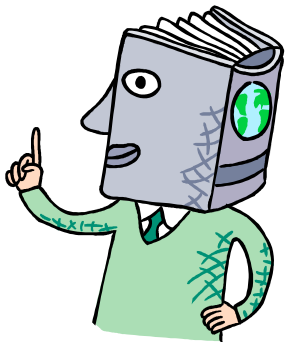
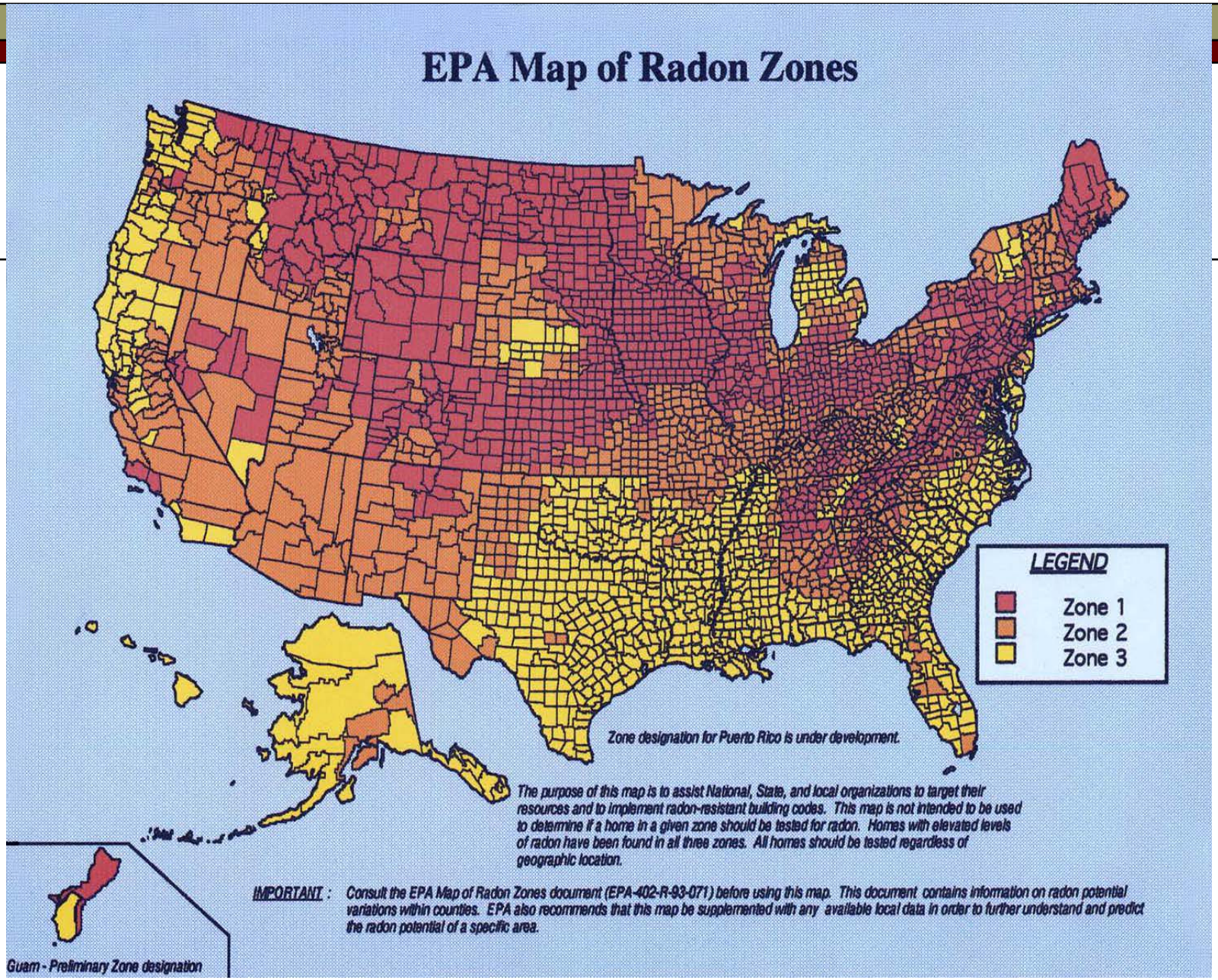
RADON MEASUREMENTS IN SCHOOLS—BEST PRACTICES--LECTURE

What we will discuss

- What is radon?
- Why we should care.
- Occurrence
- Protocols for testing
- Interpreting results
- Follow up and Mitigation Strategies



EPA Map of Radon Zones

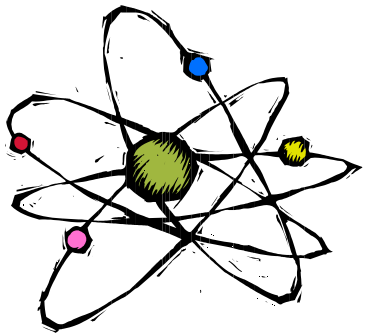


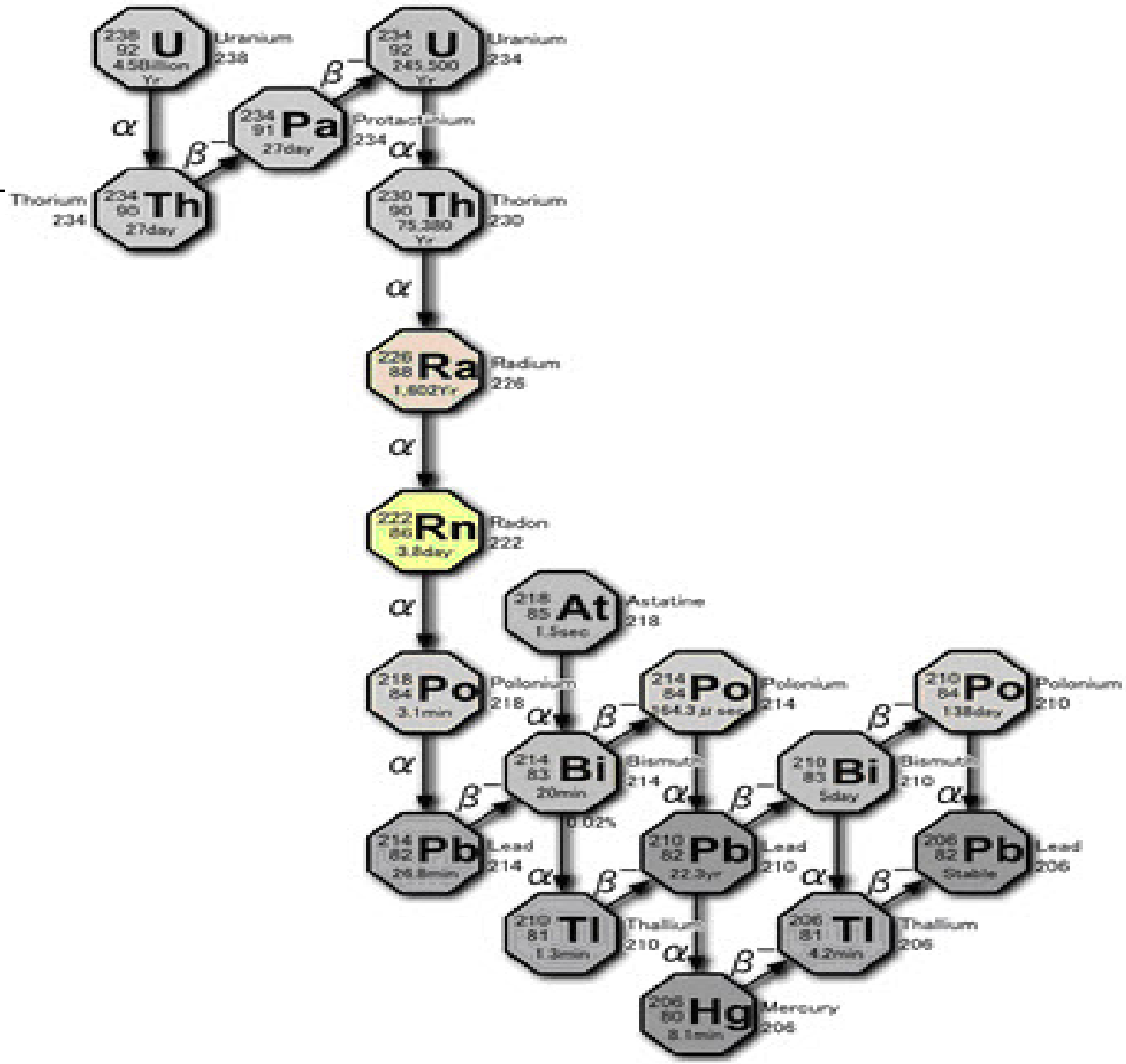
Radon Properties

- Radon
  - Colorless
  - Odorless
  - Tasteless
  - Radioactive gas
  - Widely prevalent in soil and rock
  - Produces other radioactive elements
  - Can have high concentrations indoors

