Appendix H – Task 1 Policy Workshop Presentation Slides

Colorado Radionuclide Abatement and Disposal Strategy (CO-RADS)

Interim Protection Measures and Point-of-Use (POU)/Point-of-Entry (POE) Treatment for Compliance

November 28, 2007

Colorado Department of Public Health and Environment

INDEPENDENT ENVIRONMENTAL ENGINEERS, SCIENTISTS AND CONSULTANTS

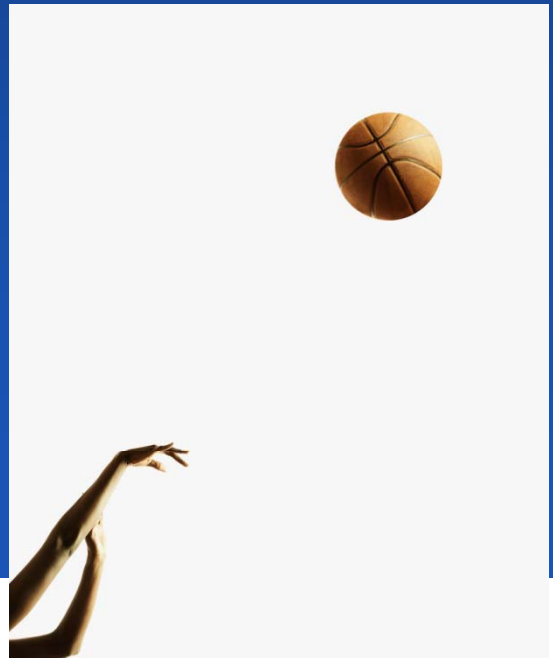
MALCOLM PIRNIE

Agenda

- Project background and status
  - Introduction of workshop participants
- Point-of-use (POU)/point-of-entry (POE) for compliance with the Radionuclides Rule
- Lunch
- Interim health protection measures and regulatory options

CO-RADS Goals

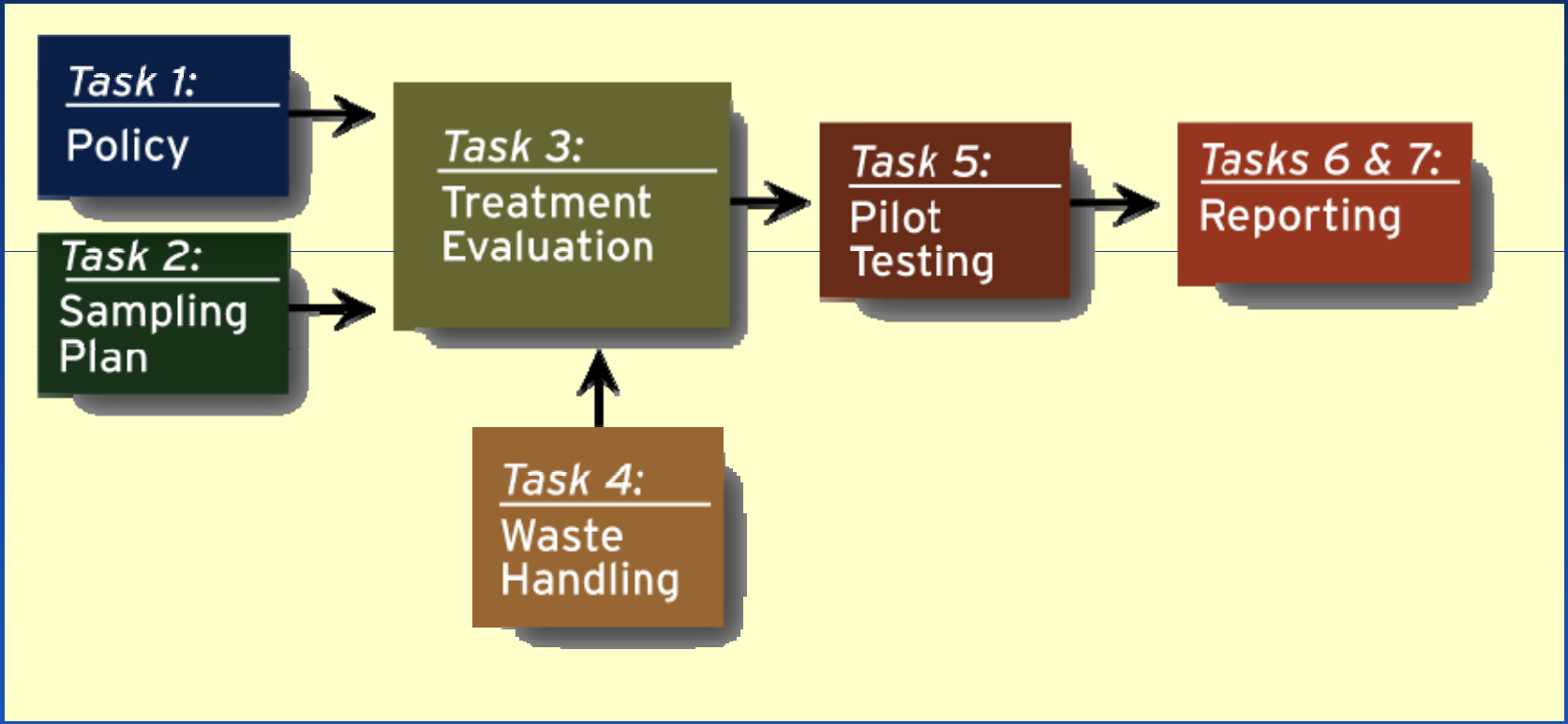
- Offer free compliance and technical assistance to communities struggling to comply with the Radionuclides Rule
- Ultimately, help water systems resolve radionuclides violations



CO-RADS Overview

- Phase 1
  - Review existing data and identify affected systems
- Phase 2
  - Sample affected sources to characterize water quality
- Phase 3
  - Perform engineering analyses and pilot-studies of treatment and disposal options
- Phase 4
  - Offer financial and compliance assistance to affected systems
- Phase 5
  - Provide recommendations and implementation assistance for affected systems

Malcolm Pirnie's Scope of Work



Why are we here today?

