Radionuclides Rule Training

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EPA United States Environmental Protection Agency

Office of Water

Disclaimer

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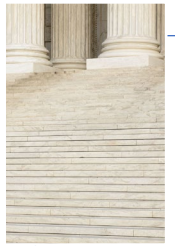
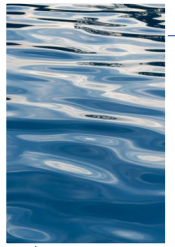
Introduction

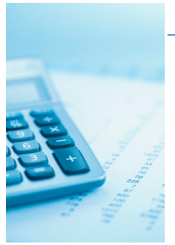


The history and importance of the Radionuclides Rule

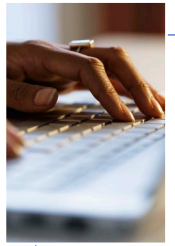


Monitoring requirements

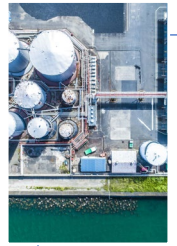
Analytical methods



Compliance calculations



Reporting and recordkeeping requirements



Compliance options

Relevance

- As EPA staff, primacy agencies, water system operators, and technical assistance (TA) providers, it's important that you have an understanding of the Radionuclides Rule and its requirements, as well as why it is important that all community water systems (CWSs) are compliant, in order to best protect public health.

Radionuclide Rule History and Importance

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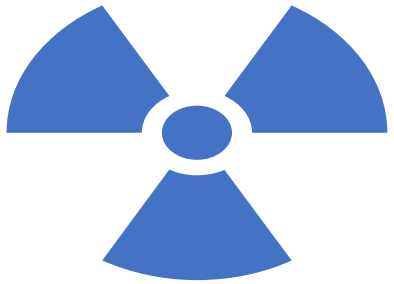
Radionuclide Sources

Naturally occurring radionuclides

- Geological (higher presence in some areas or regions)



Manmade radionuclides

- Nuclear weapons & power plants
- Hospitals/medical facilities
- Industry

Types of Radiation

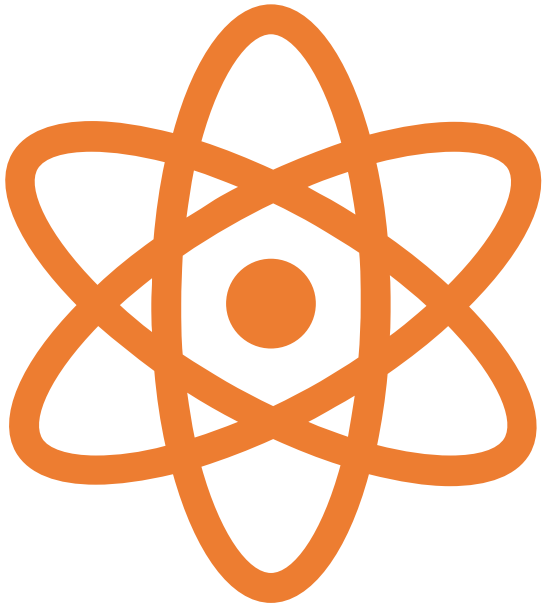
Ionizing vs. non-ionizing

Non-ionizing radiation:

- Microwaves
- Radio waves

Ionizing radiation:

- X-ray
- Alpha radiation (Ra-226, uranium)
- Beta radiation (Ra-228)
- Gamma radiation (Ra-226)



Health Effects of Radiation

Chronic exposure to radionuclides is proven to contribute to negative health outcomes, including:

- Tissue damage
- Cancer
- Congenital defects
- Kidney toxicity (uranium)

Radionuclide Rule History

1976

First radionuclide regulations under the authority of the 1974 Safe Drinking Water Act (SDWA)

1991

The EPA revised existing regulations and proposed new regulations for uranium

2000

EPA published the Final Radionuclides Rule, effective December 8, 2003.

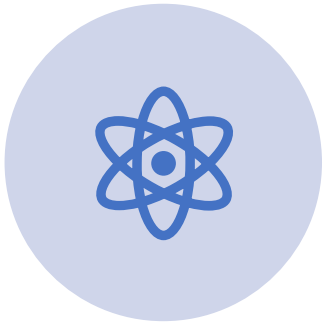
2004

The EPA published minor corrections to the Rule, which included the addition of a detection limit (DL) for uranium.

The Radionuclide Rule

- Published in December 2000
- Effective December 8, 2003
- Applies to all CWSs
- Monitor at all entry points to the distribution system (EPTDS)
- Aligns with Standard Monitoring Framework
- Intended to reduce the public's exposure to radionuclides in drinking water and improve public health
- Codified at 40 CFR 141.26 and 141.66

Which Radionuclides are Regulated?