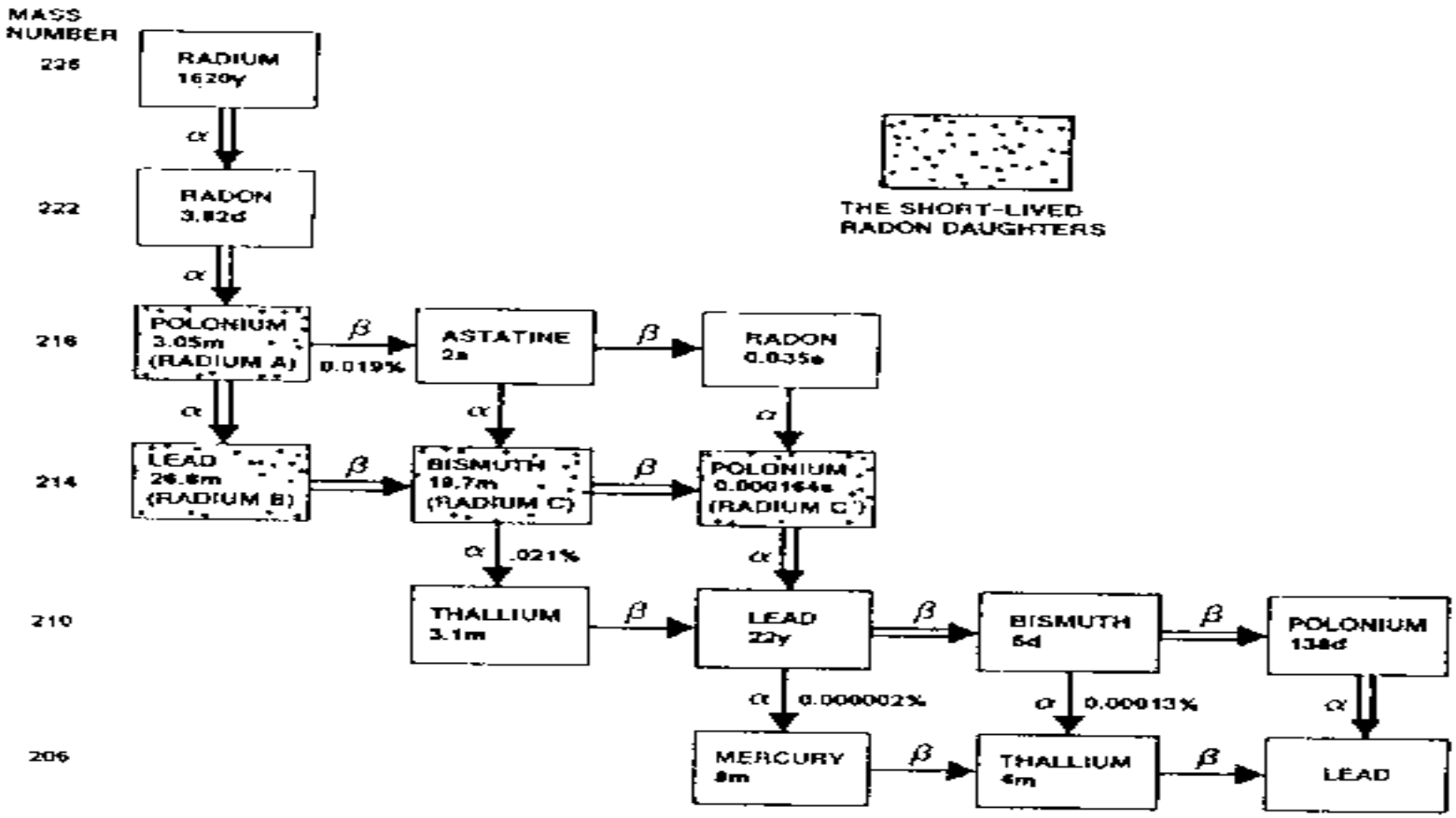
Radon is a Cancer Causing Radioactive Gas

- Different in that its atoms ‘emit particles and change’ at a given rate.
- Inert gas—does not react within the soil.
- #1 cause of lung cancer in non smokers
- #2 cause of lung cancer in smokers.



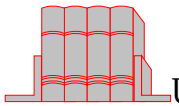

238 92 U 4.5Billion Yr Uranium 238
234 91 Pa 27day Protactinium 234
234 92 U 245,500 Yr Uranium 234
234 90 Th 27day Thorium 234
230 90 Th 75,380 Yr Thorium 230
226 88 Ra 1,602Yr Radium 226
222 86 Rn 3.8day Radon 222
218 85 At 1.5sec Astatine 218
218 84 Po 3.1min Polonium 218
214 84 Po Polonium 214
214 83 Bi 20min Bismuth 214
214 82 Pb 26.8min Lead 214
0.02%
210 84 Po 138day Polonium 210
210 83 Bi 5day Bismuth 210
210 82 Pb 22.3yr Lead 210
210 81 Tl 1.3min Thallium 210
206 82 Pb Stable Lead 206
206 81 Tl 4.2min Thallium 206
206 80 Hg 8.1min Mercury 206
α
β

Radon Decay Scheme



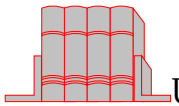
The pCi/l

- Nuclei decay at given rates:
  - 1 pCi/l= 2.2 dis./min./l



Why 4 pCi/l?

- Choice made in 1986
  - We could mitigate to below 4 pci/l.
  - False positives and false negatives would be minimized. I.e. we were confident at measuring down to 4 pCi/l.
  - At 4 pCi/l, each lung cancer death saved costs $700,000.
  - At 3 pCi/l, each lung cancer death saved costs $1.7 million
  - At 2 pCi/l, each lung cancer death saved costs $2.4 million
  - Outside, northern hemisphere about 0.4pci/l.



Other Action levels

- United Kingdom, Norway, Canada 5.4 pCi/l
- Greece, China 10.8pCi/l
- Switzerland 27 pCi/l

Corroborating Agencies

- US EPA
- US Surgeon General
- American Lung Association
- World Health Organization
- United Nations Scientific Committee on the Effects of Atomic Radiation

