2 Definitions.

* * * * *

Alternative Maximum Contaminant Level (AMCL) is the permissible level of radon in drinking water delivered by a community water system in a State with an EPA-approved multimedia mitigation (MMM) program plan, or by a community water system with a State-approved local MMM program plan.

* * * * *

Multimedia Mitigation (MMM) Program Plan is a State or community water system program plan of goals and strategies developed with public participation to promote indoor radon risk reduction. MMM programs for radon in indoor air may use a variety of strategies, including public education, testing, training, technical assistance, remediation grant and loan or incentive programs, or other regulatory or non-regulatory measures.

* * * * *

3. Section 141.6 is amended by adding paragraph (j) to read as follows:

141.6 Effective dates.

* * * * *

(j) The regulations set forth in Subpart R of this part are effective [60 days after date of publication of the final rule in the **Federal Register**].

Subpart C—[Amended]

4. A new § 141.20 is added to Subpart C to read as follows:

§ 141.20 Analytical methods, monitoring, and compliance requirements for radon.

(a) *Analytical methods.* (1) Analysis for radon shall be conducted using one of the methods in the following table:

PROPOSED ANALYTICAL METHODS FOR RADON IN DRINKING WATER

Methodology	References (method or page number)		
	SM	ASTM	EPA
Liquid Scintillation Counting	7500–Rn[1]	D 5072 92[2]	
De-emanation			EPA 1987[3]

[1] *Standard Methods for the Examination of Water and Wastewater.* 19th Edition Supplement. Clesceri, L., A. Eaton, A. Greenberg, and M. Franson, eds. American Public Health Association, American Water Works Association, and Water Environment Federation. Washington, DC. 1996.

[2] American Society for Testing and Materials (ASTM). Standard Test Method for Radon in Drinking Water. Designation: D 5072–92. *Annual Book of ASTM Standards.* Vol. 11.02. 1996.

[3] Appendix D, Analytical Test Procedure, ''The Determination of Radon in Drinking Water''. In ''Two Test Procedures for Radon in Drinking Water, Interlaboratory Collaborative Study''. EPA/600/2–87/082. March 1987. p. 22.

(2) Sample collection for radon shall be conducted using the sample preservation, container, and maximum holding time procedures specified in the following table.

SAMPLING METHODS AND SAMPLE HANDLING, PRESERVATION, AND HOLDING TIME

Sampling methods	Preservative	Sample Container	Maximum holding time for sample
(i) As described in SM 7500–Rn[1]	Ship sample in an insulated package to avoid large temperature changes.	Glass with teflon-lined septum.	4 days.

Sampling Methods and Sample Handling, Preservation, and Holding Time

Sampling methods	Preservative	Sample Ccntainer	Maximum holding time for sample
(ii) As described in EPA 1987 [2].			

[1] *Standard Methods for the Examination of Water and Wastewater.* 19th Edition Supplement. Clesceri, L., A. Eaton, A. Greenberg, and M. Franson, eds. American Public Health Association, American Water Works Association, and Water Environment Federation. Washington, DC. 1996.

[2] ''Two Test Procedures for Radon in Drinking Water, Interlaboratory Collaborative Study''. EPA/600/2–87/082. March 1987.

(b) Monitoring and compliance requirements. Community water systems (CWSs) shall conduct monitoring to determine compliance with the maximum contaminant level (MCL) or alternate maximum contaminant level (AMCL) specified in § 141.66 in accordance with this chapter. The monitoring requirements have been developed to be consistent with the Phase II/V monitoring schedule.

(1) Applicability and sampling location. CWSs using a ground water source or CWSs using ground water and surface water sources (for the purpose of this section hereafter referred to as systems) shall sample at every entry point to the distribution system which is representative of each well after treatment and/or storage (hereafter called a sampling point) under normal operating conditions in accordance with paragraph (b)(2) of this section.

(2) Monitoring—(i) Initial monitoring requirements. (A) Systems must collect four consecutive quarterly samples beginning by the date specified in § 141.301(b).

(B) States may allow previous sampling data collected after [60 days after date of publication of the final rule] to satisfy the initial monitoring requirements, provided the system has conducted monitoring to satisfy the requirements specified in this section. If a system's early monitoring data indicates an MCL/AMCL exceedence, the system will not be considered in violation until the end of the applicable initial monitoring period specified in § 141.301(b).

(ii) Routine monitoring requirements. Systems must continue quarterly monitoring until the running average of four consecutive quarterly samples is less than the MCL/AMCL. If the running average of four consecutive quarterly samples is less than the MCL/AMCL then systems may conduct annual monitoring at the State's discretion.

(iii) Reduced monitoring requirements. States may allow systems to reduce the frequency of monitoring to once every three years (one sample per compliance period) beginning the following compliance period provided the systems:

(A) Demonstrate that the average of four consecutive quarterly samples is below ½ MCL/AMCL;

(B) No individual samples exceed the MCL/AMCL; and

(C) The States determine that the systems are reliably and consistently below the MCL/AMCL.

(iv) Increased monitoring requirements. (A) Systems which exceed the MCL/AMCL shall monitor quarterly beginning the quarter following the exceedence. States may allow systems to reduce their monitoring frequency if the requirements specified in paragraph (b)(2)(iii) or (b)(2)(iv)(B) of this section are met.

(B) Systems monitoring once every three years, or less frequently, which exceed ½ MCL/AMCL shall begin annual monitoring the year following the exceedence. Systems may reduce monitoring to once every three years if the average of the initial and three consecutive annual samples is less than ½ MCL/AMCL and the State determines the system is reliably and consistently below the MCL/AMCL.