Radium-226 &

Radium 228

Uranium

Gross alpha particle radioactivity

Beta particle and photon radioactivity

Maximum Contaminant Level Goals (MCLG)

Radionuclide	MCLG
Combined Ra-226 and Ra-228	Zero
Gross alpha particle activity	Zero
Uranium	Zero
Beta/photon emitters	Zero

Maximum Contaminant Levels (MCLs)

Radionuclide	MCL
Combined Ra-226 and Ra-228	5 picocuries per liter (pCi/L)
Gross alpha particle activity	15 pCi/L
Uranium	30 microgram per liter (µg/L)
Beta/photon emitters	4 millirem/year (mrem/year)*

* This is a dose rather than a measure of radioactivity.

Beta/Photon Applicability

- States determine if a water system is contaminated by or vulnerable to beta and photon emitters
- Vulnerability should be determined by:
  - An evaluation of the quality, completeness, and results of any historical beta/photon monitoring
  - The Nuclear Regulatory Commission's list of licensees and locations
  - The location and proximity of the drinking water facility to nuclear power facilities, military bases, etc.
  - Geology of the aquifer and/or hydrology of the watershed
- Systems designated as vulnerable by the State must continue to sample until the State reviews and either reaffirms or removes the designation

Monitoring Requirements

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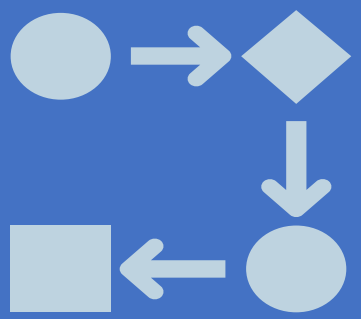
Gross Alpha, Ra-226, Ra-228, and Uranium

- Monitoring requirements
- Monitoring frequency
- Monitoring locations

Initial Monitoring Gross Alpha, Ra-226, Ra-228, and Uranium

- Applies to new systems and systems using a new source
- Four consecutive quarters at each EPTDS
  - States can waive the last two quarters of sampling if previous two quarters were below DL
- Substitution for gross alpha may be allowed
  - Sample(s) for uranium are required if the gross alpha level is greater than 15 pCi/L
  - Sample(s) for Ra-226 are required if the gross alpha level is greater than 5 pCi/L
- Compositing monitoring samples

Consecutive Public Water Systems (PWSs) Monitoring



When a PWS supplies water to one or more other water systems, the state may allow the interconnection to be treated as a single system for monitoring purposes. Because the interconnection is not the EPTDS, completely consecutive systems are not required to monitor under the Radionuclides Rule.

Any modified monitoring schedule must be specified by the state and approved by EPA.

Routine/Reduced Monitoring Gross Alpha, Ra-226, Ra-228, and Uranium

- Use the running annual average (RAA) from initial monitoring or the most recent monitoring result to determine routine or reduced sampling frequency
- Schedules are determined for each contaminant and for each EPTDS
- Reduced monitoring at 3, 6, or 9-year frequencies

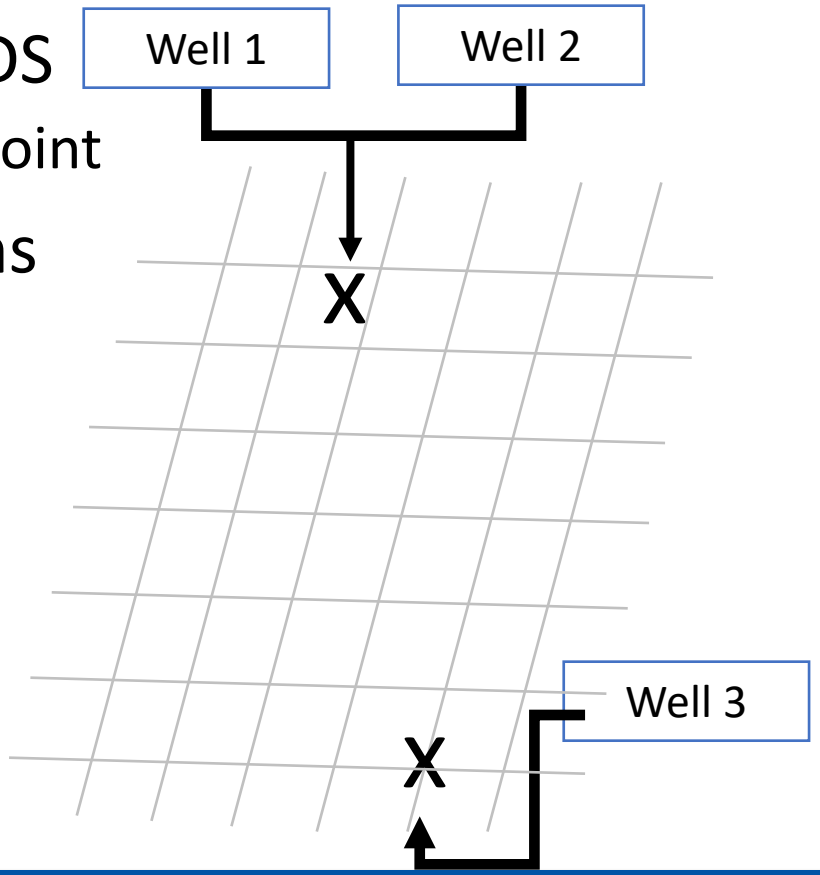
Monitoring Frequency Gross Alpha, Ra-226, Ra-228, and Uranium