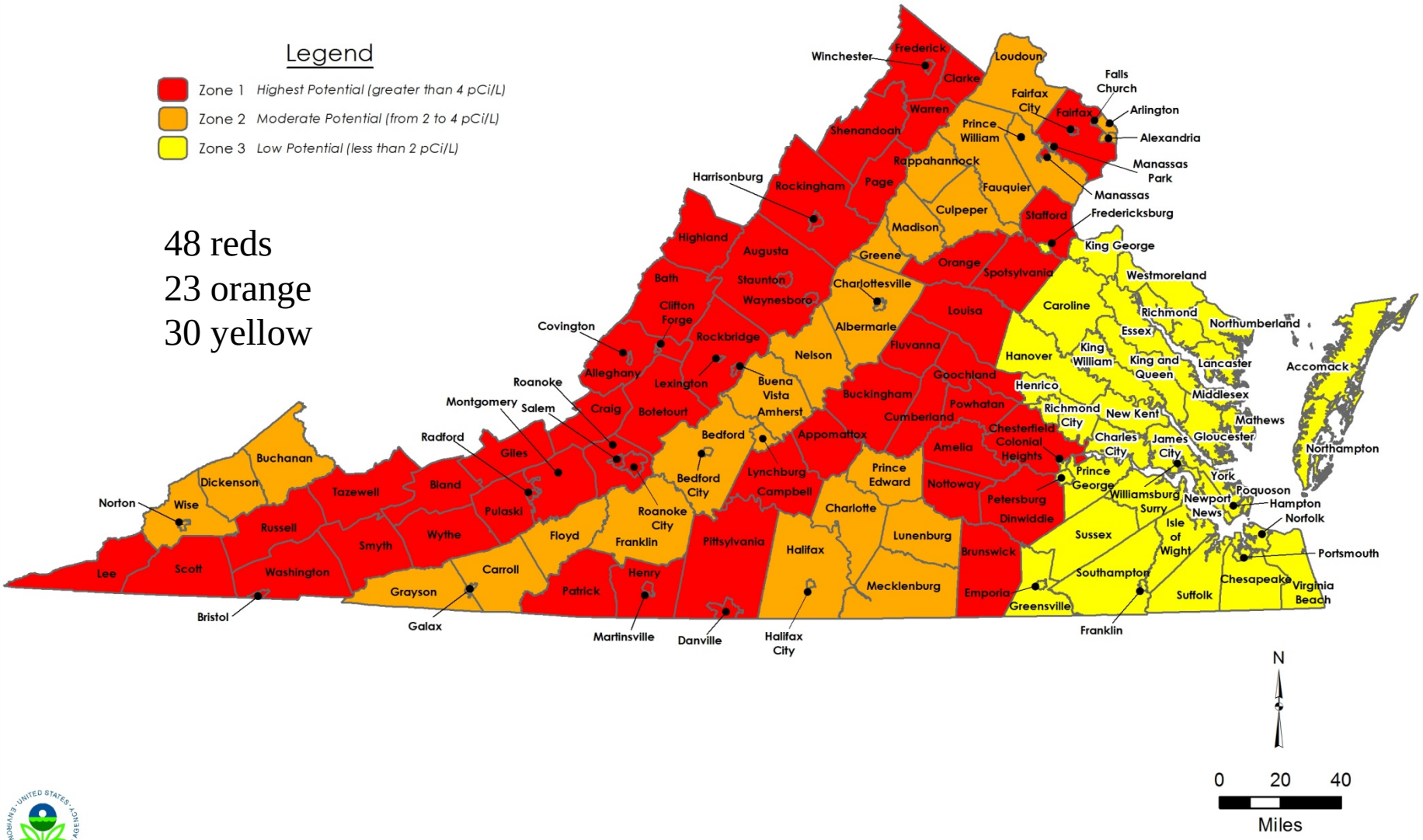
How much is too much?

- Action guide---4 pCi/l

- Consider action 2-4 pCi/l

Virginia - Radon Zones

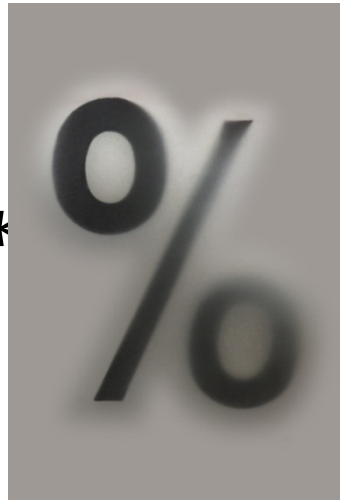
Virginia requires schools be tested since 1994 .ref:Va code 22.1-138B



National vs Virginia

- Nationally 15% of all homes ≥ 4pCi/l

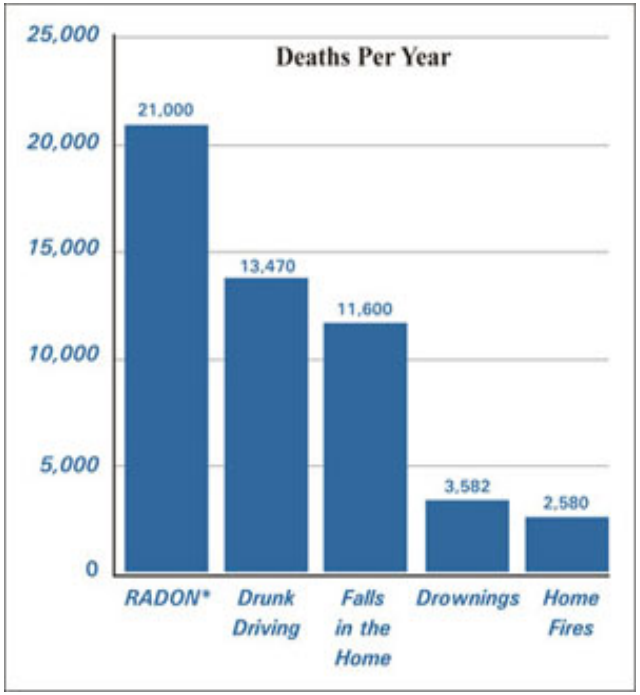
- Virginia 20-25% of all homes ≥ 4pCi/l*



  - *Results indicate radon levels are not elevated in Tidewater, Va, E. of Interstate 90

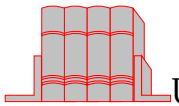
Why Be Concerned

- 21,000 estimated deaths/yr.
- Widespread contamination in schools at the national level.
- 20% of all schools will have at least one room with a concentrations greater than 4 pCi/l. (nationwide)



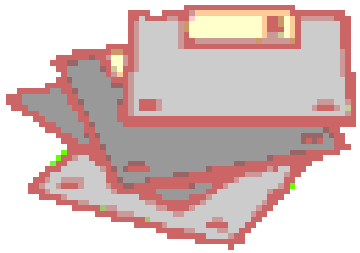
Why be Concerned (cont'd)

- EPA recommends testing all schools.
- Every state is expected to have some schools where radon levels are > 4 pCi/l.
- Some schools have been found with concentrations >100 pCi/l.
- Class A carcinogen

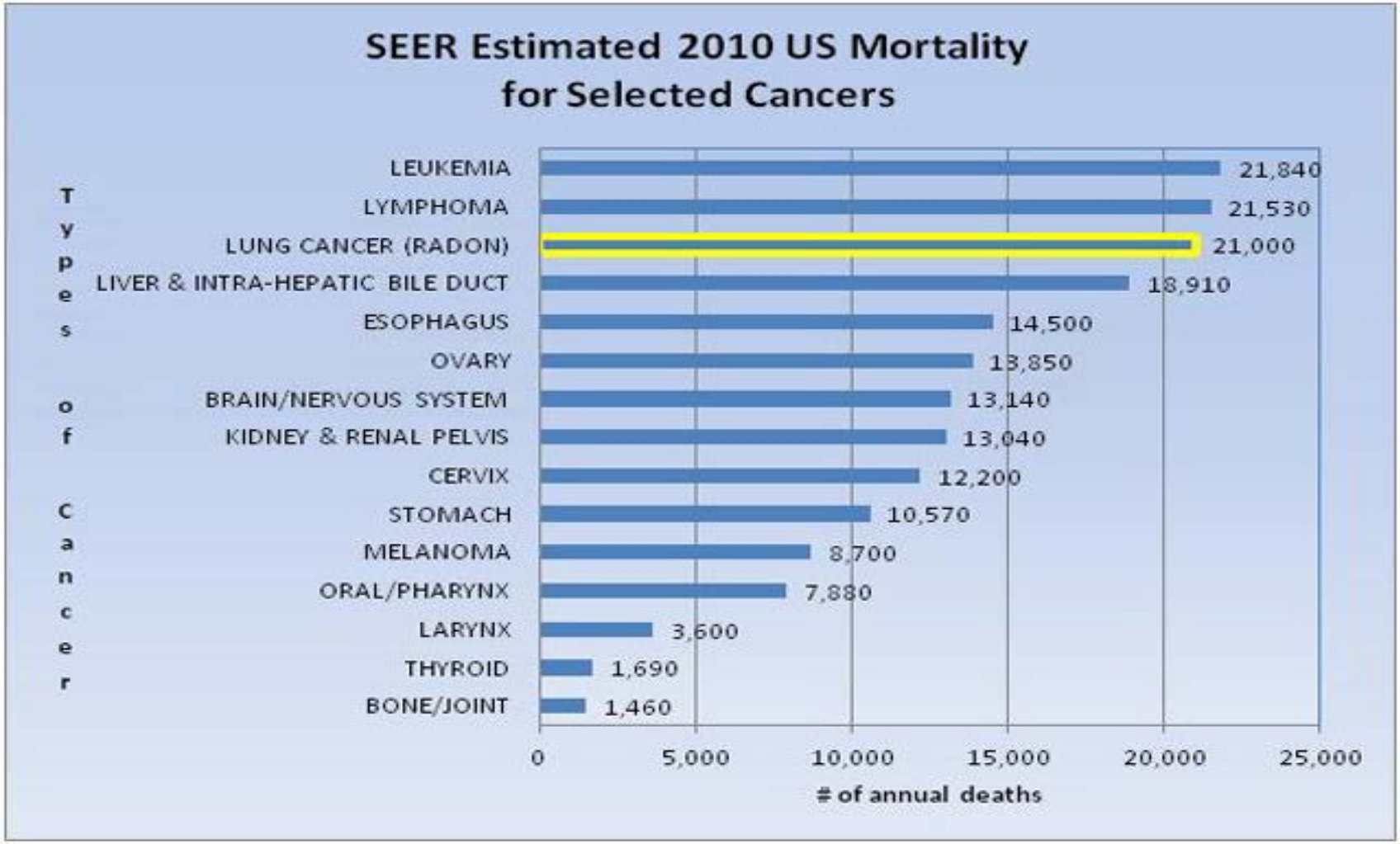


National School Data

- About 2.7% of ground contact classrooms have radon conc. > 4 pCi/l
- About 19.3% of the nations public schools have at least one ground contact room above 4 pCi/l—That's about 70,000 rooms!