(C) If a community water system has a portion of its distribution system separable from other parts of the distribution system with no interconnections, increased monitoring need only be conducted at points of entry to those portions of system.

(v) Failure to conduct monitoring as described in this section is a monitoring violation.

(3) Monitoring waivers. (i) States may grant a monitoring waiver to systems provided that:

(A) The system has completed initial monitoring requirements as specified in paragraph (b)(2)(i) of this section. Systems shall demonstrate that all previous analytical results were less than ½ MCL/AMCL. New systems and systems using a new ground water source must complete four consecutive quarters of monitoring before the system is eligible for a monitoring waiver; and

(B) States determine that the systems are reliably and consistently below the MCL/AMCL, based on a consideration of potential radon contamination of the source water due to the geological characteristics of the source water aquifer.

(ii) Systems with a monitoring waiver must collect a minimum of 1 sample every nine-years (once per compliance cycle).

(iii) A monitoring waiver remains in effect until completion of the nine-year compliance cycle.

(iv) A decision by States to grant a monitoring waiver shall be made in writing and shall set forth the basis for the determination.

(4) Confirmation samples. Systems may take additional samples to verify initial sample results as specified by the State. The results of the initial and confirmation samples will be averaged for use in calculation of compliance.

(5) Compliance. Compliance with § 141.66 shall be determined based on the analytical result(s) obtained at each sampling point. If one sampling point is in violation, the system is in violation.

(i) For systems monitoring more frequently than annually, compliance with the MCL/AMCL is determined by a running annual average at each sampling point. If the average at any sampling point is greater than the MCL/AMCL, then the system is out of compliance with the MCL/AMCL.

(ii) If any one quarterly sampling result will cause the running average to exceed the MCL/AMCL, the system is out of compliance.

(iii) Systems monitoring annually or less frequently whose sample result exceeds the MCL/AMCL will revert to quarterly sampling immediately. The system will not be considered in violation of the MCL/AMCL until they have completed one year of quarterly sampling.

(iv) All samples taken and analyzed under the provisions of this section must be included in determining compliance, even if that number is greater than the minimum required.

(v) If a system does not collect all required samples when compliance is based on a running annual average of quarterly samples, compliance will be based on available data.

(vi) If a sample result is less than the detection limit, zero will be used to calculate the annual average.

(vii) During the initial monitoring period, if the compliance determination for a system in a non-MMM State exceeds the MCL, the system will incur a MCL violation unless the system notifies the State by [four years after date of publication of the final rule in the **Federal Register**] of their intent to submit a local MMM plan, submits a local MMM plan to the State within [5 years after date of publication of the final rule in the **Federal Register**] and begins implementation by [5.5 years after date of publication of the final rule in the **Federal Register**]. The State shall approve or disapprove a local MMM program plan within 6 months from the date of receipt. If the State does not disapprove the local MMM program plan during such period, then the CWS shall implement the plan submitted to the State for approval. The compliance determination will be conducted as described in this paragraph.

(viii) Following the completion of the initial monitoring period, if the compliance determination for a system in a non-MMM State exceeds the MCL, the system will incur a MCL violation unless the system submits a local MMM plan to the State within 1 year from the date of the exceedence and begins implementation 1.5 years from the date of the exceedence. The State shall approve or disapprove a local MMM program plan within 6 months from the date of receipt. If the State does not disapprove the local MMM program plan during such period, then the CWS shall implement the plan submitted to the State for approval. The compliance determination will be conducted as described in this paragraph.

(6) If a community water system has a distribution system separable from other parts of the distribution system with no interconnections, the State may allow the system to give public notice to only the area served by that portion of the system which is out of compliance.

5. Section 141.28 is revised to read as follows:

§ 141.28 Certified laboratories.

(a) For the purpose of determining compliance with § 141.20 through 141.27, 141.41, and 141.42, samples may be considered only if they have been analyzed by a laboratory certified by the State except that measurements for turbidity, free chlorine residual, temperature and pH may be performed by any person acceptable to the State.

(b) Nothing in this part shall be construed to preclude the State or any duly designated representative of the State from taking samples or from using the results from such samples to determine compliance by a supplier of water with the applicable requirements of this part.

Subpart F—[Amended]

6. A new § 141.55 is added to Subpart F to read as follows:

§ 141.55 Maximum contaminant level goals for radionuclides.

MCLGs are as indicated in the following table:

Contaminant	MCLG
Radon–222	Zero.

Subpart G—[Amended]

7. A new § 141.66 is added to Subpart G to read as follows:

§ 141.66 Maximum contaminant level for radionuclides.

(a) The maximum contaminant level for radon-222 is as follows: (1) A community water system (CWS) using a ground water source or using ground water and surface water sources that serves 10,000 or fewer people shall comply with the alternative maximum contaminant level (AMCL) of 4000 pCi/L, and implement a State-approved multimedia mitigation (MMM) program to address radon in indoor air (unless the State in which the system is located has a MMM approved by the Environmental Protection Agency). These systems may elect to comply with the MCL of 300 pCi/L instead of developing a local CWS MMM program plan.

(2) A CWS using a ground water source or using ground water and surface water sources that serves more than 10,000 people shall comply with the MCL of 300 pCi/L, except that the system may comply with an AMCL of 4000 pCi/L where:

(i) The State in which the CWS is located has adopted an MMM program plan approved by EPA; or,

(ii) The CWS has adopted an MMM program plan approved by the State.