Trigger Level	Monitoring Frequency
< DL	1 sample every 9 years
≧ DL but ≤ one-half MCL	1 sample every 6 years
> one-half MCL but ≤ MCL	1 sample every 3 years
> MCL	Quarterly samples until RAA is < MCL

Note: It is possible to have different monitoring frequencies per contaminant at the same EPTDS.

Monitoring Locations

- Sample for each radionuclide at each EPTDS
  - State can designate representative sampling point
- Sample during normal operating conditions
  - Water should represent all sources in use



Beta/Photon Emitters

- Monitoring requirements
- Monitoring frequency

FOR

- Vulnerable Systems
- Contaminated Systems

Monitoring for Beta/Photon Emitters

	Quarterly	Annually
Vulnerable Systems	Gross Beta	Tritium & Strontium-90
Contaminated Systems	Gross Beta & Iodine-131	

- Systems in the vicinity of nuclear facilities
  - Environmental surveillance data
  - Applies to systems designated as vulnerable or contaminated

Reduced Monitoring Beta/Photon Emitters

If RAA of Gross Beta Minus Potassium-40 is…	Monitoring Frequency
≤ 50 pCi/L in Vulnerable Systems	1 sample every 3 years
≤ 15 pCi/L in Contaminated Systems	1 sample every 3 years

Increased Monitoring Beta/Photon Emitters

- Exceedance of gross beta minus potassium-40
  - Speciate for most likely emitters
- MCL violation
  - Monthly monitoring
- Beta emitter concentration units
  - Conversion between mrem/year (exposure) and pCi/L (activity)

Analytical Methods

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Gross Alpha Analysis

- Two basic analytical methodologies
  - Evaporation
  - Coprecipitation
- Depending on gross alpha values, substitution for uranium and Ra-226 measurements will impact monitoring frequency

Ra-226 Analysis

- Two basic analytical methodologies
  - Radiochemical
  - Emanation
- Can substitute gross alpha analysis if less than 5 pCi/L
  - Potential maximum reduction of monitoring frequency to once every six years if using gross alpha substitution

Ra-228 Analysis

- Single basic analytical methodology
  - Radiochemical
- No substitution for the Ra-228 measurement

Uranium Analysis

- Several methodologies
  - Radiochemical
  - Fluorometric
  - Alpha spectrometry
  - ICP-MS
  - Laser phosphorimetry
- Can substitute gross alpha result if less than 15 pCi/L (conversion factor 1.49 µg/pCi)
  - Potential maximum reduction of monitoring frequency to once every six years

Beta Particle and Photon Radioactivity Analysis

- Can subtract beta activity from K-40 to determine compliance status for gross beta
- Laboratory can measure total elemental K in units of mg/L and multiply the result by 0.82 pCi/mg to determine activity from K-40

DLs for Gross Alpha, Ra-226, Ra-228, and Uranium

Radionuclide	DL
Gross alpha particle activity	3 pCi/L
Radium 226	1 pCi/L
Radium 228	1 pCi/L
Uranium	1 µg/L

DLs for Beta Particle and Photon Emitters

Radionuclide	DL
Tritium	1,000 pCi/L
Strontium-89	10 pCi/L
Strontium-90	2 pCi/L
Iodine-131	1 pCi/L
Cesium-134	10 pCi/L
Gross beta	4 pCi/L
Other radionuclides	1/10 of the application limit