- Two policy decisions are critical for Task 3
  - Allowance of POU/POE treatment for compliance
  - Interim health protection measure requirements
- Discuss approaches to establishing these policies
  - Start a dialogue
  - Begin to identify critical decision items
- Identify next steps for CDPHE to develop formal policies

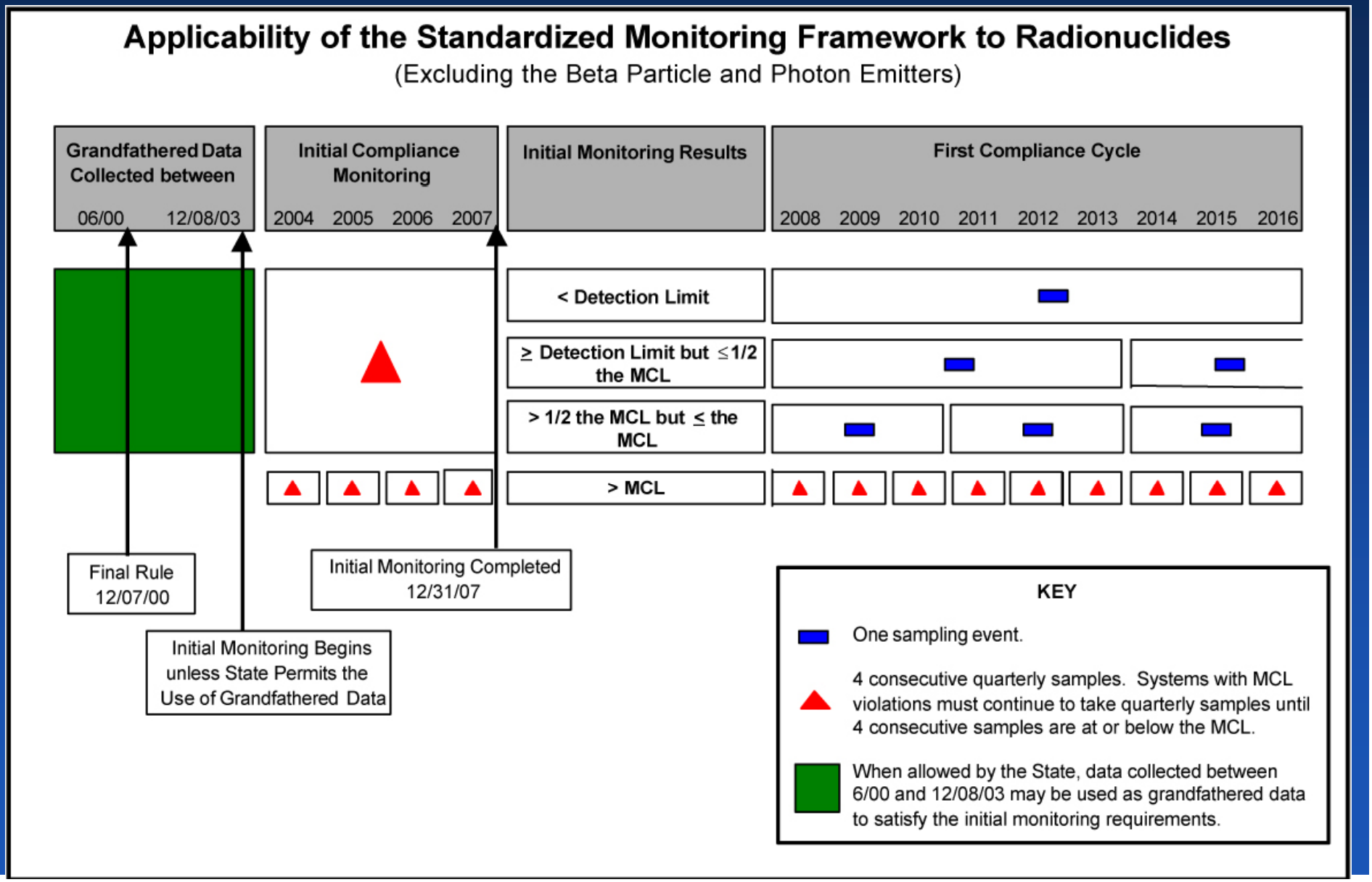
Background: Radionuclides Formation

- Occur naturally as trace elements in rocks/soils due to radioactive decay of uranium-238 and thorium-232
  - As radioactive atoms release or transfer energy, decay occurs
  - Energy released = ionizing radiation
    - Alpha particles
    - Beta particles
    - Gamma rays
- Products of uranium and thorium decay
  - Radon-222
  - Radium-226 and -228
  - Uranium-238 and -234
- Most commonly found in groundwater