(3) A CWS shall monitor for radon in drinking water according to the requirements in § 141.20, and report the results to the State, and continue to monitor as described in § 141.20. If the State determines that the CWS is in compliance with the MCL of 300 pCi/L, the CWS has met the requirements of this section and is not subject to the requirements of subpart R of this part, regarding MMM programs.

(4) The Administrator, pursuant to section 1412 of the Act, hereby identifies, as indicated in the following table, the best technology available for achieving compliance with the maximum contaminant levels for radon identified in paragraphs (a)(1) and (a)(2) of this section:

BAT for Radon–222

High-Performance Aeration [1]

(5) The Administrator, pursuant to section 1412 of the Act, hereby identifies in the following table the best technology available to systems serving 10,000 persons or fewer for achieving compliance with the MCL or AMCL. The table addresses affordability and technical feasibility for such BAT.

PROPOSED SMALL SYSTEMS COMPLIANCE TECHNOLOGIES (SSCTS) [1] AND ASSOCIATED CONTAMINANT REMOVAL EFFICIENCIES

Small systems compliance technology	Affordable for listed small systems categories [2]	Removal efficiency	Operator level required [3]	Limitations (see footnotes)
Packed Tower Aeration (PTA)	All Size Categories	90–>99.9% Removal	Intermediate	(a)
High Performance Package Plant Aeration (e.g., Multi-Stage Bubble Aeration, Shallow Tray Aeration).	All Size Categories	90–> 99.9% Removal	Basic to Intermediate.	(a)
Diffused Bubble Aeration	All Size Categories	70 to >99% removal	Basic	(a, b)

[1] High Performance Aeration is defined as the group of aeration technologies that are capable of being designed for high radon removal efficiencies, i.e., Packed Tower Aeration, Multi-Stage Bubble Aeration and other suitable diffused bubble aeration technologies, Shallow Tray and other suitable Tray Aeration technologies, and any other aeration technologies that are capable of similar high performance.

PROPOSED SMALL SYSTEMS COMPLIANCE TECHNOLOGIES (SSCTS)[1] AND ASSOCIATED CONTAMINANT REMOVAL EFFICIENCIES—Continued

Small systems compliance technology	Affordable for listed small systems categories[2]	Removal efficiency	Operator level required[3]	Limitations (see footnotes)
Tray Aeration	All Size Categories	80 to >90%	Basic	(a, c)
Spray Aeration	All Size Categories	80 to >90%	Basic	(a, d)
Mechanical Surface Aeration	All Size Categories	>90%	Basic	(a, e)
Centralized granular activated carbon	May not be affordable, except for very small flows.	50 to >99% Removal	Basic	(f)
Point-of-Entry (POE) granular activated carbon	May be affordable for systems serving fewer than 500 persons.	50 to >99% Removal	Basic	(f, g)

[1] Section 1412(b)(4)(E)(ii) of the SDWA specifies that SSCTs must be affordable and technically feasible for small systems.

[2] The Act (ibid.) specifies three categories of small systems: i) those serving 25 or more, but fewer than 501, ii) those serving more than 500, but fewer than 3,301, and iii) those serving more than 3,300, but fewer than 10,001.

[3] From National Research Council. *Safe Water from Every Tap: Improving Water Service to Small Communities.* National Academy Press. Washington, DC. 1997. Limitations: a) Pre-treatment to inhibit fouling may be needed. Post-treatment disinfection and/or corrosion control may be needed. b) May not be as efficient as other aeration technologies because it does not provide for convective movement of the water, which reduces the air:water contact. It is generally used in adaptation to existing basins. c) Costs may increase if a forced draft is used. Slime and algae growth can be a problem, but may be controlled with chemicals, e.g., copper sulfate or chlorine. d) In single pass mode, may be limited to uses where low removals are required. In multiple pass mode (or with multiple compartments), higher removals may be achieved. e) May be most applicable for low removals, since long detention times, high energy consumption, and large basins may be required for larger removal efficiencies. f) Applicability may be restricted to radon influent levels below around 5000 pCi/L to reduce risk of the build-up of radioactive radon progeny. Carbon bed disposal frequency should be designed to allow for standard disposal practices. If disposal frequency is too long, radon progeny, radium, and/or uranium build-up may make disposal costs prohibitive. Proper shielding may be required to reduce gamma emissions from the GAC unit. GAC may be cost-prohibitive except for very small flows. g) When POE devices are used for compliance, programs to ensure proper long-term operation, maintenance, and monitoring must be provided by the water system to ensure adequate performance.

Subpart O—[Amended]

8. Section 141.151 is amended by revising paragraph (d) to read as follows:

141.151 Purpose and applicability of this subpart.

* * * * *

(d) For the purpose of this subpart, *detected* means: at or above the levels prescribed by § 141.23(a)(4) for inorganic contaminants, at or above the levels prescribed by § 141.24(f)(7) for the contaminants listed in § 141.61(a), at or above the level prescribed by § 141.24(h)(18) for the contaminants listed in § 141.61(c), at or above the level prescribed by § 141.66 for radon, and at or above the levels prescribed by § 141.25(c) for radioactive contaminants.

* * * * *

9. Section 141.153 is amended by revising paragraph (d)(1)(i); removing paragraph (e)(2) and redesignating paragraph (e)(3) as (e)(2); redesignating paragraphs (f)(5), (f)(6), and (f)(7) as (f)(6), (f)(7), and (f)(8); and adding paragraph (f)(5) to read as follows:

§ 141.153 Content of the reports.