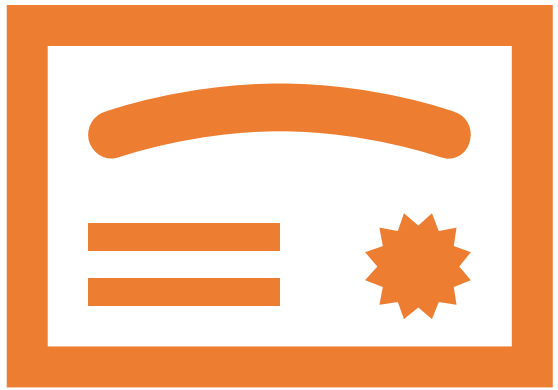
Alternate Techniques

An alternate analytical technique may be used with the written permission of the state and approval by EPA

- Precision and accuracy in determining compliance with the MCL must be equivalent to the preferred technique
- Does not reduce the required monitoring frequency

Certified Laboratories

- Radionuclide samples may only be used for determining compliance if they have been analyzed by a laboratory certified by the state.
- Commercial labs are certified by state labs, and state labs are certified by EPA regional labs.



Laboratory Issues

- DL determined by counting times and sample volume
- Low throughput
- Expense of analysis

Compliance Calculations

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Determining Compliance for Gross Alpha, Ra-226, Ra228, and Uranium

- Analytical result at each EPTDS
- Systems monitoring less than once per year
- Systems monitoring more than once per year, MCL violations as determined by RAA occur when:
  - Any sampling point's RAA violates MCL
  - Any sample results causes RAA to exceed MCL
- New systems/new sources

RAA to Determine Monitoring Requirements

Ground Water System Monitors for Gross Alpha (MCL 15 pCi/L)	
Date	Result
Jan 06	9
Apr 06	13
Jul 06	12
Oct 06	10
RAA	11

Rounding Memo

System must collect gross alpha samples from this EPTDS once every three years

$$\frac{9 + 13 + 12 + 10}{4} = 11$$

Substituting Gross Alpha for Ra-226

If Gross Alpha Is:	For Ra-226 Use:	Calculate Combined Ra Value:	Determines
< Detect	½ DL reported by lab	½ DL reported by lab + Ra-228	Reduced monitoring frequency (Quarterly, 3, or 6 years)
≥ Detect but ≤ 5	Gross alpha result	Gross alpha result + Ra-228	Compliance with MCL Reduced monitoring frequency (Quarterly or 3 years)

Substituting Gross Alpha for Uranium

Gross Alpha Result	Substitution:
≤ 15 pCi/L	Assume all gross alpha = Uranium
> 15 pCi/L	Require Uranium sampling & calculate net alpha

Calculating Net Gross Alpha

1. Lab analyzes and reports activity measurement to the state **OR** converts uranium by one of two means:
    - Convert uranium mass to activity
        - Multiply by 0.67 pCi/µg
    - Convert uranium activity to mass
        - Multiply by 1.49 µg/pCi
2. Gross alpha activity minus uranium
3. State uses “net” result for compliance/monitoring determination

FAQs about Substitution

- Regarding the conversion factor, are there any geographic limitations to its use, and may other conversion factors be used?
  - The use of the conversion factor of 0.67 for U-234:U-238 is based on a conservative assumption and is not intended to be accurate, but instead to provide a conservative screening-level value when the less costly U-mass analysis is used.
- Can the primacy agency tell the system to analyze for isotopic uranium activity (instead of using the conservative conversion from uranium mass) to use in the MCL compliance calculation?
  - A system cannot be compelled to (re)analyze for isotopic uranium activity to calculate the gross alpha, but this can be recommended as it will provide a more definitive measure.
  - There is no “rule of thumb” for a level of uranium at which you should change your analytical approach. This must be evaluated on a case-by-case basis.

Determining Compliance for Gross Beta and Photon Emitters

- Sum of the fractions
- MCL = 4 mrem/year
- Conversion tables listed in “Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air or Water for Occupational Exposure”
  - Simplified version in EPA’s Radionuclides in Drinking Water: A Small Entity Compliance Guide

Sum of the Fractions: Beta Particle and Photon Emitters Example

	X	Y	X/Y	4(X/Y)
Emitter	Lab Analysis (pCi/L)	Conversion factor from table (pCi/4mrem)	Calculate Fraction	Calculate Total (mrem)
Cs-134	5,023	20,000	0.25115	1.0046
Cs-137	30	200	0.150	0.6
Sr-90	4	8	0.5	2
I-131	2	3	0.7	2.8
			Sum of Fractions = 1.60115	**6**

6.4046 mrem is rounded to 6 mrem.