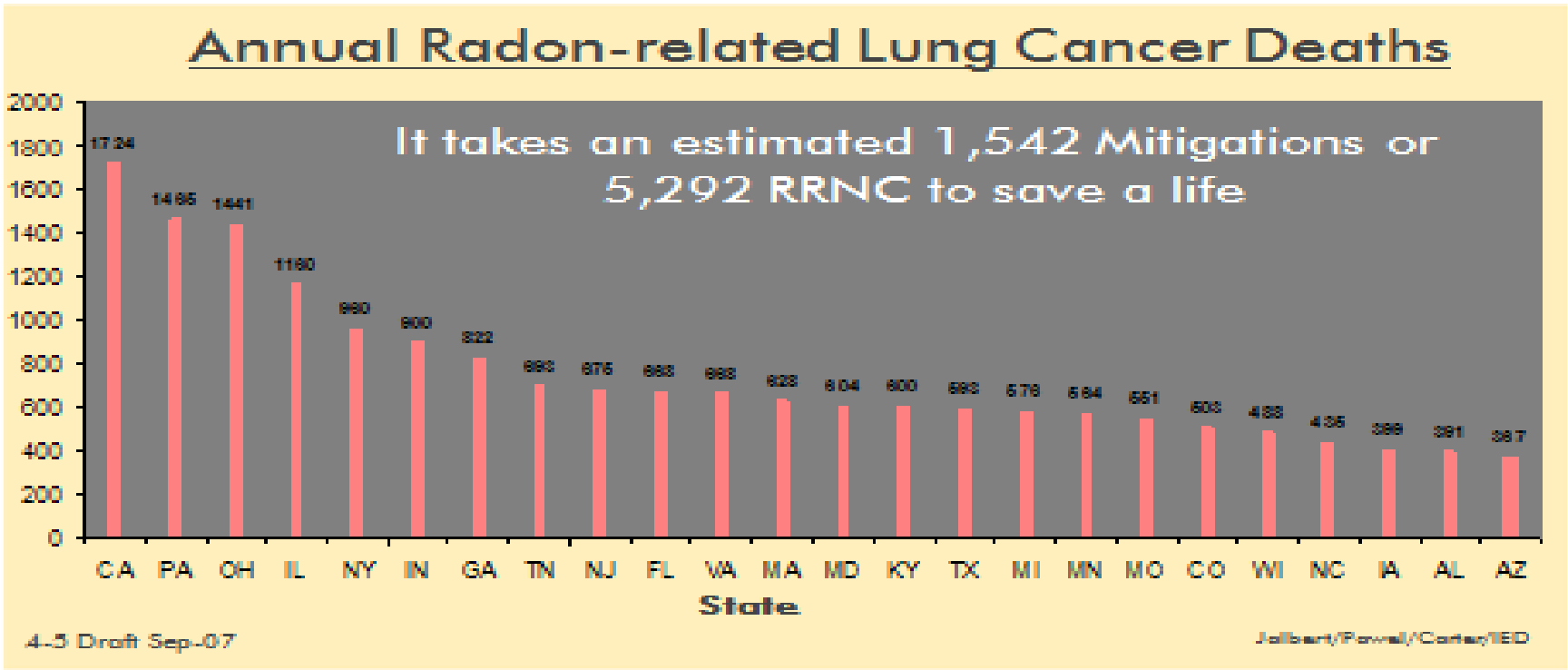
National Cancer Institute's 2010 Surveillance, Epidemiology, and End Results (SEER)



Annual Radon Related Lung Cancer Deaths
US EPA, Sept, 2007

NATIONAL RADON PROGRAM

17th National Radon Conference 2007
International Radon Symposium
Sept 9-12, 2007



Who Can Test?

Certified Testers

- Increased costs---$1000 and up/building
- Fewer details for school staff
- Must be NRSB or NRPP certified

School Staff

- Much lower costs—especially if the school intends to repeat testing later---$150/building
- More control of when and other conditions
- Increased education of staff
- Greater sensitivity of staff to testing

No two school buildings alike

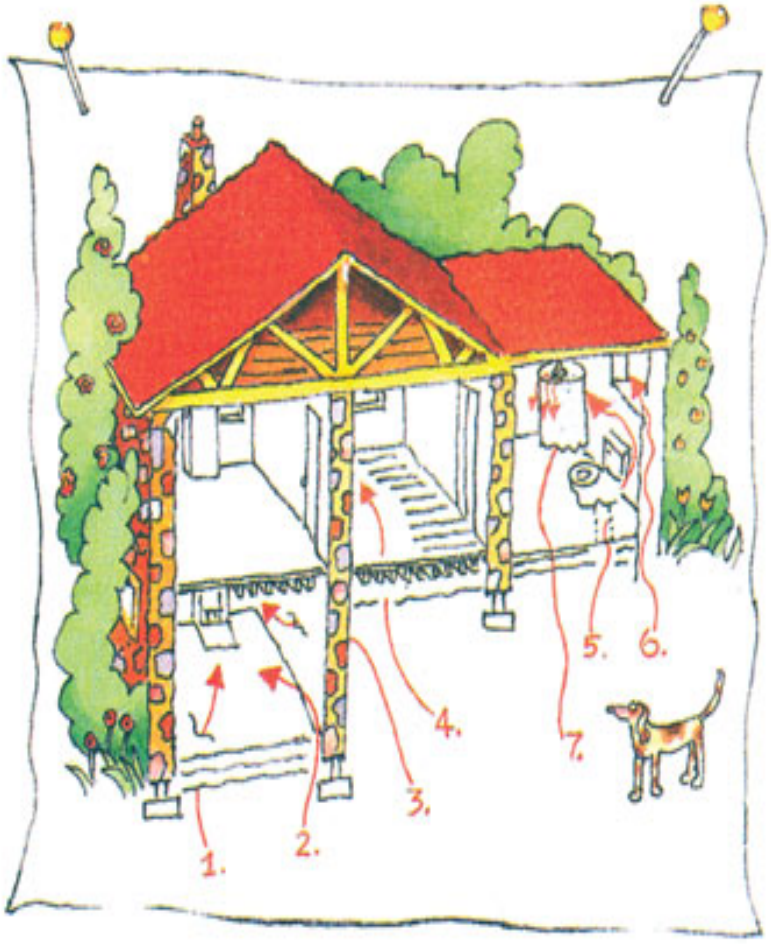
- Soil gas concentrations may be different
- Building structures are different
- HVAC designs and operations may be different

DETECTIVE MYSTERY

- No one knows ahead of time where the radon concentrations will be a problem.
- It will be our job to ‘hunt down’ and identify those rooms.

Radon Entry

- Cracks in solid floors
- Construction joints
- Cracks in walls
- Gaps in suspended floors
- Gaps around service pipes
- Cavities inside walls
- The water supply
- HVAC operations
- Pressure driven flows



HVAC AFFECTS

- May increase ventilation
- May decrease ventilation
- May pressurize a building
- May depressurize a building

Measurement Methods

- Charcoal Canisters
- Liquid Scintillation
- Alpha Track
- Electret
- Continuous Monitors

Charcoal Canisters

- They adsorb the radon gas
- The Radon gas continues to decay
- They must be Returned to lab for analysis quickly.