* * * * *

(d) * * *

(1) * * *

(i) Contaminants subject to a MCL, AMCL, action level, or treatment technique (regulated contaminants);

* * * * *

(f) * * *

(5) Local multimedia radon mitigation programs prescribed by subpart R of this part.

* * * * *

10. Section 141.154 is amended by adding paragraph (f) as follows:

§ 141.154 Required additional health information.

* * * * *

(f) In each complete calendar year between [date of publication of final rule in the **Federal Register**] and [4 years after date of publication of the final rule in the **Federal Register**], each report from a system that has ground water as a source must include the following notice (except that a system developing a local MMM program in a non-MMM State needs to include this statement in each calendar year between [date of publication of the final rule in the **Federal Register**] and [5 years after date of publication of the final rule in the **Federal Register**] :

Radon is a naturally-occurring radioactive gas found in soil and outdoor air that may also be found in drinking water and indoor air. Some people exposed to elevated radon levels over many years in drinking water may have an increased risk of getting cancer. The main health risk is lung cancer from radon entering indoor air from soil under homes. Your water system plans to test for radon by [insert date], and if radon is detected your water system will provide the results of testing to their customers. The best way to reduce the overall risk from radon is to reduce radon levels in indoor air. Some States, and water systems, may now be working to develop a program to reduce radon exposure in indoor air and drinking water. To get more information and to help develop the program, call the Radon Hotline (800–SOS–RADON) or visit the web site http://www.epa.gov/iaq/radon/.

Subpart Q—[Amended]

11. In § 141.201, Table 1 proposed on May 13, 1999, at 64 FR 25964 is amended by revising paragraphs (1) introductory text and (1)(i) to read as follows:

§ 141.201 General Public Notification Requirements.

* * * * *

Table 1 to § 141.201—Violation Categories and Other Situations Requiring a Public Notice.

(1) NPDWR violations (MCL/AMCL, local MMM, MRDL, treatment technique, monitoring and testing procedure)

(i) Failure to comply with an applicable maximum contaminant level (MCL), alternative maximum contaminant level (AMCL), the local multimedia mitigation requirement for small systems in non-MMM States, or maximum residual disinfectant level (MRDL).

* * * * *

12. In § 141.203, Table 1 proposed on May 13, 1999, at 64 FR 25964 is amended by revising paragraph (1) to read as follows:

§ 141.203 Tier 2 Public Notice—Form, manner, and frequency of notice.

* * * * *

Table 1 to § 141.203. Violation Categories and Other Situations Requiring a Tier 2 Public Notice

(1) All violations of the MCL, AMCL, MRDL, and treatment technique requirements not included in the Tier 1 notice category;

* * * * *

13. In § 141.204, Table 1 proposed on May 13, 1999, at 64 FR 25964 is amended by adding paragraph (5) to read as follows:

§ 141.204. Tier 3 Public Notice—Form, manner, and frequency of notice.

* * * * *

Table 1 to § 141.204. Violation Categories and Other Situations Requiring a Tier 3 Public Notice

(5) All violations of the MMM requirements not included in the Tier 1 or 2 notice category;

* * * * *

14. Section 141.205 proposed on May 13, 1999, at 64 FR 25964 is amended by revising paragraph (d)(1), to read as follows:

§ 141.205 Content of the public notice.

* * * * *

(d) * * *

(1) *Standard health effects language for MCL, AMCL, MMM or MRDL violations, treatment technique violations, and violations of the condition of a variance or exemption.* Public water systems must include in each public notice the health effects language specified in Appendix B to this subpart corresponding to each MCL, AMCL, MMM, MRDL, and treatment technique violation listed in Appendix A to this subpart, and for each violation of a condition of a variance or exemption.

* * * * *

15. Part 141 is amended by adding a new Subpart R to read as follows:

Subpart R—Reducing Radon Risks In Indoor Air and Drinking Water

Subpart R—Reducing Radon Risks in Indoor Air and Drinking Water

§ 141.300 Applicability.

(a) The requirements of this subpart constitute national primary drinking water regulations for radon. The provisions of this subpart apply to community water systems (CWS) using a ground water source or using ground water and surface water sources. CWSs must monitor for radon in drinking water according to the requirements described in § 141.20, and report the results to the State, and continue to monitor as described in § 141.20. If the State determines that the CWS is in compliance with the MCL of 300 pCi/L, the CWS has met the requirements of this section and is not subject to the requirements of this subpart.

(b) These regulations in this subpart establish criteria for the development and implementation of program plans to mitigate radon in indoor air and drinking water (multimedia mitigation or MMM program plan). In general, where a State, CWS, or Tribal MMM program plan is approved, CWSs comply with an AMCL of 4000 pCi/L (§ 141.66). In jurisdictions without an approved MMM program plan, large CWSs (serving greater than 10,000 people) must comply with an MCL of 300 pCi/L (§ 141.66), except they comply with the AMCL of 4000 pCi/L if they develop a CWS MMM program plan approved by the State. Small community water systems serving 10,000 or fewer people must comply with 4000 pCi/L and implement a State-approved multimedia mitigation program plan to address radon in indoor air (unless the State in which the system is located has a multimedia mitigation program plan approved by the Environmental Protection Agency); these systems have the option of complying with the MCL instead of implementing a MMM program.

§ 141.301 General requirements.

(a) The requirements for the MMM program plan are set out in this subpart. The requirements for the MCL are set out in § 141.20(a) (analytical methods), § 141.20(b) (monitoring and compliance), § 141.66(a) through (c) (requirements for systems, including MCL and AMCL), and § 141.66(d) (BAT).