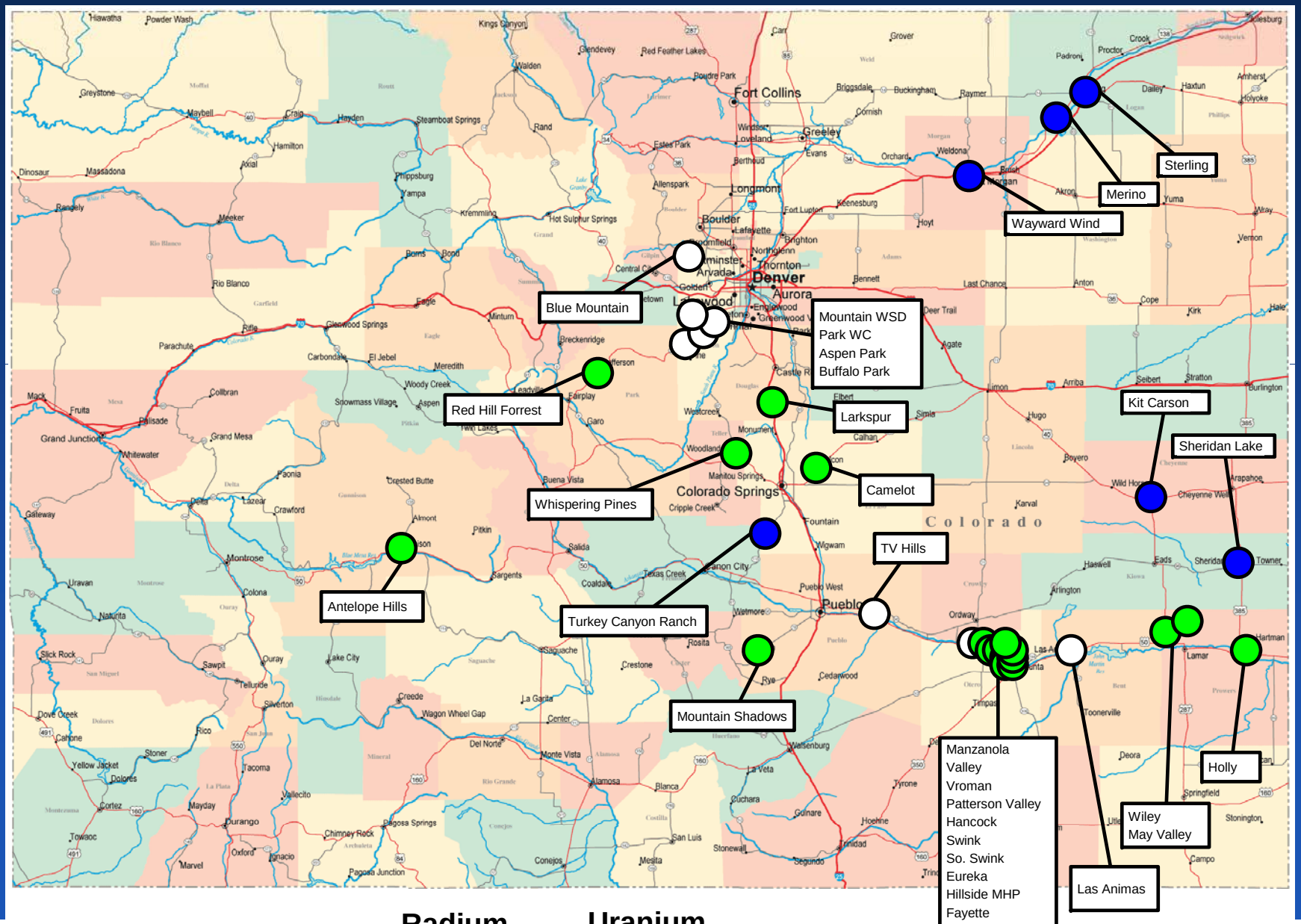
Radionuclides Rule

- Issued December 7, 2000
- Effective December 8, 2003
- MCLs
  - Combined radium (226 and 228) = 5 pCi/L
  - Uranium = 30 μg/L (only new MCL)
  - Adjusted gross alpha particle activity (excluding uranium and radon) = 15 pCi/L
  - Beta/photon particle activity = 4 mrem/year
- Revised monitoring requirements
- Applies to all CWSs (groundwater and surface water)