LSC Vial or Charcoal Canisters

- Weapons of choice:

Liq. Scin. (Cont'd)

- Small amount of charcoal in vial which is deployed just like charcoal canisters.
- When returned to the lab, a small amount of liquid 'cocktail' is inserted into the vial.
- The emissions of the radon and daughters 'light up' the cocktail and that light is measured by the LS counter. The more light, the more radon.
- These must be returned promptly to the lab.


ThinkPad
PerkinElmer
Liquid Scintillation Analyzer
Tri-Carb 3110 TR
LSC B
One-Source

Alpha Track

- Most commonly used for long term measurements.

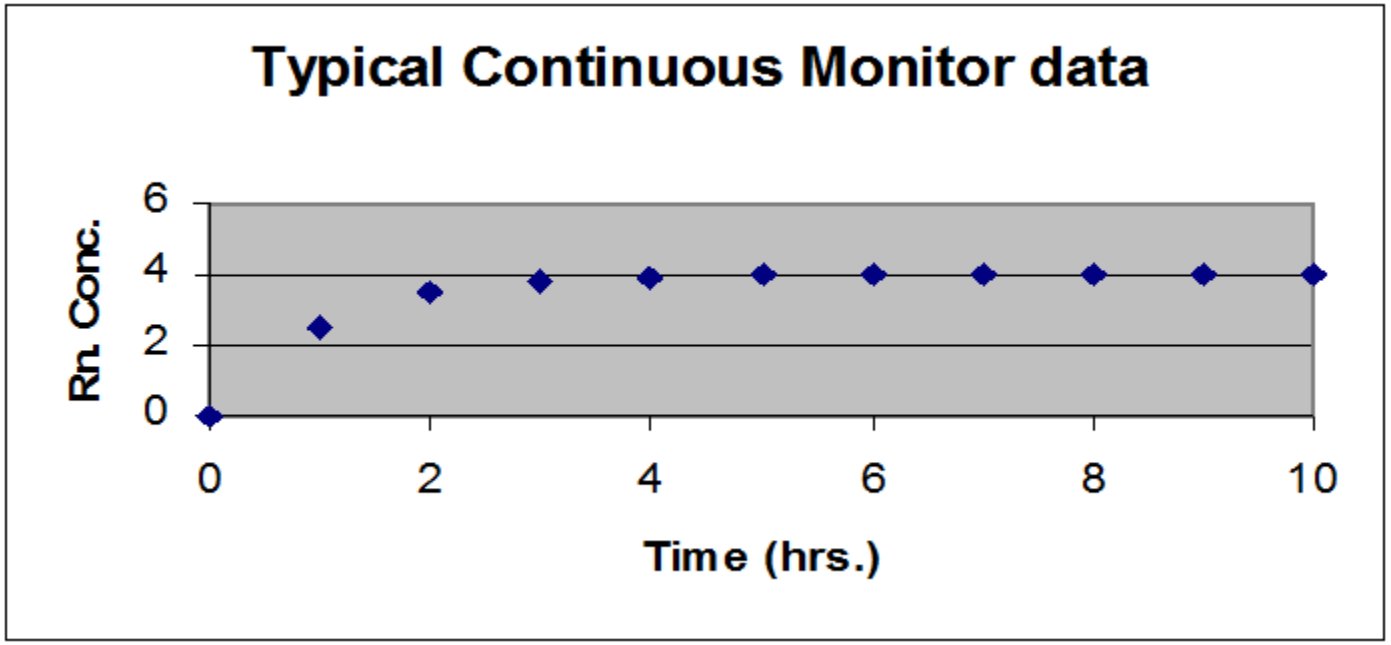
Courtesy Accustar

Electrets

Continuous Radon Monitiors (CRM)

- Pylon AB-5

RAMP UP TIME



Idealized

Measurement strategy Initial, then Followup

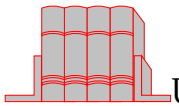
- Initial
  - Short Term (2-90days)
    - **all frequently occupied rooms in contact with the ground.**
    - **All rooms to be tested should be tested simultaneously.**
    - **During the school year, preferably during the heating season.**
    - **OR**
  - Long Term
    - **Greater than 90 days up to one school year.**

If Initial (Screening) is Short Term

- Followup is either short or long term
  - **Do a follow-up test in every room with a short-term, initial test result of 4 pCi/L or greater.**
  - **Perform them in the same location and under the same conditions as the Initial measurement and simultaneously.**
  - **If the initial result is between 4 and 10 pCi/l,**
    - **Followup may be either short or long term.**
  - **If the initial result is >10 pCi/l,**
    - **Followup is recommended to be short term and to be done immediately.**
  - **All followups to be done simultaneously**

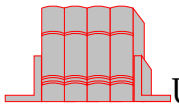
Take Action based on results

- If the average of two short term measurements is equal to or greater than 4 pCi/l.
- OR
- If the result of a long term follow-up measurement is equal to or greater than 4pCi/l.



Testing per Design

- Slab on Grade
- Open-Plan or Pod design
- Crawl Space Design
- Basement Design



Slab on Grade

- Measure only frequently occupied rooms in contact with the ground.
- Not: closets, storage rooms, etc.

Open-Plan or Pod Design

- If sections of a pod have moveable walls that can physically separate them from other sections, measure each section separately.
- If moveable walls are absent or inoperable, measure the pod as one room

  placing detectors every 2000 square feet.

Crawl Space Design

- If classrooms are above an enclosed crawl space, measure rooms directly above the crawl space.

Basement Design

- In addition to measuring all frequently occupied basement rooms and rooms with a floor or wall with ground contact, measure all rooms that have no ground-contact but that are directly above a basement space that is not frequently occupied.

Detector Placement Concerns

- Do not place detectors near drafts resulting from heating, ventilating vents, air conditioning vents, fans, doors, and windows.
- Place detectors where they are least likely to be disturbed or covered up. (Teacher's desk?)
- Do not place detectors in direct sunlight or in areas of high humidity.

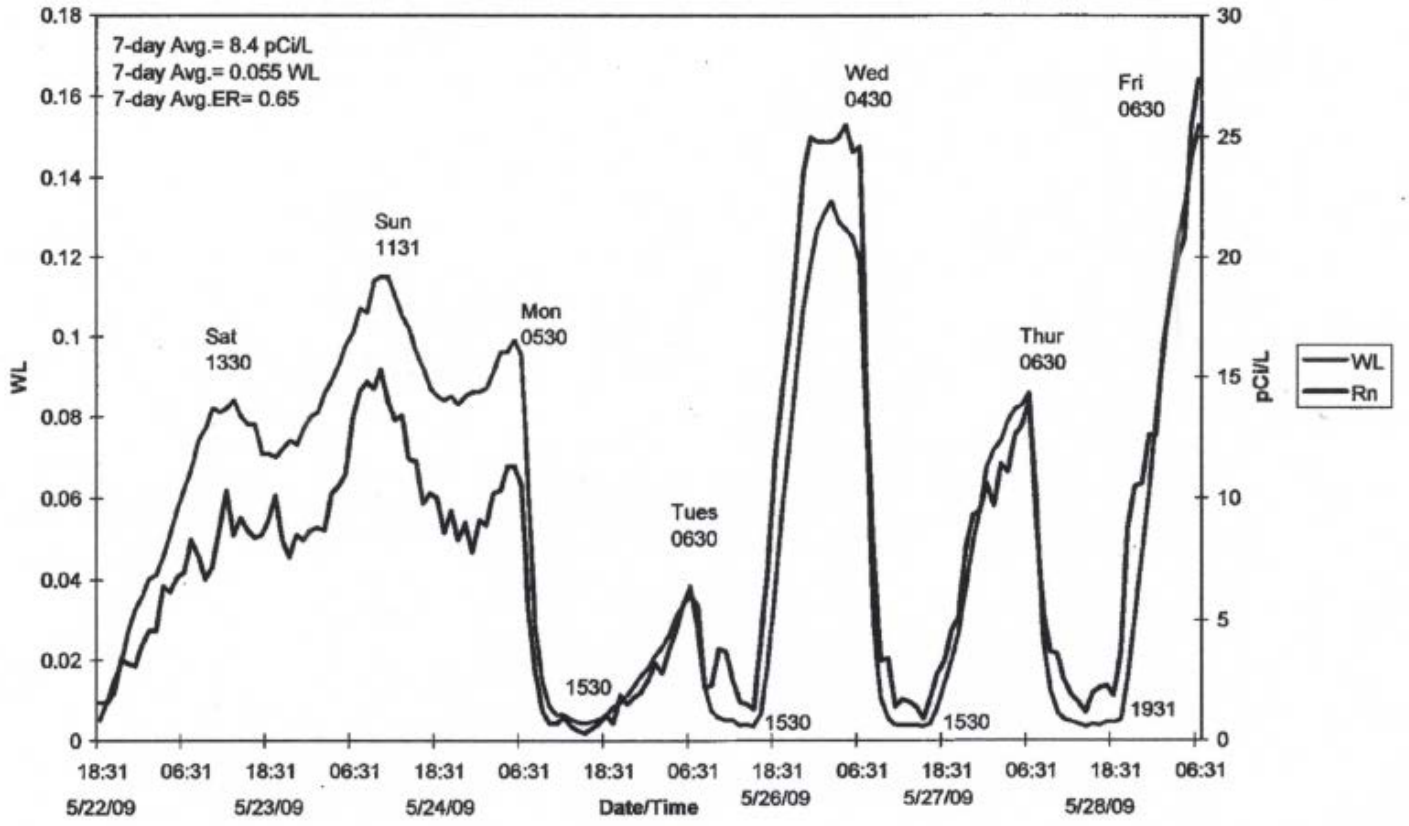
Detector Placement Concerns (Cont'd)