(b) *Compliance dates.*—(1) *Initial monitoring.* (i) For States that submit a letter to the Administrator by [90 days after date of publication of the final rule in the **Federal Register**] committing to develop an MMM program plan in accordance with section 1412(b)(13)(G)(v) of the Act, CWSs must begin one year of quarterly monitoring for compliance with the AMCL by [4.5 years after date of publication of the final rule in the **Federal Register**].

(ii) For States not submitting a letter to the Administrator by [90 days after date of publication of final rule in the **Federal Register**] committing to develop an MMM program plan, CWSs must begin one year of quarterly monitoring for compliance with the MCL/AMCL by [3 years after date of publication of final rule in the **Federal Register**].

(2) *State-wide MMM programs.* (i) For States that submit a letter to the Administrator by [90 days after date of publication of the final rule in the **Federal Register**] committing to develop an MMM program plan in accordance with section 1412(b)(13)(G)(v), implementation of the State-wide MMM program must begin by [4.5 years after date of publication of the final rule in the **Federal Register**].

(ii) For States not submitting a letter to the Administrator by [90 days after date of publication of the final rule in the **Federal Register**] committing to develop an MMM program plan, but which subsequently decide to adopt the AMCL, implementation of the State-wide MMM program must begin by [3 years after date of publication of the final rule in the **Federal Register**].

(iii) If EPA-approval of a State MMM program plan is revoked, all systems have one year from notification by the State to comply with the MCL. If a system chooses to continue complying with the AMCL and develop and implement a local MMM program, the State will specify a timeframe for compliance.

(3) Local MMM programs. (i) During the initial monitoring period, if the compliance determination for a CWS in a non-MMM State exceeds the MCL, the CWS will incur an MCL violation unless the system notifies the State by [four years after date of publication of the final rule in the **Federal Register**] of their intent to submit a local MMM plan, submits a local MMM plan to the State within [5 years after date of publication of the final rule in the **Federal Register**] and begins implementation by [5.5 years after date of publication of the final rule in the **Federal Register**]. The compliance determination will be conducted as described in § 141.20(b)(2).

(ii) Following the completion of the initial monitoring period, if the compliance determination for a CWS in a non-MMM State exceeds the MCL, the system will incur an MCL violation unless the system submits a local MMM plan to the State within 1 year from the date of the exceedence and begins implementation 1.5 years from the date of the exceedence. The compliance determination will be conducted as described in this paragraph.

(iii) The State shall approve or disapprove a local MMM program plan within 6 months from the date of receipt. If the State does not disapprove the local MMM program plan during such period, the CWS shall implement the plan submitted to the State for approval.

(iv) If the State determines the CWS is not adequately implementing the local MMM plan approved by the State, the system shall incur an MMM violation.

(v) During the MMM program 5-year review periods, the system shall incur an MMM violation if the State determines the CWS is not meeting MMM program plan objectives.

§ 141.302 Multimedia mitigation (MMM) requirements (required elements of MMM program plans).

The following are required for approval of State MMM program plans by EPA. Local MMM program plans developed by community water systems (CWS) are deemed to be approved by EPA if they meet these criteria (as appropriate for the local level) and are approved by the State. The term ''State'', as referenced next, means any entity submitting an MMM program plan for approval, including States, with and without primacy, Indian Tribes and community water systems.

(a) *Description of process for involving the public.* (1) States are required to involve community water system customers, and other sectors of the public with an interest in radon, both in drinking water and in indoor air, in developing their MMM program plan. The MMM program plan must include:

(i) A description of processes the State used to provide for public participation in the development of its MMM program plan, including the components identified in paragraphs (b), (c), and (d) of this section;

(ii) A description of the nature and extent of public participation that occurred, including a list of groups and organizations that participated;

(iii) A summary describing the recommendations, issues, and concerns arising from the public participation process and how these were considered in developing the State's MMM program plan; and

(iv) A description of how the State made information available to the public to support informed public participation, including information on the State's existing indoor radon program activities and radon risk reductions achieved, and on options considered for the MMM program plan along with any analyses supporting the development of such options.

(2) Once the draft program plan has been developed, the State must provide notice and opportunity for public comment on the draft plan prior to submitting it to EPA.

(b) *Quantitative goals.* (1) States are required to establish and include in their plans quantitative goals, to measure the effectiveness of their MMM program, for the following:

(i) Existing houses with elevated indoor radon levels that will be mitigated by the public; and

(ii) New houses that will be built radon-resistant by home builders.

(2) These goals must be defined quantitatively either as absolute numbers or as rates. If goals are defined as rates, a detailed explanation of the basis for determining the rates must be included.

(3) States are required to establish goals for promoting public awareness of radon health risks, for testing of existing homes by the public, for testing and mitigation of existing schools, and for construction of new public schools to be radon-resistant, or to include an explanation of why goals were not established in these program areas.

(c) *Implementation Plans.* (1) States are required to include in their MMM program plan implementation plans outlining the strategic approaches and specific activities the State will undertake to achieve the quantitative goals identified in paragraph (b) of this section. This must include implementation plans in the following two key areas:

(i) Promoting increased testing and mitigation of existing housing by the public through public outreach and education and during residential real estate transactions.

(ii) Promoting increased use of radon-resistant techniques in the construction of new homes.

(2) If a State has included goals for promoting public awareness of radon health risks; promoting testing of existing homes by the public; promoting testing and mitigation of existing schools; and promoting construction of new public schools to be radon resistant, then the State is required to submit a description of the strategic approach that will be used to achieve the goals.