Violations for Gross Alpha, Radium-226/228, and Uranium

- If one sampling point within a water system is in violation of an MCL, the whole system is in violation of the MCL and thus is out of compliance.
  - **Systems monitoring > annually**: compliance with the MCL is determined by the RAA at each sampling point
  - **Systems monitoring < annually**: if any sample result will cause the running average to exceed the MCL at any sampling point, the system is immediately out of compliance with the MCL
  - **Include all samples taken and analyzed**
  - **Sample result < DL**: zero will be used to calculate the RAA, unless a gross alpha particle activity is being used in lieu of radium-226 and/or uranium
    - Gross alpha particle activity result < detection: 1⁄2 the DL will be used to calculate the RAA

Reporting and Recordkeeping Requirements

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General Water System Reporting Requirements

Radionuclides results: Report **within 10 days** following the month when results were received or within 10 days of end of monitoring period

Failure to comply with Radionuclides Rule: Report **within 48 hours** of learning of the violation or situation

Tier 2 or Tier 3 public notice (PN) and certification: Report **within 10 days** of completing PN requirements

Reporting MCL Violations

- The RAA of samples at any EPTDS is above the MCL
  - If any one sample is 4 times the MCL **OR**
  - If any one quarterly sample would cause the RAA to exceed the MCL
- Average annual concentration of beta particle and photon radioactivity is greater than 4 mrem/year

System must report violation to state within 48 hours

Reporting Monitoring and Reporting (M/R) Violations

- Failure to sample during required compliance period
- Failure to sample at required frequency
- Failure to report sample results with 10 days following end of compliance period
- Failure to correctly analyze sample or use of uncertified laboratory

System must report violation to state within 48 hours

Violations Requiring Tier 2 PN

- Public Notification Rule (PN Rule) requires systems to provide PN for violations and certain situations
  - Three tiers of PN are based on the seriousness of the violation or situation
- Radionuclides Rule MCL violations requiring Tier 2 PN
- Appendix A to Subpart Q (Section F)

Tier 2 PN Requirements

- Basic Tier 2 PN requirements (form, manner, and frequency)

MCL Violation: **Notify the state within 48 hours of the violation**

Notify customers: **As soon as practical but no later than 30 days**
Send a copy of PN to the state: **Within 10 days of notifying customers**

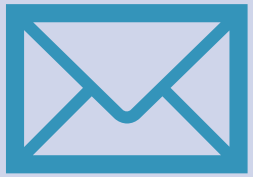
Violations Requiring Tier 3 PN

- Radionuclides Rules violation/situations requiring Tier 3 PN:
  - Failure to monitor as required
  - Failure to comply with required testing procedure or approved analytical methods
  - Failure to meet DLs
- Appendix A to Subpart Q (Section F)

Tier 3 PN Requirements

- Basic Tier 3 PN requirements (form, manner, and frequency)

Notify customers: **Within 12 months**
Notification may be included in Consumer Confidence Report (CCR)
Send a copy of PN to the state: **Within 10 days of notifying customers**

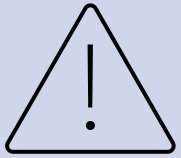


Water System Recordkeeping Requirements

- Radionuclide analyses – **10 years**
- Variances from radionuclide MCLs – **5 years** after variance or exemption expires
- Documentation of correction of violations – **3 years**
- Copies of PN documentation – **3 years**