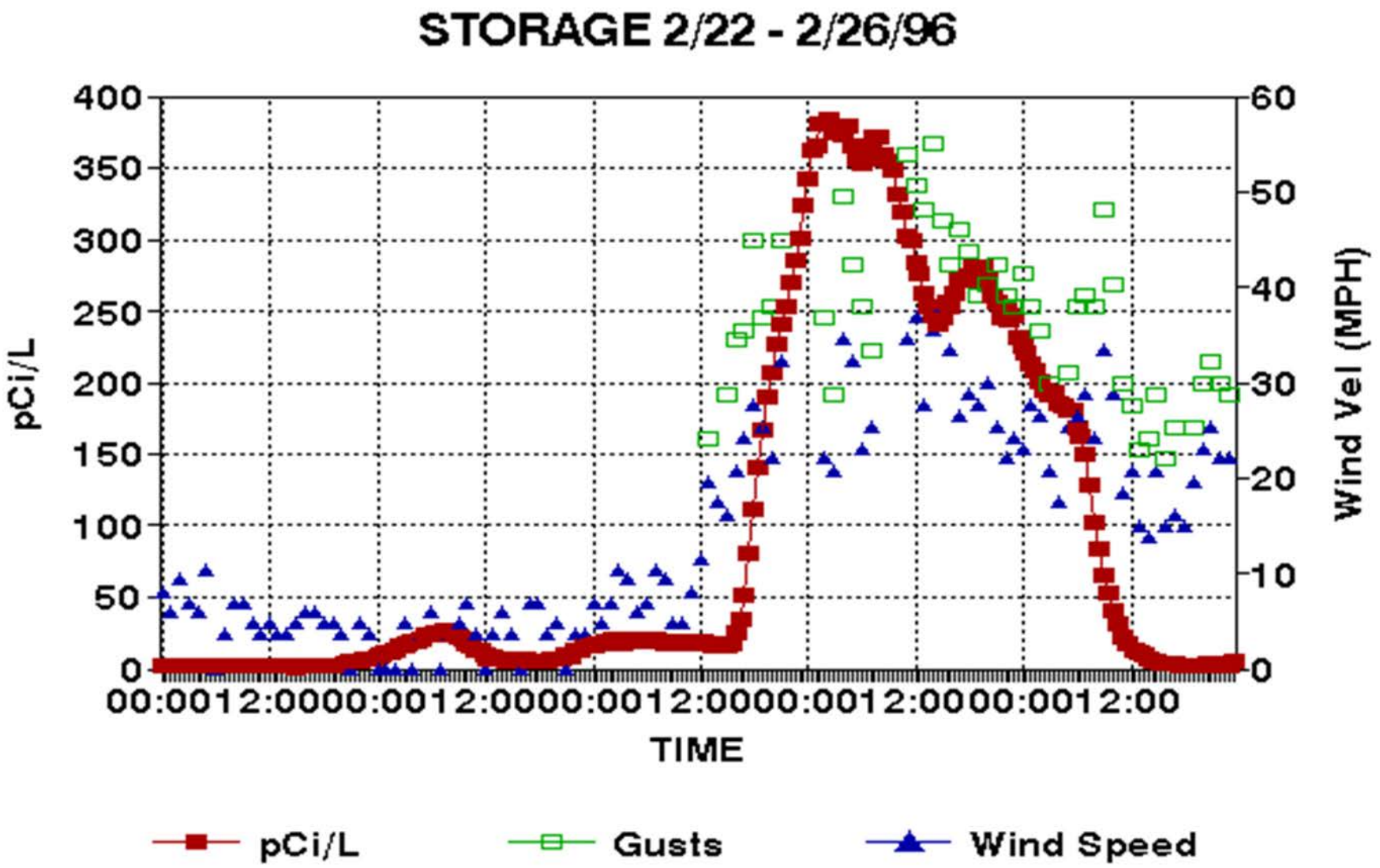
- Place detectors at least approximately 20 inches from the floor and 4 inches from other objects and away from the exterior walls of the building and 3 feet from windows, 1 foot from exterior walls.
- Place detectors about every 2,000 square feet for large spaces.
- Do not disturb the test device at any time during the test.

When to Test--Initially

- Under closed conditions (closed windows/doors except for normal exit/entry).
- After 12-hours of closed building conditions when using a 2 to 5-day test (e.g., initiate testing after a weekend).
- During colder months (October through March, depending on geographical location).
- During weekdays with HVAC systems operating normally when conducting a 2 to 5-day test.