(3) States are required to provide the overall rationale and support for why their proposed quantitative goals identified in paragraph (b) of this section, in conjunction with their program implementation plans, will satisfy the statutory requirement that an MMM program be expected to achieve equal or greater risk reduction benefits to what would have been expected if all community water systems in the State complied with the MCL.

(d) *Plans for measuring and reporting results.* (1) States are required to include in the MMM plan submitted to EPA a description of the approach that will be used to assess the results from implementation of the State MMM program, and to assess progress towards the quantitative goals in paragraph (b) of this section. This specifically includes a description of the methodologies the State will use to determine or track the number or rate of existing homes with elevated levels of radon in indoor air that are mitigated and the number or the rate of new homes built radon-resistant. This must also include a description of the approaches, methods, or processes the State will use to make the results of these assessments available to the public.

(2) If a State includes goals for promoting public awareness of radon health risks; testing of existing homes by the public; testing and mitigation of existing schools; and construction of new public schools to be radon-resistant; the State is required to submit a description of how the State will determine or track progress in achieving each of these goals. This must also include a description of the approaches, methods, or processes the State will use to make these results of these assessments available to the public.

§ 141.303 Multimedia mitigation (MMM) reporting and compliance requirements.

(a) In accordance with the Safe Drinking Water Act (SDWA), EPA is to review State MMM programs at least every five years. For the purposes of this review, the States with EPA-approved MMM program plans shall provide written reports to EPA in the second and fourth years between initial implementation of the MMM program and the first 5-year review period, and in the second and fourth years of every subsequent 5-year review period. States that submit a letter to the Administrator by [90 days after date of publication of the final rule in the **Federal Register**] committing to develop an MMM program plan, must submit their first 2-year report by 6.5 years from publication of the final rule. For States not submitting the 90-day letter, but choosing subsequently to submit an MMM program plan and adopt the AMCL, the first 2-year report must be submitted to EPA by 5 years from publication of the final rule. EPA will review these programs to determine whether they continue to be expected to achieve risk reduction of indoor radon using the information provided in the two biennial reports.

(b)(1) These reports are required to include the following information:

(i) A quantitative assessment of progress towards meeting the required goals described in § 141.302(b), including the number or rate of existing homes mitigated and the number or rate of new homes built radon-resistant since implementation of the States' MMM program, and,

(ii) A description of accomplishments and activities that implement the required program strategies, described in § 141.302(c), outlined in the implementation plans and in the two required areas of promoting increased testing and mitigation of existing homes and promoting increased use of radon-resistant techniques in construction of new homes.

(2) If goals were defined as rates, the State must also provide an estimate of the number of mitigations and radon-resistant new homes represented by the reported rate increase for the two-year period.

(3) If the MMM program plan includes goals for promoting public awareness of the health effects of indoor radon, testing of homes by the public; testing and mitigation of existing schools; and construction of new public schools to be radon-resistant, the report is also required to include information on results and accomplishments in these areas.

(c) If EPA determines that a MMM program is not achieving progress towards its goals, EPA and the State shall collaborate to develop modifications and adjustments to the program to be implemented over the five year period following the review. EPA will prepare a summary of the outcome of the program evaluation and the proposed modification and adjustments, if any, to be made by the State.

(d) If EPA determines that a State MMM program is not achieving progress towards its MMM goals, and the State repeatedly fails to correct, modify and adjust implementation of their MMM program after notice by EPA, EPA will withdraw approval of the State's MMM program plan. CWSs in the State would then be required to comply with the MCL, or develop a State-approved CWS MMM program plan. The State will be responsible for notifying CWSs of the Administrator's withdrawal of approval of the State-wide MMM program plan. EPA will work with the State to establish a State process for review and approval of CWS MMM program plans that meet the required criteria, including local public participation in development and review of the program plan, and a time frame for submission of program plans by CWSs that choose to continue complying with the AMCL.

(e) States shall make available to the public each of these two-year reports identified in paragraph (a) of this section, as well as the EPA summaries of the five-year reviews of a State's MMM program, within 90 days of completion of the reports and the review.

(f) In primacy States without a State-wide MMM program, the States shall provide a report to EPA every five-years on the status and progress of CWS MMM programs towards meeting their goals. The first of such reports would be due by [10.5 years after date of publication of the final rule in **Federal Register**].

§ 141.304 Local multimedia mitigation program plan approval and program review.

(a) In States without an EPA-approved MMM program plan, any community water system may elect to develop and implement a local MMM program plan that meets the criteria in § 141.302 and comply with the AMCL in lieu of the MCL. Local CWS MMM program plans must be approved by the State.

(b) CWSs with State-approved MMM program plans shall report to the State as required by the State. States shall review such local programs at least every five years to determine if CWSs are implementing their program plans and making progress towards their goals. If the CWS fails to meet those requirements, the State shall require the system to comply with the MCL.

§ 141.305 States that do not have primacy.

(a) If a State, as defined in section 1401 of the Act, that does not have primary enforcement responsibility for the Public Water System Program under section 1413 of the Act chooses to submit an MMM program plan to EPA, that program plan must meet the criteria in § 141.301. EPA will approve such program plans in accordance with the requirements of § 141.302.

(b) States with EPA-approved MMM program plans shall report to EPA in accordance with the requirements of § 141.303.

PART 142—NATIONAL PRIMARY DRINKING WATER REGULATIONS IMPLEMENTATION

1. The authority citation for part 142 continues to read as follows:

Authority: 42 U.S.C. 300f, 300g–1, 300g–2, 300g–3, 300g–4, 300g–5, 300g–6, 300j–4, 300j–9, and 300j–11.