Primacy Agency Reporting Requirements

All Radionuclides Rule violations

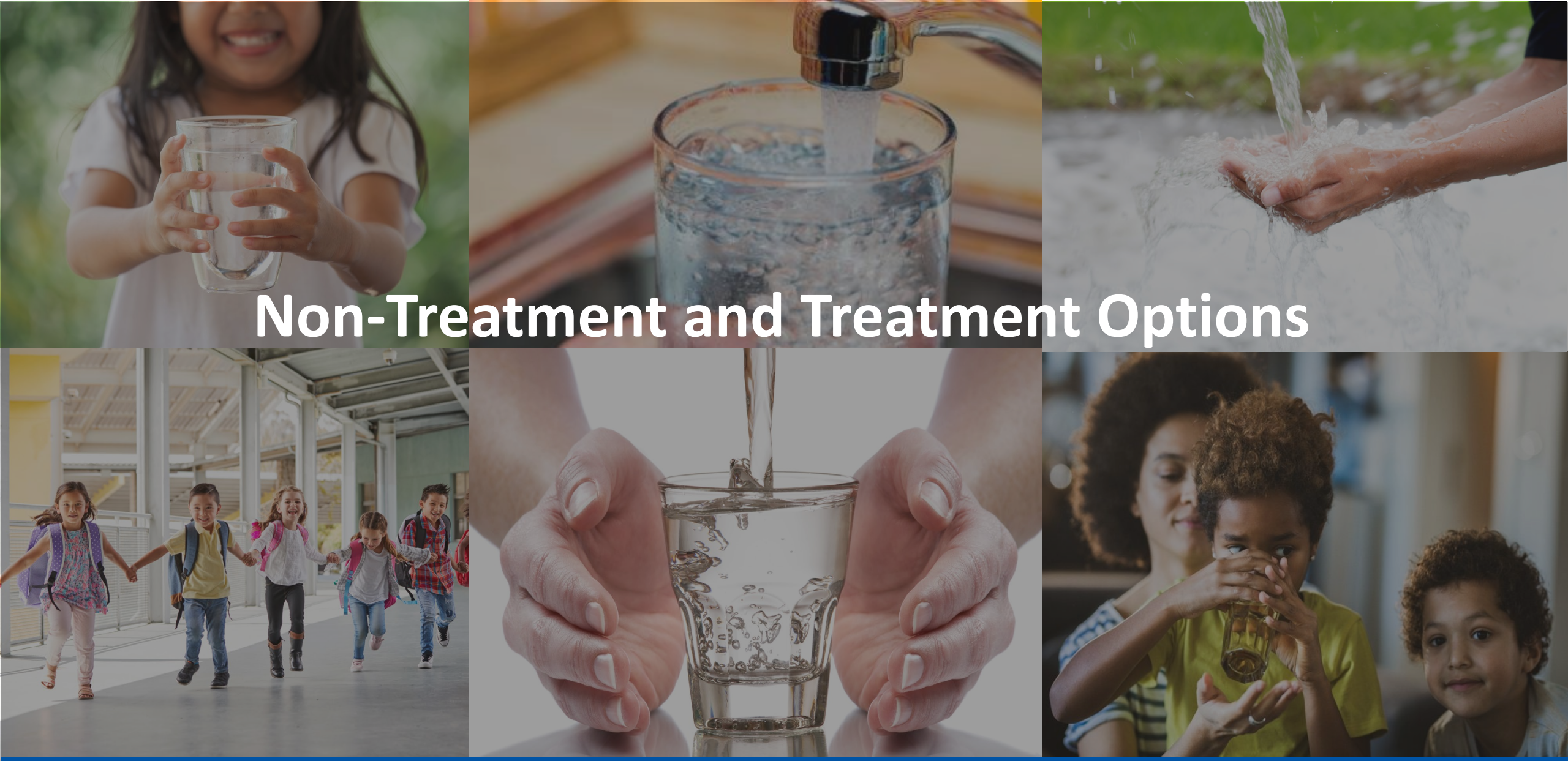


Radionuclides Rule enforcement actions taken by primacy agency

Radionuclides Rule enforcement actions taken by primacy agency

Primacy Agency Recordkeeping Requirements

- PN certifications, copies of PNs and records, state determinations establishing alternative PN requirements – **3 years**
- Radionuclide variance and exemption determination documentation – **5 years after variance or exemption expires**
- Current inventory information for every PWS – **12 years**
- Records of state approvals – **12 years**
- Records of radionuclide enforcement actions – **12 years**
- Monitoring requirements and primacy agency monitoring frequency decision documentation – **in perpetuity**



Non-Treatment and Treatment Options

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Non-Treatment Options

Finding a Better Source of Water

- Find another, higher quality, water source(s) with little to no radionuclide concentrations

Blending Source Waters

- Combine contaminated source with another source with radionuclide levels below the MCL prior to distribution

Interconnecting or Consolidating

- Interconnect with and/or purchase water from a nearby system, or consolidate with a nearby system

Treatment Options

- Can you modify existing treatment to remove radionuclides while still meeting the original goal of treatment?
- Considerations for choosing treatment options:
  - What kind of compliance problem is the system dealing with?
  - Size and location of the system
  - Average demand
  - Levels and types of radionuclides in the source water
  - Disposal options
  - Capital and operation and maintenance costs
  - Operator expertise

Best Available Technologies (BATs)

Contaminant	BAT
Combined Ra-226 and Ra-228	Ion exchange, reverse osmosis, lime softening
Uranium	Ion exchange, reverse osmosis, lime softening, coagulation/filtration
Gross alpha particle activity (excluding Radon and Uranium)	Reverse osmosis
Beta particle and photon radioactivity	Ion exchange, reverse osmosis

Note: CWSs are not required to use the EPA-identified BATs.