Actual School Room Measurments

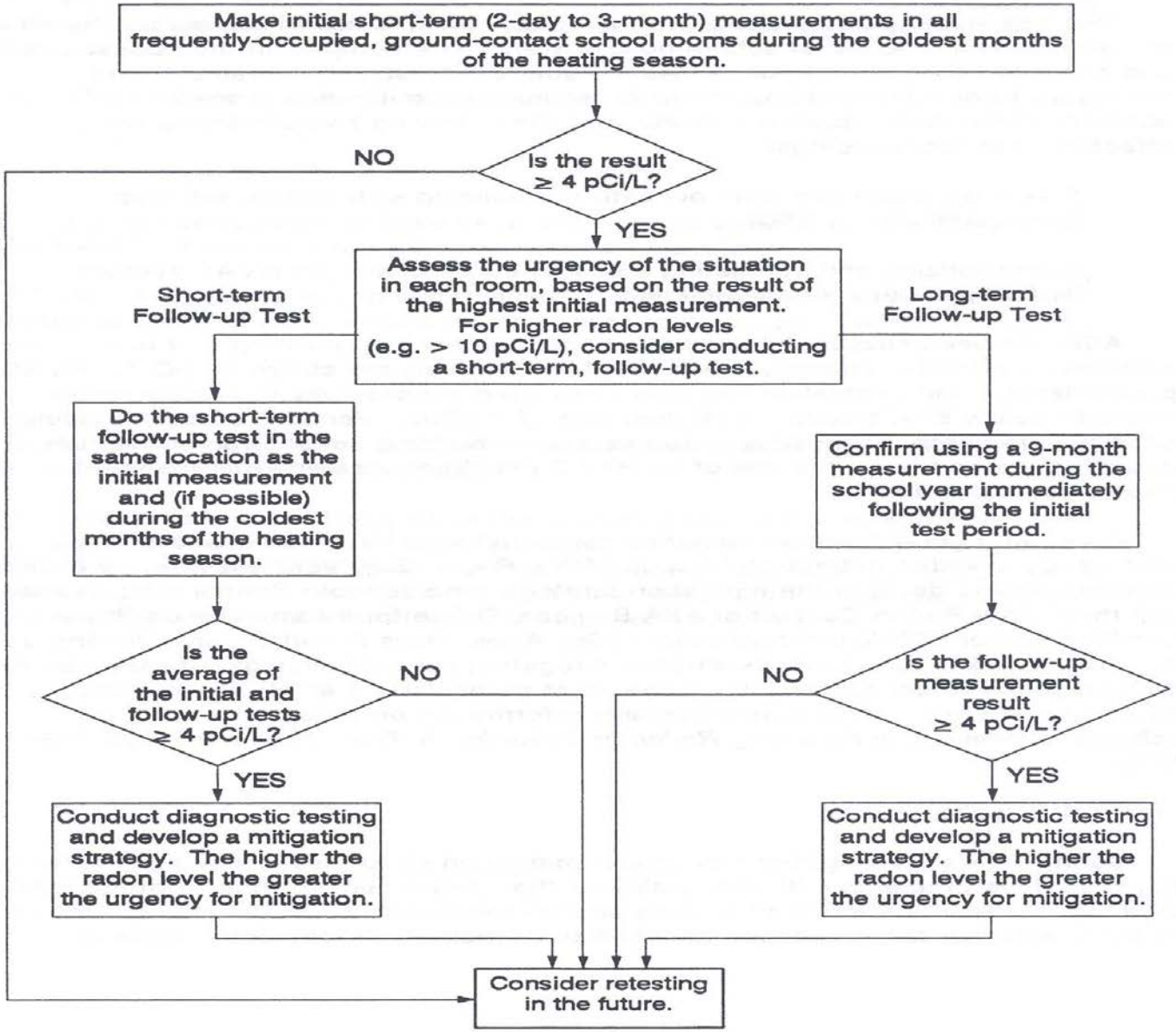



STORAGE 2/22 - 2/26/96
pCi/L
Wind Vel (MPH)
400
350
300
250
200
150
100
50
0
60
50
40
30
20
10
0
00:0012:0000:0012:0000:0012:0000:0012:0000:0012:00
TIME
pCi/L
Gusts
Wind Speed

When Not to Test

- During abnormal weather or barometric conditions (e.g., storms and high winds).
  - Check the weather
- During structural changes to a school building and/or the renovation or replacement of the HVAC system.

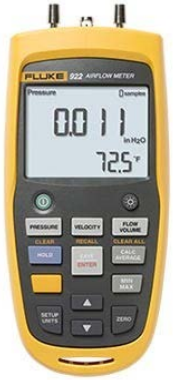
Decision-Making Flow Chart



How Quickly to Mitigate

- How quickly to begin the diagnostic measurements that precede mitigation will depend on the urgency of the situation as dictated by the radon level detected. Elevated radon concentrations (e.g., several times the action level or around 10 pCi/L) demand a quicker response.
- In addition, if radon levels are near 100 pCi/L or greater, school officials should call their State Radon Contact and consider relocating students and staff until the levels can be reduced.

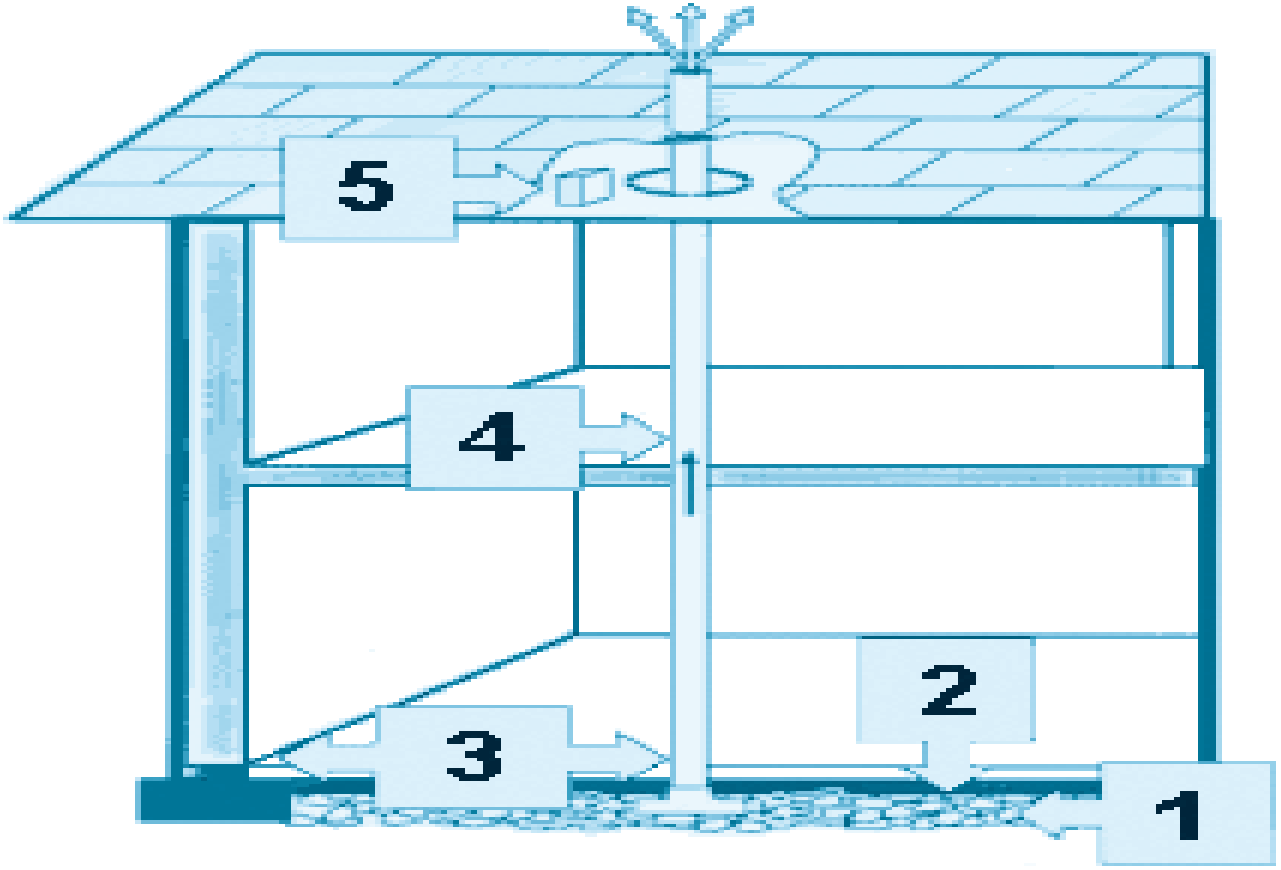
Diagnostic Tools



Mitigation Techniques

- Active Soil Depressurization (ASD or SSD)
- HVAC proper operation and Maintenance
- HVAC pressurzation and Ventilation
- Re-locate

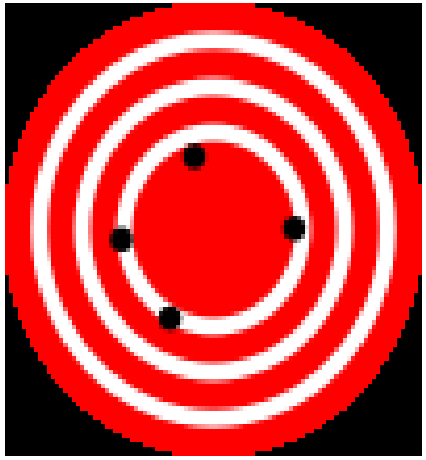
SUB SLAB DEPRESSURIZATION



QUALITY ASSURANCE

- Why do QA?
- Duplicates—10% of devices deployed, but not more than 50 (Side by side measurements—4 in. apart)
- Blanks—5% of devices deployed, not more than 25 (Unopened)

Precision vs. Accuracy



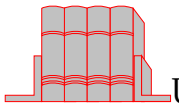
Quality Assurance

- Blanks
  - Should return with values close to 0.0 pCi/l
  - May come back saying e.g. <0.5 pCi/l
  - Do not deploy, but do unwrap.

Quality Assurance Duplicate log

D_1	D_2	M	M ≥ 4 *	RPD
			N =	TRPD =

D_1 and D_2 are the radon values of one duplicate pair, M is the mean of the two, RPD is the relative percent difference N represents the total number of duplicate pairs whose mean value is equal to or greater than 4 pCi/l and TRPD is the sum of the RPD column.