2. Section 142.12 is amended by adding new paragraph (b)(4) to read as follows:

§ 142.12 Revision of State programs.

* * * * *

(b) * * *

(4) To be granted an extension for radon regulatory requirements included under 40 CFR part 141, subpart R, the State must commit to adopt the AMCL and MMM program plan, or MCL.

* * * * *

3. Section 142.15 is amended by adding new paragraph (c)(6) to read as follows:

§ 142.15 Reports by States.

* * * * *

(c) * * *

(6) In accordance with the Safe Drinking Water Act (SDWA), EPA is to review State MMM programs at least every five years. EPA will review these programs to determine whether they continue to be expected to achieve risk reduction of indoor radon using the information provided in the two biennial reports. For the purposes of this review:

(i)(A) States with EPA-approved MMM program plans shall provide written reports to EPA in the second and fourth years between initial implementation of the MMM program and the first 5-year review period, and in the second and fourth years of every subsequent 5-year review period.

(B) States that submit a letter to the Administrator by [90 days after date of publication of the final rule in the **Federal Register**] committing to develop an MMM program plan, must submit their first 2-year report by [6.5 years after date of publication of the final rule in the **Federal Register**]. For States not submitting the 90-day letter, but choosing subsequently to submit an MMM program plan and adopt the AMCL, the first 2-year report must be submitted to EPA by [5 years after date of publication of the final rule in the **Federal Register**].

(ii) These reports are required to include the following information:

(A) A quantitative assessment of progress towards meeting the required goals described in § 141.302(b), including the number or rate of existing homes mitigated and the number or rate of new homes built radon-resistant since implementation of the States' MMM program, and

(B) A description of accomplishments and activities that implement the required program strategies, described in § 141.302(c), outlined in the implementation plans and in the two required areas of promoting increased testing and mitigation of existing homes and promoting increased use of radon-resistant techniques in construction of new homes.

(C) If goals were defined as rates, the State must also provide an estimate of the number of mitigations and radon-resistant new homes represented by the reported rate increase for the two-year period.

(D) If the MMM program plan includes goals for promoting public awareness of the health effects of indoor radon, testing of homes by the public; testing and mitigation of existing schools; and construction of new public schools to be radon-resistant, the report is also required to include information on results and accomplishments in these areas.

(iii) States shall make available to the public each of these two-year reports, as well as the EPA summaries of the five-year reviews of a State's MMM program, within 90 days of completion of the reports and the review.

(iv) In primacy States without a State-wide MMM program, the States shall provide a report to EPA every five-years on the status and progress of CWS MMM programs towards meeting their goals. The first of such reports would be due by [10.5 years after date of publication of the final rule in the **Federal Register**].

* * * * *

4. Section 142.16 is amended by adding new paragraph (i) to read as follows:

§ 142.16 Special primacy requirements.

* * * * *

(i) Requirements for States to adopt 40 CFR part 141, subpart R. In addition to the general primacy requirements elsewhere in this part, including the requirement that State regulations be at least as stringent as federal requirements, an application for approval of a State program revision that adopts 40 CFR part 141, subpart R, must contain a description of how the State will accomplish the program requirements for implementation of the AMCL and MMM program plan or the MCL as follows:

(1) If a State chooses to develop and implement a State-wide MMM program plan and adopt the AMCL, the primacy application must include the following elements:

(i) A copy of the State-wide MMM program plan prepared to meet the criteria outlined in § 141.302 of this chapter.

(ii) A description of how the State will make resources available for implementation of the State-wide MMM program plan.

(iii) A description of the extent and nature of coordination between interagency programs (*i.e.,* indoor radon and drinking water programs) on development and implementation of the MMM program plan, including the level of resources that will be made available for implementation and coordination between interagency programs (*i.e.,* indoor air and drinking water programs).

(2) If a State chooses to adopt the MCL the primacy application must contain the following:

(i) A description of how the State will implement a program to approve local CWS MMM program plans prepared to meet the criteria outlined in § 141.302 of this chapter and a description of the State's authority to implement this program.

(ii) A description of how the State will ensure local CWS MMM program plans are implemented.

(iii) A description of reporting and record keeping requirements for local CWS MMM programs.

(iv) A description of how the State will review local CWS program plans at least every five years to determine if they are implementing the MMM program and making progress towards their goals.

(v) A description of the procedures and schedule the State will use in withdrawing State approval of a CWS MMM program plan and notifying the CWS that they are required to comply with the MCL.

(vi) A description of the extent and nature of coordination between interagency programs (*i.e.,* indoor radon and drinking water programs) on development and implementation of the State process for review and approval of CWS MMM program plans. This description includes the level of resources that will be made available for implementation and coordination between interagency programs (*i.e.,* indoor air and drinking water programs).

(vii) A description of how the State will make required CWS reports available to the public.

5. A new § 142.65 is added to subpart G, to read as follows:

§ 142.65. Variances and exemptions from the maximum contaminant level for radon.

(a) The Administrator, pursuant to section 1415(a)(1)(A) of the Act, hereby identifies in the following table as the best technology, treatment techniques, or other means available for achieving compliance with the maximum contaminant level for radon:

BAT for Radon–222

1. For all systems: High-Performance Aeration [1]

2. For systems serving 10,000 persons or fewer: High-Performance Aeration [1] or [2], Granular Activated Carbon [2] (GAC), and Point-of-Entry GAC [2].

(b) A State shall require a community water system to install and/or use any treatment method identified in paragraph (a) of this section as a condition for granting a variance, based upon an evaluation satisfactory to the State that indicates that alternative sources of water are not reasonably available to the system.