Radionuclides Monitoring Timeline

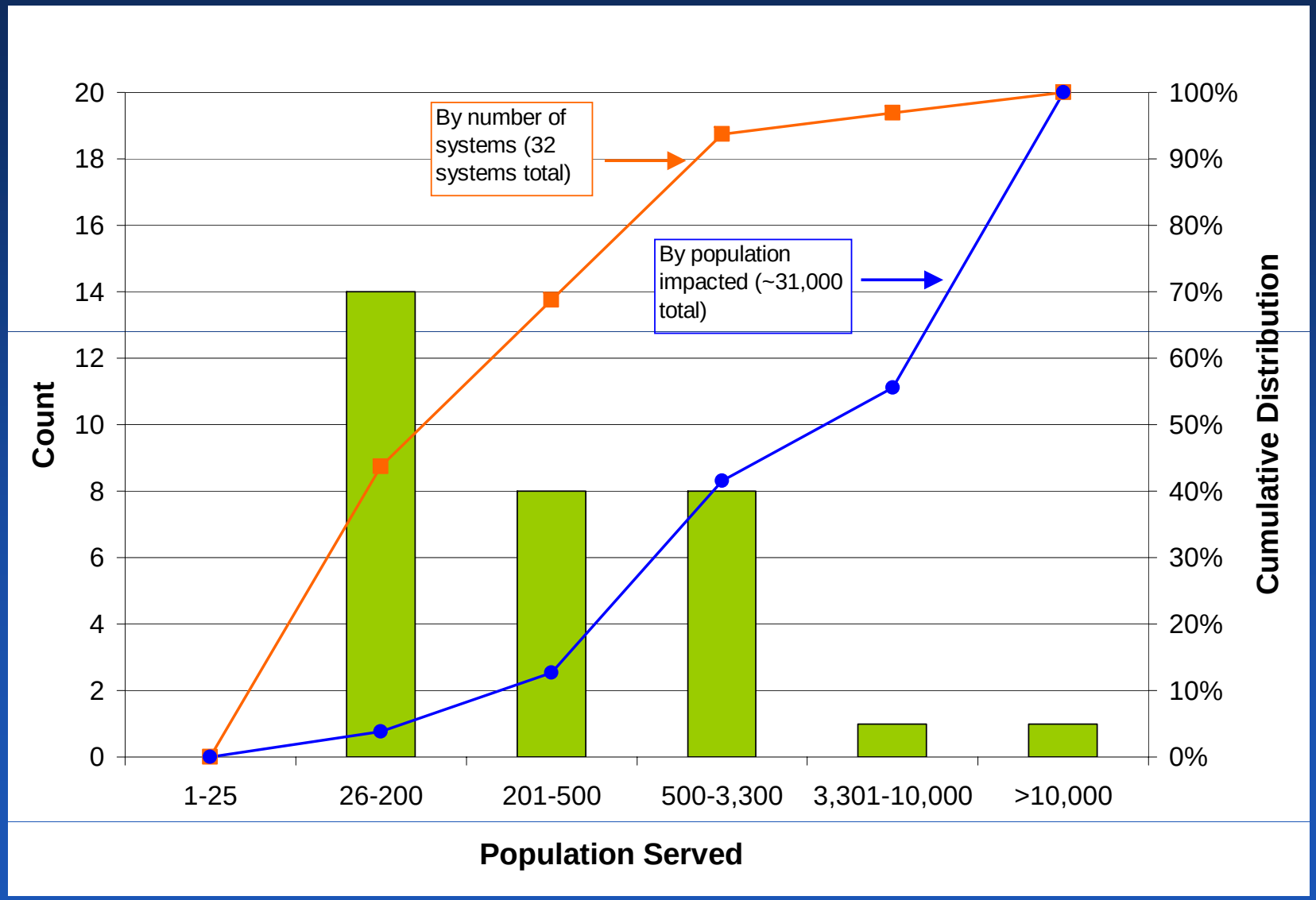


CO-RADS Systems Map



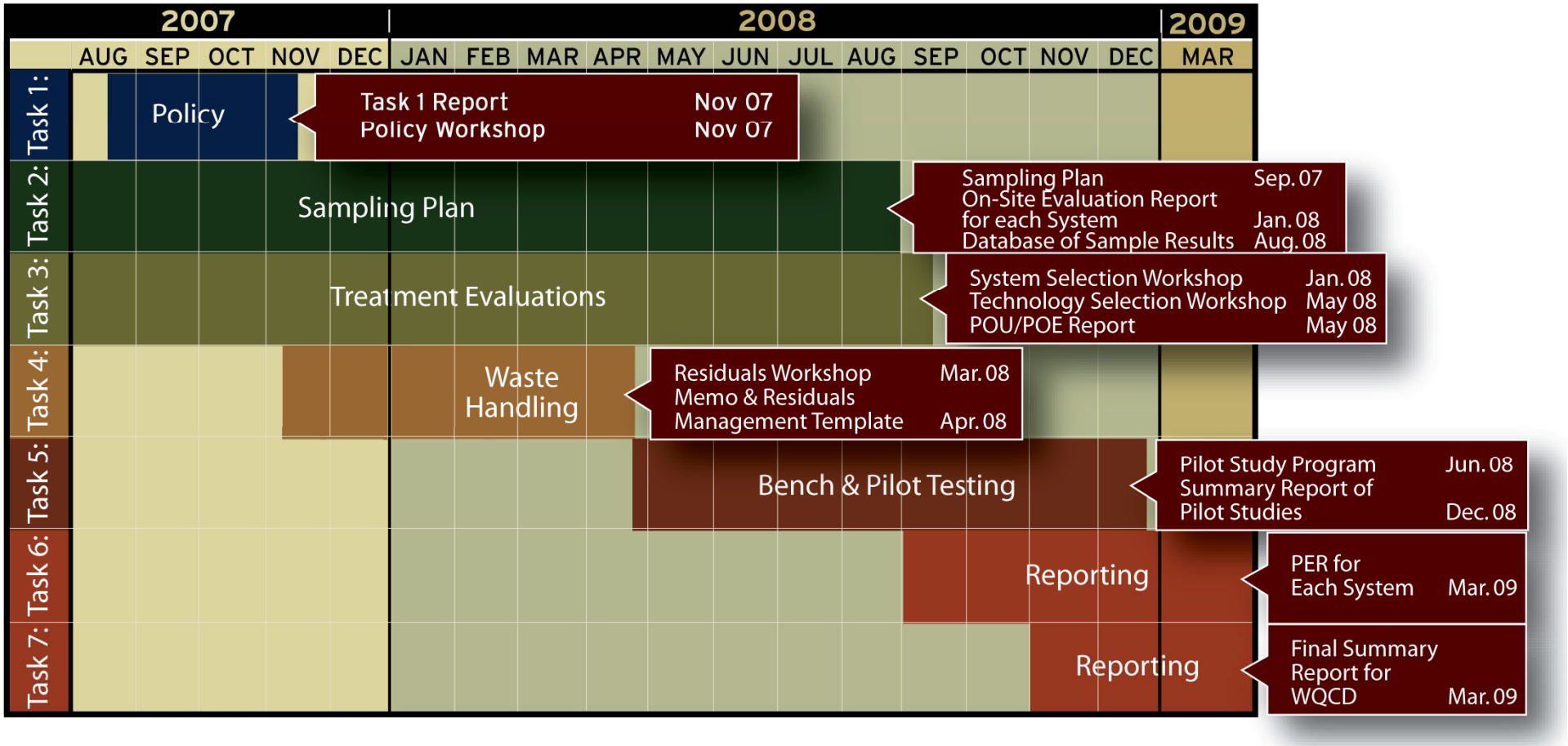
Radium Only — Uranium Only — Combo.

Size of Systems



NOTE: not shown is a system that only has commercial customers

Project Schedule and Status



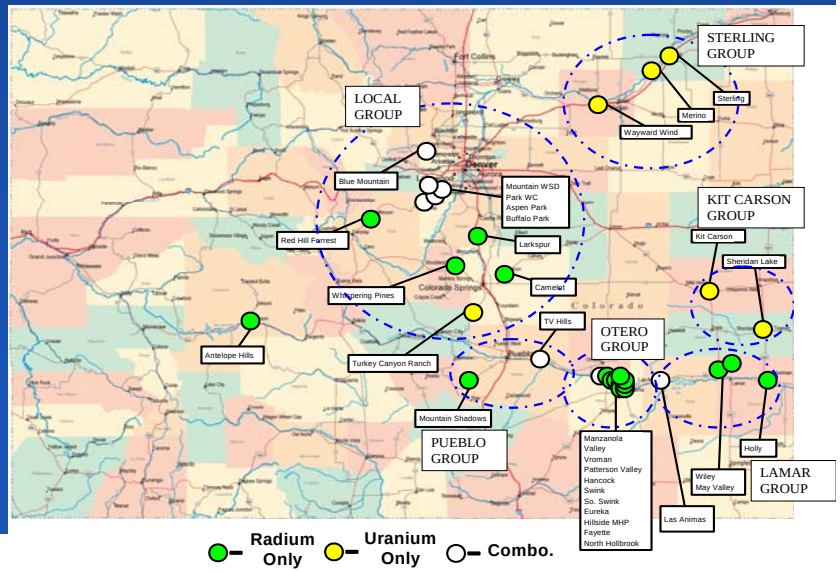
Preliminary Field Assessment Results

- 33 water systems participating in CO-RADS
- 22 of 33 site visits completed
- 4 of 33 systems currently treat for radionuclides
  - Blue Mountain Water District – Ion Exchange
  - City of Las Animas – Reverse Osmosis
  - Redhill Forest POW – Ion Exchange
  - TV Hills Water, LLC – Ion Exchange
- May Valley Water Association – Rapid Sand Filtration*

*Iron treatment likely removing radium

Preliminary Field Observations Cont'd

- Systems have similar issues
  - Limited staff
  - Minimal existing treatment infrastructure and associated operator experience
  - Limited financial resources
- Some systems have expressed interest in POU/POE treatment options
- ~15 systems hoping to connect to Arkansas River Pipeline
- Several systems already working towards compliance solutions
  - Drilling new wells
  - Installing treatment



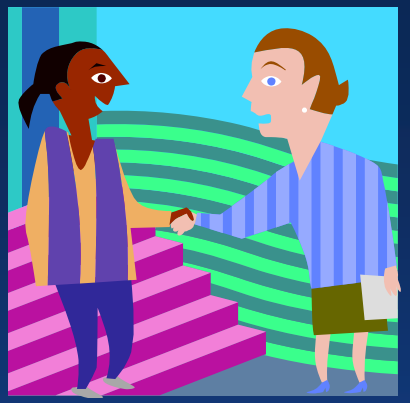
Preliminary Field Observations - Residuals Issues

Preliminary Field Observations – Residuals Issues Cont'd

Background Summary/Highlights

- Importance of POU/POE Policy:
  - Many of the CO-RADS small systems are interested in POU/POE
  - Could be cost-effective option if allowable
- Importance of Interim Measure Policy:
  - ~15 systems are hoping to obtain water from the Arkansas River Pipeline
  - It may take many other systems an extended period to implement long-term compliance solutions (such as new treatment installation)
- These must be addressed in order to confidently make recommendations through CO-RADS

Introductions



- Name
- Title
- Role in CO-RADS
- What defines success?