Small System Compliance Technologies (SSCTs)

Unite Technologies	Raw Water Quality Range and Considerations
Ion exchange	All ground waters
Point-of-use ion exchange	All ground waters
Reverse osmosis	Surface waters usually require pre-filtration
Lime softening	All waters
Electrodialysis/electrodialysis reversal	All ground waters
Pre-formed hydrous Manganese oxide filtration	All ground waters
Activated alumina	All ground waters; competing anion concentrations may affect regeneration frequency
Coagulation/filtration	Can treat a wide range of water qualities

Radionuclides Rule Variances

- Variances allow for a system to exceed an MCL due to its source water quality
  - Variances are granted by the primacy agency
  - Must still be protective of human health
- Variances can be granted for MCL exceedances of all radionuclides
  - Includes combined Ra-226/228, uranium, gross alpha particle activity (excluding Radon and Uranium), and beta particle and photon radioactivity
- Small system variances are not available for any of the radionuclide MCLs

Concluding Notes

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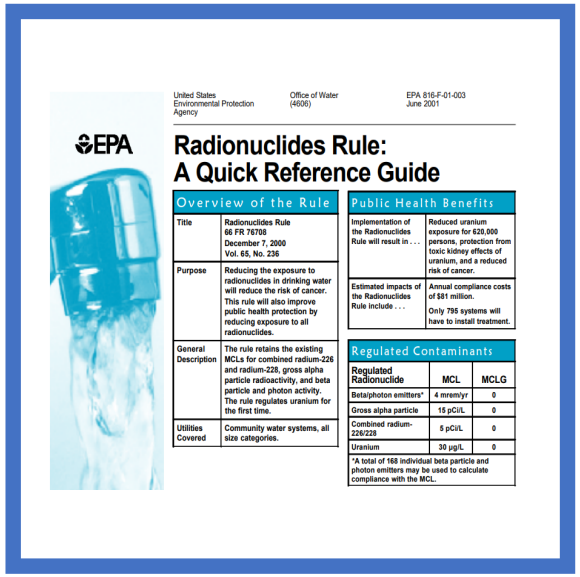
Training Summary

- The purpose and importance of the Radionuclides Rule
- MCLs and MCLGs for radionuclides in drinking water
- How to monitor for applicable radionuclides
- Approved methods for analyzing samples
- How to calculate compliance from analytical results
- Reporting and recordkeeping requirements
- Compliance options and variances

Additional Resources

- Radionuclides Rule: A Quick Reference Guide
- Radionuclides in Drinking Water: A Small Entity Compliance Guide
- Steps to Selecting a Compliance Option for the Radionuclides Rule
- A System's Guide to the Management of Radioactive Residuals from Drinking Water Treatment Technologies
- Implementation Guidance for Radionuclides


United States Environmental Protection Agency | Office of Water (4606) | EPA 816-F-01-003 June 2001

EPA

Radionuclides Rule: A Quick Reference Guide

Overview of the Rule

Title	Radionuclides Rule 66 FR 76708 December 7, 2000 Vol. 65, No. 236
Purpose	Reducing the exposure to radionuclides in drinking water will reduce the risk of cancer. This rule will also improve public health protection by reducing exposure to all radionuclides.
General Description	The rule retains the existing MCLs for combined radium-226 and radium-228, gross alpha particle radioactivity, and beta particle and photon activity. The rule regulates uranium for the first time.
Utilities Covered	Community water systems, all size categories.

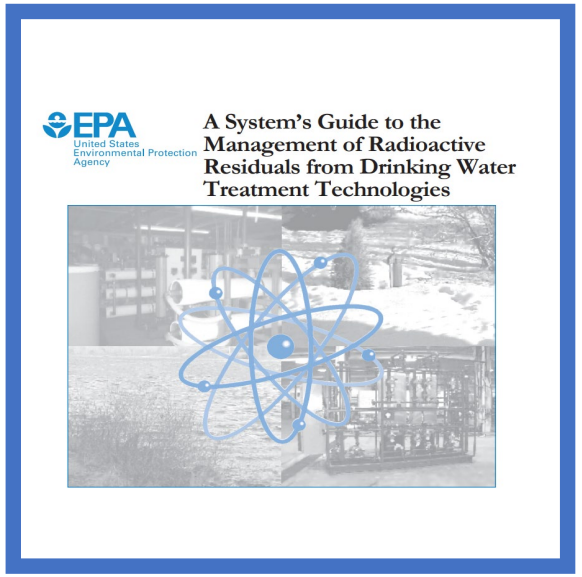
Public Health Benefits

Implementation of the Radionuclides Rule will result in . . .	Reduced uranium exposure for 620,000 persons, protection from toxic kidney effects of uranium, and a reduced risk of cancer.
Estimated impacts of the Radionuclides Rule include . . .	Annual compliance costs of $81 million. Only 795 systems will have to install treatment.