(c) Bottled water and/or granular activated carbon point-of-use devices cannot be used as means of being granted a variance or an exemption for radon.

(d) Community water systems that use point-of-entry devices as a condition for obtaining a variance or an exemption from NPDWRs must meet the following requirements:

(1) All point-of-entry units shall be owned, controlled, and maintained by the community water system or by a person or persons under contract with the public water system to ensure proper operation and maintenance of the unit under the terms of the variance or exemption.

(2) All point-of-entry units shall be equipped with mechanical warning devices to ensure that customers are notified of operational problems.

(3) If the American National Standards Institute has issued product standards applicable to a specific type of point-of-entry device for radon,

[1] High Performance Aeration is defined as the group of aeration technologies that are capable of being designed for high radon removal efficiencies, *i.e.,* Packed Tower Aeration, Multi-Stage Bubble Aeration and other suitable diffused bubble aeration technologies, Shallow Tray and other suitable Tray Aeration technologies, and any other aeration technologies that are capable of similar high performance.

[2] As defined and described in 40 CFR 141.66 (e).

individual units of that type shall not be accepted under the terms of the variance or exemption unless they are independently certified in accordance with such standards.

(4) Before point-of-entry devices are installed, the community water system must obtain the approval of a monitoring plan which ensures that the devices provide health protection equivalent to analogous centralized water treatment.

(5) The community water system must apply effective technology under a State-approved plan. The microbiological safety of the water must be maintained at all times.

(6) The State must require adequate certification of performance, field testing, and, if not included in the certification process, a rigorous engineering review of the point-of-entry devices.

(7) The design and application of point-of-entry devices must consider the potential for increasing concentrations of heterotrophic bacteria in water treated with activated carbon. It may be necessary to use frequent backwashing, post-GAC contactor disinfection, and Heterotrophic Plate Count monitoring to ensure that the microbiological safety of the water is not compromised.

6. Section 142.72 is amended by removing the introductory text, by redesignating paragraphs (a) through (d) as (b)(1) through (b)(4), and by adding a new paragraph (a) to read as follows:

§ 142.72. Requirements for Tribal eligibility.

(a) If a Tribe meets the criteria in paragraph (b) of this section, the Administrator is authorized to treat an Indian Tribe as eligible to apply for:

(1) Primary enforcement responsibility for the Public Water System Program:

(2) Authority to waive the mailing requirements of 40 CFR 141.155(a); and

(3) Authority to develop and implement a radon multimedia mitigation program in accordance with 40 CFR part 141, subpart R.

* * * * *

7. Section 142.78 is amended by revising paragraph (b) to read as follows:

§ 142.78. Procedure for processing an Indian Tribe's application.

* * * * *

(b) A Tribe that meets the requirements of § 142.72 is eligible to apply for development grants and primary enforcement responsibility for a Public Water System and associated funding under section 1443(a) of the Act, for primary enforcement responsibility for public water systems under section 1413 of the Act, for the authority to waive the mailing requirements of 40 CFR 141.155(a), and for the authority to develop and implement a radon multimedia mitigation program in accordance with 40 CFR part 141, subpart R.

8. Part 142 is amended by adding a new Subpart L to read as follows:

Subpart L—Review of State MMM Programs

§ 142.400 Review of State MMM programs and procedures for withdrawing approval of State MMM programs.

(a)(1)At least every five years, the Administrator shall review State MMM programs. For the purposes of this review, States with EPA-approved MMM programs shall provide written reports to the Administrator in the second and fourth years between initial implementation of the MMM program and the first 5-year review period, and in the second and fourth years of every subsequent 5-year review period. The written reports will discuss the status and progress of their program towards meeting their MMM goals. The Administrator will use the information provided in the two biennial reports in discussions and consultations with the State to review the programs to determine whether they continue to be expected to achieve risk reduction of indoor radon.

(2) If the Administrator determines that a State MMM program is not achieving progress towards its MMM goals, the Administrator and the State shall collaborate to develop modifications and adjustments to the program to be implemented over the five year period following the review. EPA will prepare a summary of the outcome of the program evaluation and the proposed modification and adjustments, if any, to be made by the State.

(3) If the State repeatedly fails to correct, modify or adjust implementation of its MMM program after notice by the Administrator, the Administrator shall initiate proceedings to withdraw approval of the State's MMM program plan. The Administrator shall notify the State in writing that EPA is initiating withdrawing a State-wide MMM program plan and shall summarize in the notice the information available that indicates that the State is no longer achieving progress towards its MMM goals.

(4) The State notified pursuant to paragraph (a)(3) of this section may, within 30 days of receiving the Administrator's notice, submit to the Administrator evidence that the State plans to implement modifications to the State MMM program.

(5) After reviewing the submission of the State, if any, made pursuant to paragraph (a)(4) of this section, the Administrator shall make a final determination either that the State no longer continues to achieve progress towards its MMM goals, or that the State continues to implement modifications to the State MMM program, and shall notify the State of his or her determination. Before a final determination that the State no longer continues to achieve progress towards its MMM goals, the Administrator shall offer a public hearing and will publish a notice in the **Federal Register**.

(b) If approval of a State's MMM program is withdrawn, the State will be responsible for notifying CWSs of the Administrator's withdrawal of approval of the State-wide MMM program plan. The CWSs in the State would then be required to comply with the MCL. EPA will work with the State to establish a State process for review and approval of CWS MMM program plans that meet the required criteria and a time frame for submittal of program plans by CWSs that choose to continue complying with the AMCL. The review process will allow for local public participation in development and review of the program plan.

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