D_1	D_2	M	M ≥ 4*	RPD
1.4	1.2	1.3		
0.8	1.1	1.0		
3.9	3.5	3.7		
4.6	5.1	4.9	X	10.2
4.1	3.8	4.0	X	7.5
0.3	2.0	1.2		
0.8	0.5	0.7		
6.4	7.2	6.8	X	11.8
4.2	2.5	3.4		
1.8	2.4	2.1		
3.0	2.3	2.7		
4.5	3.7	4.1	X	19.5
0.5	0.6	0.6		
			N = 4	TRPD = 49.0

$$M = \frac{D1 + D2}{2} \qquad RPD = \left|\frac{D1-D2}{M}\right| \text{ x } 100\% \qquad ARPD = \frac{TRPD}{N}\%$$

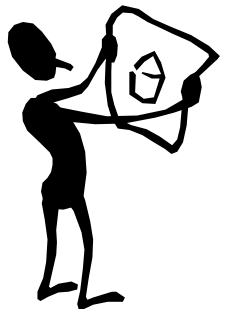
If ARPD >25%, contact lab

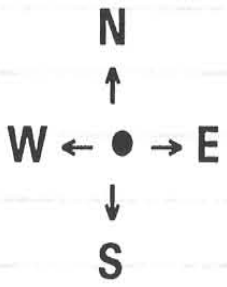
Checklist

1. Planning the Testing Program.
2. Deploying the devices—use anti tampering ideas.
3. Record Keeping.
4. Retrieving the devices.
5. Preparing the devices for laboratory analysis.
6. Quality Assurance
7. Letters to teachers, staff and parents

1. Planning the Testing Program

- Plan to test in early part of cold season.
- Consider holidays.
- Count the number of rooms to be tested.
- Add 15% for duplicates and blanks
  - This sum is the number of detectors needed.
- Make sure the device is NRSB/NRPP or state approved.
- Use a simple floor plan, e.g.





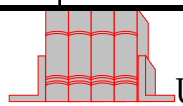
102	104	106 B	108	110	112	114	116
			Central	Hallway			
101 D	103	105	107	109	111	113 D	115

B=blank
D=duplicate

- Choose a location in each room and put this information on the device placement log.
- Identify those rooms to be used for duplicates and blanks with a D or B on the sample floor plan.
- Count the number of detectors when they arrive and read the directions carefully.

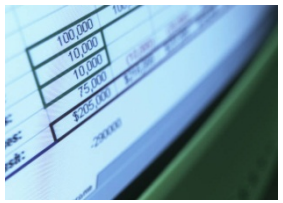
DEVICE PLACEMENT LOG

Room # name	location	Serial #	Start date	Start time	Stop date	Stop time	remarks	Result
100	s. Wall cabinet	65093	1/15/2012	7:22am				
D	D	97033	“	7:24am				
102	Bookshelf	93277	“	7:46am				
B	B	93278	“	7:50am				



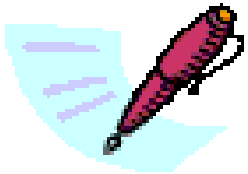
2. Deploying the devices

- Notify students and staff prior to deployment.
- Fill out the Device Placement Log while deploying the devices.
- Fill out the QA log while deploying devices.
- Deploy all detectors on the same day. (Tape, paper clips, string.)
- Be careful recording the dates and times when detectors are ‘opened’. Times may be in 5 minute increments.
- Duplicates should be placed 4 inches apart.
- Place “Radon Test in Progress” labels near or on detectors.



Blanks

- Do not deploy blanks
  - But record them as if they were deployed in customary rooms.*
- Complete any detector forms sent by the laboratory.



3. Record Keeping

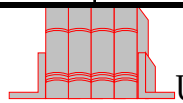
- In the comments section, record any unusual weather information, e.g. storms, high winds, building conditions, etc.

4. Retrieving the devices

- Follow detector instructions.
- Confirm the location and serial number with what's previously filled out on the log sheet.
- Check for damage.
- Record dates and times on the log sheet.
- Sign the log sheet.

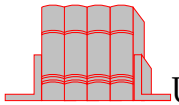
Device Placement Log

Room # name	location	Serial #	Start date	Start time	Stop date	Stop time	remarks	Result
100	s. Wall cabinet	65093	1/15/2012	7:22am	1/18/2012	4:34pm	Slight damage	
D	D	97033	“	7:24am	“	4:45pm		
102	Bookshelf	93277	“	7:46am	“	4:47pm		
B		93278	“	7:50am	“	4:47pm		



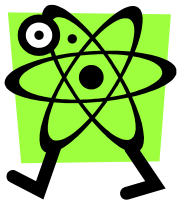
How's this device placement log?

				DEVICE PLACEMENT LOG			
Room name	location	serial number	start date	start time	stop date	stop time	remarks
100	s. wall cabinet	65093	1/15/2012	7:22 a.m.	1/18/2012	4:34pm	slight damage
102	left on teachers desk	93277	1/15/2012	7:25 a.m.	1/18/2012	4:36pm	
104	on left window sill	10455	1/15/2012	7:31 a.m.	1/18/2012	4:38pm	
108	center bookshelf	20543	1/15/2012	7:25 a.m.	1/18/2012	4:40pm	
109	in corner, on floor	93276	1/15/2012	7:32a.m.	1/18/2012	4:44pm	found on teacher's desk
110	above the first ceiling tile	40404	1/15/2012	7:35 a.m.	1/18/2012	4:48pm	
102	in left top drawer of teachers	21345	1/18/2012	7:40a.m.	1/12/2012	4:50pm	
112	On file cabinet in rear	81222	1/15/2012	7:42 a.m.	1/18/2012	4:52pm	
	Signature:	I .M . Good					



Preparing the Devices for Analysis

- Prepare the blanks (fill out the forms).
- Check the log sheet to be sure it's complete.
- Return Detectors.
- Wait for the results(7 to 10 days).



Prior To Releasing results

- Double check for correctness.
- Perform and Review all QA calculations.
- Place radon concentrations on building plan.
- Look for clusters.
- Release results via report.

- If you need help with interpreting results, contact
  - Ryan Paris, Radon Coordinator,VDH
    - 1-804-864-8161
    - Email: Ryan.Paris@vdh.virginia.gov

- Or call University Educational Services, Inc.
  - 1-570-350-0799

SUMMARY

- PRIOR TO TESTING
  - Establish floor plan
  - Identify rooms to be tested (Label on floor plan as “T”)
  - Count up number of detectors needed
    - Include additional 15% for blanks and duplicates.
  - Order detectors and anti-tampering devices.
  - Check detectors when they arrive for damage, labeling and proper quantity.

SUMMARY

- PRIOR TO TESTING (cont'd):
  - Establish testing dates
  - Check weather forecast and change testing dates as needed.
  - Inform all staff and students of dates tests will be ongoing. (provide educational materials)
  - Deploy Detectors and complete detector log forms.

DURING TESTING

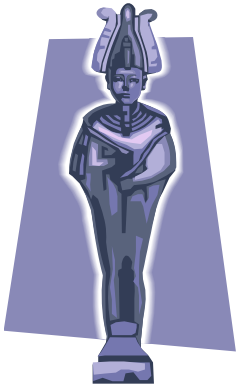
- Record unusual weather.

SUMMARY

- AFTER TESTING
  - Retrieve detectors
  - Check for damage, and labeling.
  - Fill in detector log form.
  - Ship.

SUMMARY

- UPON RECEIPT OF RESULTS
  - Complete log forms.
  - Review blank results.
  - Calculate all QA/QC calculations and assess.
  - Review for clusters.
  - Plan for Confirmatory tests.
  - Create Report. (After confirmatory tests)



- Do you have an emergency?
  - If so, contact Ryan Paris
    - 1-804-864-8161 or
    - Ryan.Paris@vdh.virginia.gov

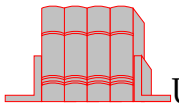
FAQs

- 1. Does radon cause headaches, eye irritation, or sick building syndrome?

NO

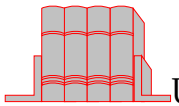
- 2. Is there any hazard involved in handling radon measurement devices?

NO



- 3. Are building materials likely to contain or emit radon?

  - Some phosphogymsum materials may emit radon but this material is rare in American buildings.
  - Some concrete and cinder blocks may emit radon but the concentrations due to them are likely to be insignificant. (There have been exceptions.)



References

- RADON MEASUREMENT IN SCHOOLS Self-Paced Training Workbook

  EPA 402-8-94-001 October 1994
- RADON MEASUREMENTS IN SCHOOLS—Revised Edition EPA 402-R-92-014, July 1993
- (Use “Corrections in the Second Printing)
- Radon Reduction Techniques in Schools EPA 520/1-89-020