POU/POE Treatment

Small System Compliance Technologies (SSCTs)

- Systems serving < 10,000
- Affordable technology or other means that achieve compliance with the MCL or achieve a treatment technique requirement

List of Small System Compliance Technologies for Radionuclides and Limitations of Use

Unit Technologies	Limitations*	Operator Skill Level Required	Raw Water Quality and Range Considerations	Compliance Technologies Appropriate for System Size**		
				25-500	501 - 3,300	3,301 - 10,000
Ion Exchange (IE)	a	Intermediate	All ground waters	C, B, U	C, B, U	C, B, U
Point of Use (POU) IE	b	Basic	All ground waters	C, B, U	C, B, U	C, B, U
Reverse Osmosis (RO)	c	Advanced	Surface waters that usually require pre-filtration	C, G, B	C, G, B, U	C, G, B, U
POU RO	b	Basic	Surface waters that usually require pre-filtration	C, G, B, U	C, G, B, U	C, G, B, U
Lime Softening	d	Advanced	All waters	C	C, U	C, U
Green Sand Filtration	e	Basic		C	C	C
Co-precipitation with Barium Sulfate	f	Intermediate to Advanced	Ground waters with suitable water quality	C	C	C
Electrodialysis/Electrodialysis Reversal	N/A	Basic to Intermediate	All ground waters	C	C	C
Re-formed Hydrous Manganese Oxide Filtration	g	Intermediate	All ground waters	C	C	C
Activated Alumina	a, h	Advanced	All ground waters; competing anion concentrations may affect regeneration frequency	U	U	U
Enhanced Coagulation/filtration	i	Advanced	Can treat a wide range of water qualities	U	U	U

*Footnotes:

a. Disposal options should be carefully considered before choosing this technology.
b. Requires careful long-term operations, maintenance, and monitoring plans to ensure proper performance.
c. Reject water disposal options should be carefully considered before choosing this technology.
d. Variable source water quality and complex water chemistry make this technology too complex for small water systems.
e. Removal efficiencies can vary depending on water quality.
f. This technology is most applicable to systems that have sufficiently high sulfate levels and that already have filtration in place.
g. This technology is most applicable to small systems that already have filtration in place.
h. Handling of chemicals required during regeneration and pH adjustment requires an adequately trained operator.
i. Assumes modication to a coagulation/filtration process already in place.

**Key:

B = Beta partical activity and photon activity

C = Combined radium-226 and radium-228

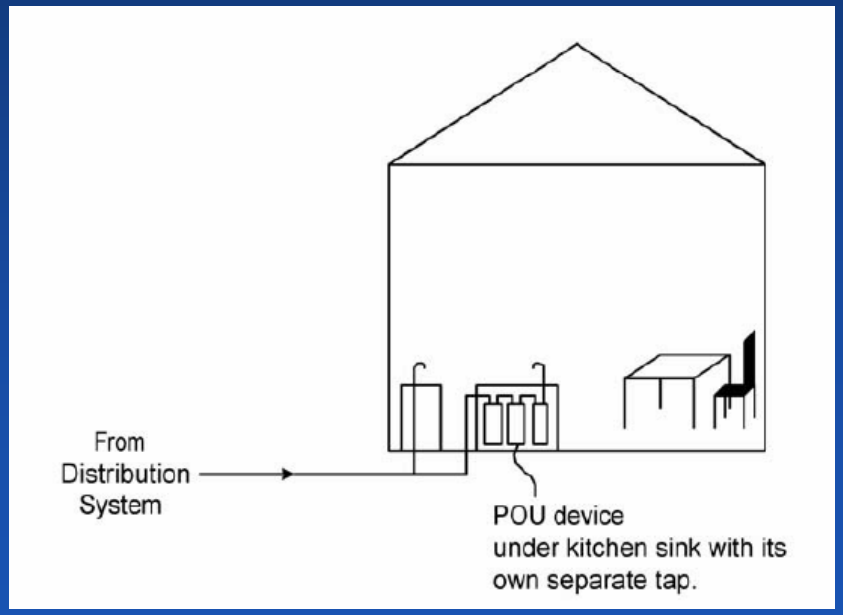
G = Gross alpha particle activity

U = Uranium

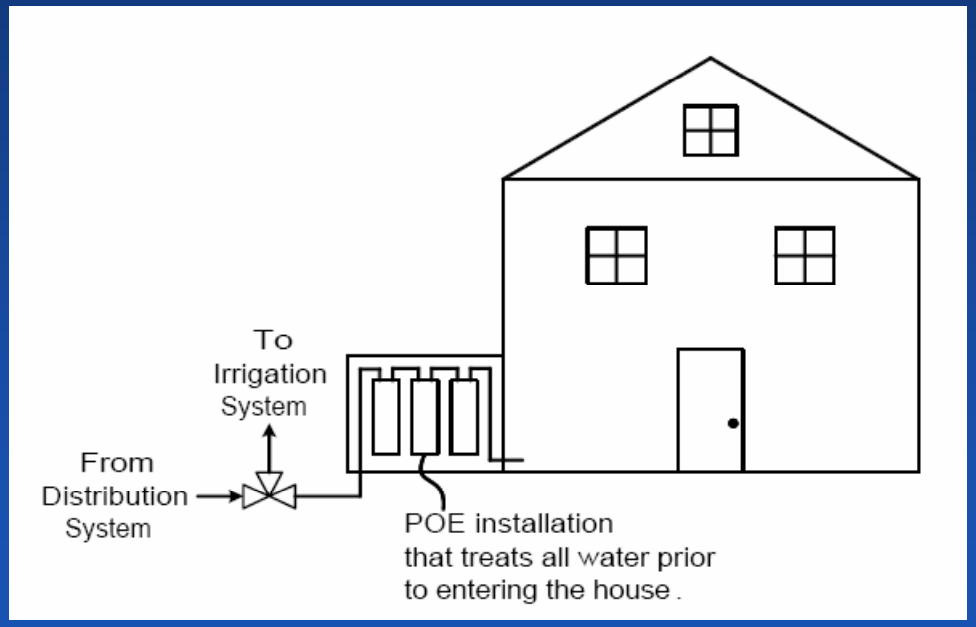
POE treatment is approved by EPA for compliance with MCLs, but is not listed as an SSCT for the Radionuclides Rule