Regulated Contaminants

Regulated Radionuclide	MCL	MCLG
Beta/photon emitters*	4 mrem/yr	0
Gross alpha particle	15 pCi/L	0
Combined radium-226/228	5 pCi/L	0
Uranium	30 µg/L	0

*A total of 168 individual beta particle and photon emitters may be used to calculate compliance with the MCL.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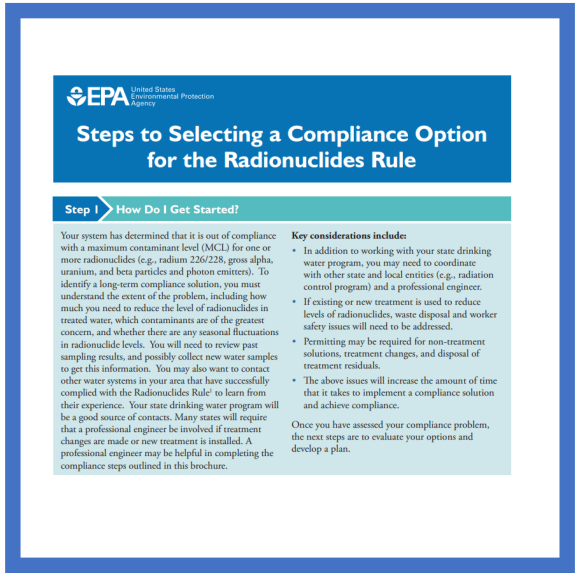
A System's Guide to the Management of Radioactive Residuals from Drinking Water Treatment Technologies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Steps to Selecting a Compliance Option for the Radionuclides Rule

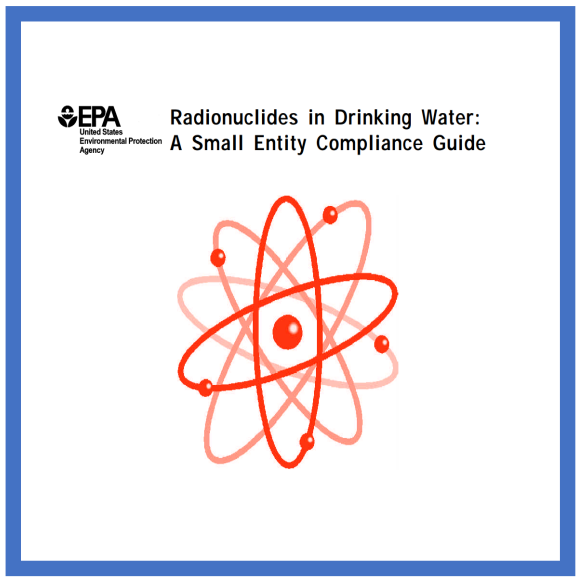
Step 1 How Do I Get Started?

Your system has determined that it is out of compliance with a maximum contaminant level (MCL) for one or more radionuclides (e.g., radium 226/228, gross alpha, uranium, and beta particles and photon emitters). To identify a long-term compliance solution, you must understand the extent of the problem, including how much you need to reduce the level of radionuclides in treated water, which contaminants are of the greatest concern, and whether there are any seasonal fluctuations in radionuclide levels. You will need to review past sampling results, and possibly collect new water samples to get this information. You may also want to contact other water systems in your area that have successfully complied with the Radionuclides Rule[1] to learn from their experience. Your state drinking water program will be a good source of contacts. Many states will require that a professional engineer be involved if treatment changes are made or new treatment is installed. A professional engineer may be helpful in completing the compliance steps outlined in this brochure.

Key considerations include:

- In addition to working with your state drinking water program, you may need to coordinate with other state and local entities (e.g., radiation control program) and a professional engineer.
- If existing or new treatment is used to reduce levels of radionuclides, waste disposal and worker safety issues will need to be addressed.
- Permitting may be required for non-treatment solutions, treatment changes, and disposal of treatment residuals.
- The above issues will increase the amount of time that it takes to implement a compliance solution and achieve compliance.

Once you have assessed your compliance problem, the next steps are to evaluate your options and develop a plan.


EPA United States Environmental Protection Agency

Radionuclides in Drinking Water: A Small Entity Compliance Guide

Any Questions?