Typical Installation

POU

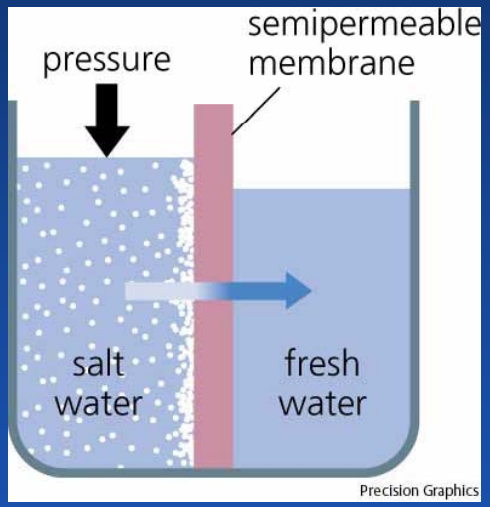


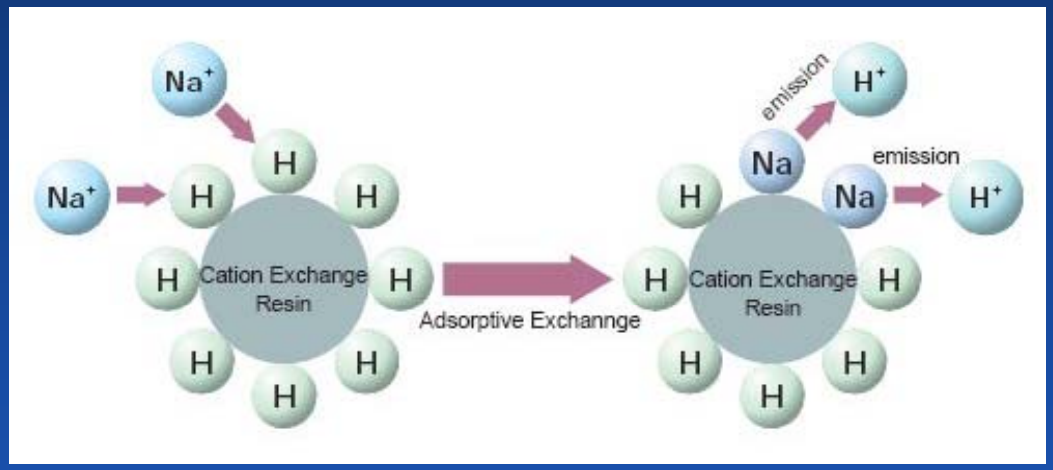
POE



Treatment Technologies

- Reverse osmosis
- Ion exchange





Examples

✓ **Reverse Osmosis System**

✓ **Ion Exchange**

Reverse Osmosis

- Advantages
  - Removes nearly all contaminants
  - Relatively insensitive to flow and total dissolved solids (TDS) concentrations
  - Simple to operate
  - May improve taste and odor
- Limitations
  - High capital and operating costs
  - Produces wastewater (brine solution) that must be managed
  - Membranes are prone to fouling
  - No disinfectant residual at the tap
  - Greater loss of water

Ion Exchange

- Advantages
  - Can be used with fluctuating flow rates
  - Large variety of specific resins available
- Limitations
  - Highly concentrated wastewater must be managed
  - May have “peaks” of contamination in effluent
  - Usually not feasible with high TDS or sulfate levels
  - Resins are sensitive to the presence of competing ions
  - Different resins required to treat radium and uranium

Types of Residuals

Treatment	Types of Residuals							
	Solid			Liquid				
	Spent Resins/ Media	Spent Membranes	Sludge	Brine	Backwash Water	Rinse Water	Acid Neutralization Water	Concentrate
IX	✓			✓	✓	✓		
RO		✓						✓
Lime Softening	✓		✓		✓			
Green Sand Filtration	✓		✓		✓			
Co-precipitation with Barium Sulfate	✓		✓		✓			
Electrodialysis/ Electrodialysis Reversal		✓						✓
Pre-formed Hydrous Manganese Oxide Filtration	✓		✓		✓			
AA	✓			✓	✓	✓	✓	
Coagulation/Filtration	✓		✓		✓			

A Regulators' Guide to the Management of Radioactive Residuals from Drinking water Treatment Technologies (EPA)

Residuals Disposal Options

	Direct Discharge[1]	Discharge to Sanitary Sewer[2]	Beneficial Reuse	Underground Injection	Disposal	ISDS
Liquid Wastes	X	X	X	X	X	X
Solids and Sludges		X	X		X	
Spent Resins and other Media					X	

[1]May require a National Pollutant Discharge Elimination Permit (NPDES)
[2]Must be approved by the local publicly owned treatment works (POTW)

Federal Requirements for POU/POE

- POU treatment may not be used for microbial contamination
- POU/POE units must be owned, controlled, and maintained by the public water system (PWS) or a contractor hired by the PWS
- POU/POE units must have mechanical warnings to notify customers of operational problems
- If the American National Standards Institute (ANSI) has issued product standards, then only certified units may be used as a compliance strategy

National Sanitation Foundation (NSF)/ANSI Standards

NSF Standard	POU	POE
44 – Cation exchange water softeners	No	Yes (with reduction claim for radium)
53 – Drinking water treatment units – health effects	Yes	Yes
58 – Reverse osmosis drinking water treatment systems	Yes (with reduction claim for radium)	No

- Would prefer to have systems certified by NSF 61 (drinking water components)
- Radium is the only radionuclide for which NSF reduction claims are available

POU/POE vs. Central Treatment

- Cost breakpoint for POU RO and POU adsorption compared to centralized treatment for arsenic was 120 to 200 connections (AwwaRF Study)
  - e.g., for systems with more than 200 taps, centralized treatment will likely be less expensive than POU treatment
  - Exact cost breakpoint for radionuclides may differ; however, this approximation is likely in the range
- ~22 CO-RADS systems serve 200 taps or less (assuming 2.5 persons per tap)

Information from Vendors

- Several industry POU/POE treatment vendors were contacted for interviews to discuss POU/POE treatment for radionuclides
  - Most vendors had done or no work on POU/POE treatment for radionuclides
  - Vendors were reluctant to discuss or provide information for this analysis

State of the Industry

- Approximately 15 States have policies in place allowing POU and/or POE treatment for regulatory compliance
- 9 States allow POU and/or POE treatment for compliance with the Radionuclides Rule

State of the Industry

State	Additional State Requirements over CFR	Contaminants	Size of systems allowed to use POUs	Size of Systems using POUs	Info on Systems currently using POEs for compliance
AZ	• Approved monitoring plan • ADEQ approval of design of the POU device • Install a sufficient # of devices to ensure every person served by the system is protected • Rights and responsibilities of persons served by the water system convey with title upon sale of property	Radionuclides As, Cr, VOCs	All	About 18 systems (<50 connections) have POU and/or POE in place for arsenic or fluoride for long-term treatment	~3 systems have POE or POU and POE in place for arsenic and/or fluoride
IL	• POU and POE are not allowed for municipalities (only private systems such as home owner's associations (HOAs); must have 100% participation) • POU rules for emergency situations only	Only radium	None	None	Two small HOAs with less than 60 homes currently have POE cation exchange (water softeners) installed for removal of radium
TX	• Must develop a program for the long-term operation, maintenance, and monitoring of the devices to ensure adequate performance	Any non-microbial contaminant violating the MCL	<10,000	None, though an application from a public school is under review	None used
WI	• The Wisconsin Department of Commerce requires installation of POU on all faucets in a home; cannot install POU on only one faucet (Source: phone conversation with Wisconsin Department of Natural Resources)	Radionuclides, Total Coliform Rule, and nitrate	All	None	Small non-community GW systems for TCR compliance

POU/POE Implementation Challenges

- Requires 100% customer participation
- Insurance issues with having systems installed in or at private residences
- Unknowns regarding radioactive waste disposal
- Maintenance by qualified personnel
- Record keeping
- Encourage drinking water from the treated faucet (liability issue)
- Accessibility

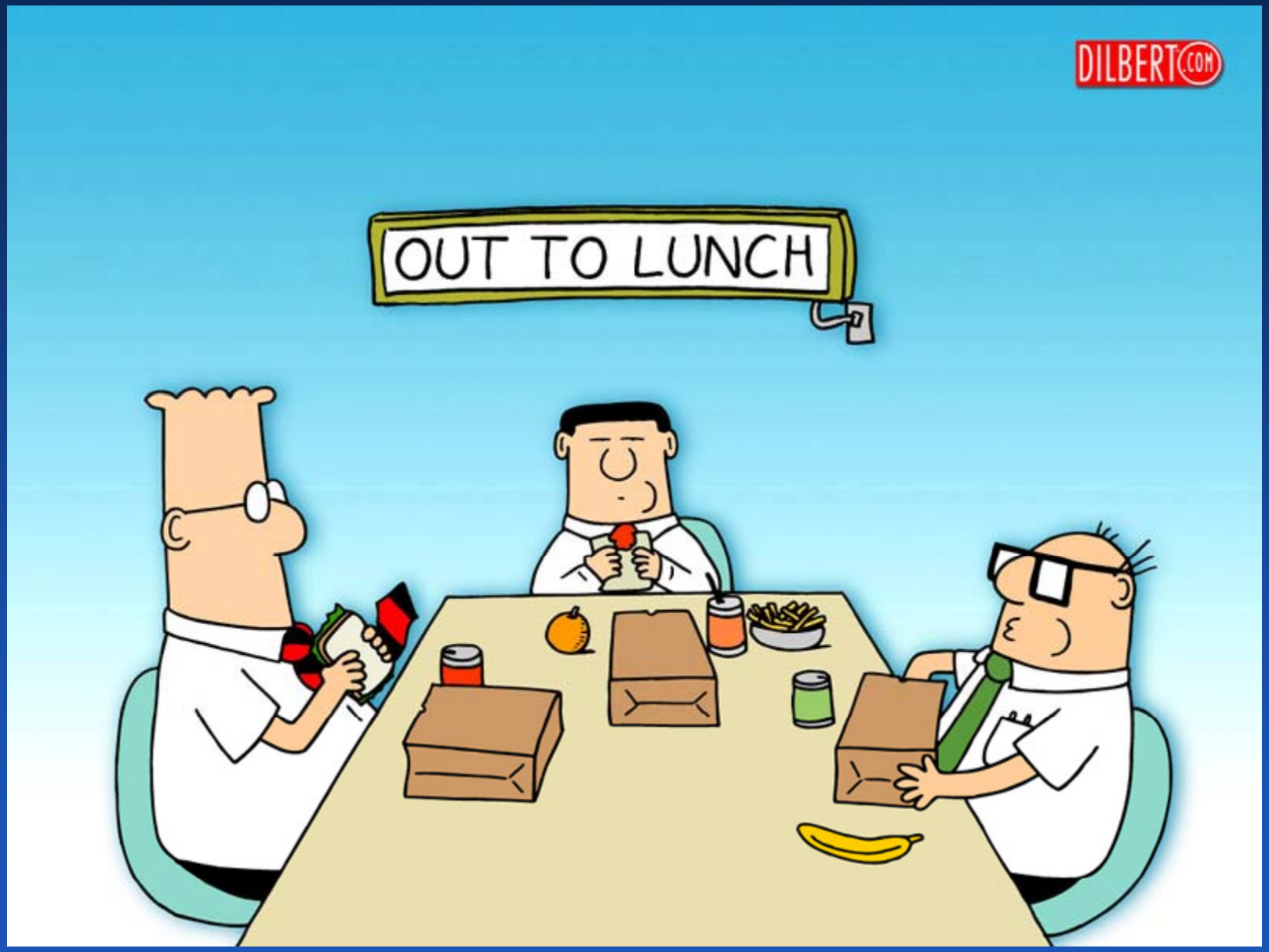
CDPHE Questions about POU/POE

- Management and liability issues
  - Waste ownership, disposal and handling
  - Who is liable if an ISDS must be remediated?
  - How does treatment and disposal vary for different rads?
  - Potential systems with concentrations so high that POU/POE not viable?
- POU/POE costs compared to centralized treatment
- Exposure to consumer due to rads accumulation in POU/POE

CDPHE Questions Cont'd

- CDPHE design criteria for POU/POE
- Operations and maintenance
  - Operator training/certification
  - Testing plans
  - ISDS maintenance practices?
- POU only at one tap per residence/business/school (?) – how important is public education?
- Potential for bio-growth (RO units)
- Potential radon exposure

Next Steps


DILBERT.COM
OUT TO LUNCH

Interim Protection Measures

Interim Protection Measures: Background

- Some long-term compliance projects will take years to implement (possibly up to ~10)
  - Planning, testing, design, construction, and start-up of new treatment systems
  - Regionalization efforts, such as the Arkansas River Pipeline project
- Need to discuss the degree of protection that should be provided by a water system, on an interim basis, before a long-term compliance option is successfully implemented

This Afternoon's Discussion

- Interim measures
- Interim regulatory options
- Interim measures benefits and applicability

Interim Measures

- Public education and awareness
- Bottled water
- POU
- POE

Public Education and Awareness

- "Do Nothing" Alternative
  - Possible for uranium exemption
  - Maximum exemption period is three years with potential for extensions (feasibility assessments)
- For implementation of interim measure
  - Facilitates 100% customer acceptance
  - Buy-in from customers for rate increases
  - Reduces liability to water providers
- Community outreach and education
  - Community centers, schools, libraries, churches
  - Door-hangers, bill inserts
  - Local news station

Bottled Water

- Historically, EPA did not allow bottled water for regulatory compliance
- Recently (2005-2006), some states (CA, TX) are allowing the use of bottled water as an interim measure
- Water quality
  - Plasticizers, pathogens
- Availability of service
- Environmental impact
- High societal cost
- Education of transient population
- Implementation – Customer Purchases or System Provides

Interim Regulatory Options

- Risk-based
- Exposure reduction
- Variance and exemptions

Risk-based

Description:

- Define levels of risks associated with finished water above EPA's MCL

Risk-based

Methodology for Implementation:

- Calculate risk for various pathways and radionuclide concentrations
  - Consumption of tap water
  - Inhalation from showering
  - Ingestion from irrigated food stuffs
- Determine interim level of “acceptable risk”
- Implement interim measures to meet acceptable risk level

Risk-based

What was done for this evaluation?

- Calculated risk using EPA models for:
  - Consumption of tap water
  - Inhalation from showering
  - Ingestion from irrigated food stuffs
- Generated hard copy and electronic risk look-up tables

Risk from Tap Water

- Risk is defined in terms of the added risk of developing cancer (fatal or non-fatal)
- Risk is a consequence of ingestion, inhalation or contact with radionuclides in drinking water *above* that which is naturally expected
- *Above* means either direct (ingestion) or indirect (irrigation of garden) or inhalation

Risk

- EPA's range of risk is 1 in 1,000,000 (10^{-6}) to 1 in 10,000 (10^{-4}) above normal cancer risk
  - 1:1,000,000 is 1 minute in two years
- A normal risk of developing cancer:
  - Fatal or non-fatal risk is 1 in 2 for men and 1 in 3 for women
  - Fatal risk is 1 in 5 or 0.2000
- Incremental Increase to 0.2001

Risk Coefficients

- Risk is calculated using risk coefficients for:
  - Mortality: estimate of dying from cancer as a result of the intake of a radionuclide
  - Morbidity: estimate of developing cancer as a result of the intake of a radionuclide
- To calculate risk the risk coefficient is multiplied by the amount ingested
- To set the MCLs EPA used “lifetime ingestion” where the amount ingested = concentration * 2 liters/day * 70 years

Risk Calculation

- Used EPA methodology and EPA risk coefficients (Federal Guidance Report No.13 FRG-13)
- Used EPA “weighted” coefficients for gross alpha and total radium (used to establish MCLs)
- FRG-13 gastrointestinal tract models biokentics of radionuclides
- Integrates age-organ-gender specific information

Incremental risk of developing cancer from ingestion of combined radium in drinking water

Ingestion Period (years)	Liters Ingested liters	pCi of Rad Ingested at 1*MCL (5 pCi/L)	Risk (mortality[1])	Risk (morbidity[2])	pCi of Rad Ingested at 2*MCL (10 pCi/L)	Risk (mortality[1])	Risk (morbidity[2])	pCi of Rad Ingested at 10*MCL (50 pCi/L)	Risk (mortality[1])	Risk (morbidity[2])
0.5	365	1,825	1.03E-06	1.47E-06	3,650	2.07E-06	2.93E-06	18,250	1.03E-05	1.47E-05
1	730	3,650	2.07E-06	2.93E-06	7,300	4.13E-06	5.86E-06	36,500	2.07E-05	2.93E-05
2	1,460	7,300	4.13E-06	5.86E-06	14,600	8.26E-06	1.17E-05	73,000	4.13E-05	5.86E-05
3	2,190	10,950	6.20E-06	8.79E-06	21,900	1.24E-05	1.76E-05	109,500	6.20E-05	8.79E-05
4	2,920	14,600	8.26E-06	1.17E-05	29,200	1.65E-05	2.34E-05	146,000	8.26E-05	1.17E-04
5	3,650	18,250	1.03E-05	1.47E-05	36,500	2.07E-05	2.93E-05	182,500	1.03E-04	1.47E-04
6	4,380	21,900	1.24E-05	1.76E-05	43,800	2.48E-05	3.52E-05	219,000	1.24E-04	1.76E-04
7	5,110	25,550	1.45E-05	2.05E-05	51,100	2.89E-05	4.10E-05	255,500	1.45E-04	2.05E-04
8	5,840	29,200	1.65E-05	2.34E-05	58,400	3.31E-05	4.69E-05	292,000	1.65E-04	2.34E-04
9	6,570	32,850	1.86E-05	2.64E-05	65,700	3.72E-05	5.28E-05	328,500	1.86E-04	2.64E-04
10	7,300	36,500	2.07E-05	2.93E-05	73,000	4.13E-05	5.86E-05	365,000	2.07E-04	2.93E-04
11	8,030	40,150	2.27E-05	3.22E-05	80,300	4.54E-05	6.45E-05	401,500	2.27E-04	3.22E-04
12	8,760	43,800	2.48E-05	3.52E-05	87,600	4.96E-05	7.03E-05	438,000	2.48E-04	3.52E-04
13	9,490	47,450	2.69E-05	3.81E-05	94,900	5.37E-05	7.62E-05	474,500	2.69E-04	3.81E-04
14	10,220	51,100	2.89E-05	4.10E-05	102,200	5.78E-05	8.21E-05	511,000	2.89E-04	4.10E-04
15	10,950	54,750	3.10E-05	4.40E-05	109,500	6.20E-05	8.79E-05	547,500	3.10E-04	4.40E-04
35	25550	127750	7.23E-05	1.03E-04	255500	1.45E-04	2.05E-04	1277500	7.23E-04	1.03E-03
70	51100	255500	1.45E-04	2.05E-04	511000	2.89E-04	4.10E-04	2555000	1.45E-03	2.05E-03

*Shaded gray cells represent concentrations and ingestion periods which result in risks that exceed the EPA's "ceiling" mortality risk of 1.45e-04 and morbidity risk of 2.05e-04 that are based on ingesting the MCL for 70 years.

[1] [Mortality refers to the incremental additional risk of developing a fatal cancer, above the average rate, as a result of the intake of radionuclides

[2] Morbidity refers to the incremental risk of developing a cancer ,fatal or non-fatal, above the average rate, from the intake of radionuclides]

Example Conservatism

- Consumption of 2 liters/day (8-8oz glasses)
  - EPA rounded up from 1.65 liters/day for standard man
- Linear no threshold model (LNT)

Inhalation and Vegetation

- 1999 EPA proposed radon in drinking water standards
- Transfer of radon from water to air 0.0001
- Risk estimated as 7×10^{-7}

- Calculation of radium ingestion from irrigated vegetables 1/40 of water
- Literature estimate ~1.8 pCi/day radium

Exposure Reduction

Description:

- Implement appropriate and economically feasible technology that reduces exposure meaningfully
- Not every PWS has the same risk reduction or treated water radionuclide concentration

Exposure Reduction

Methodology for Implementation:

- Identify the major contaminant of concern at each location
- Apply appropriate treatment technologies to reduce exposure
- Calculate household cost and evaluate implementation issues

Variance and Exemptions

Description:

- Defined regulatory process to manage non-compliant systems and ultimately meet rule requirements
  - A variance gives you more time to come into compliance if you install a Best Available Technology (BAT)
  - An exemption means you do not have to comply with an MCL for a period of time because of compelling circumstances
- Exemption only applies to uranium (MCL established after 1986)

Variance and Exemptions

Methodology for Implementation:

- Determine contaminant-specific BAT for each system
- Evaluate treatment cost
- Apply variance or exemption

Advantages and Disadvantages

Option	Advantages	Disadvantages
Risk-Based	• Consistent with EPA MCL methodology • Appears scientifically defensible • All consumers have same calculated risk	• Overall population-based exposure reduction is not maximized • Difficult to explain to the public
Exposure Reduction	• All systems have a meaningful reduction in exposure • Easily explained to the public	• All consumers do not drink water at or below a fixed concentration
Variance and Exemptions	• Available regulatory language • More easily implemented • Easier oversight • Easily explained to the public	• Exposure reduction may not be maximized

Option Comparison

Option	Degree of Public Health Protection	Cost Effectiveness	Public Endorsement	Ease of Implementation
Risk-Based	✓ (?)			
Exposure Reduction	✓	✓	✓	
Variance and Exemptions			✓	✓

Next Steps