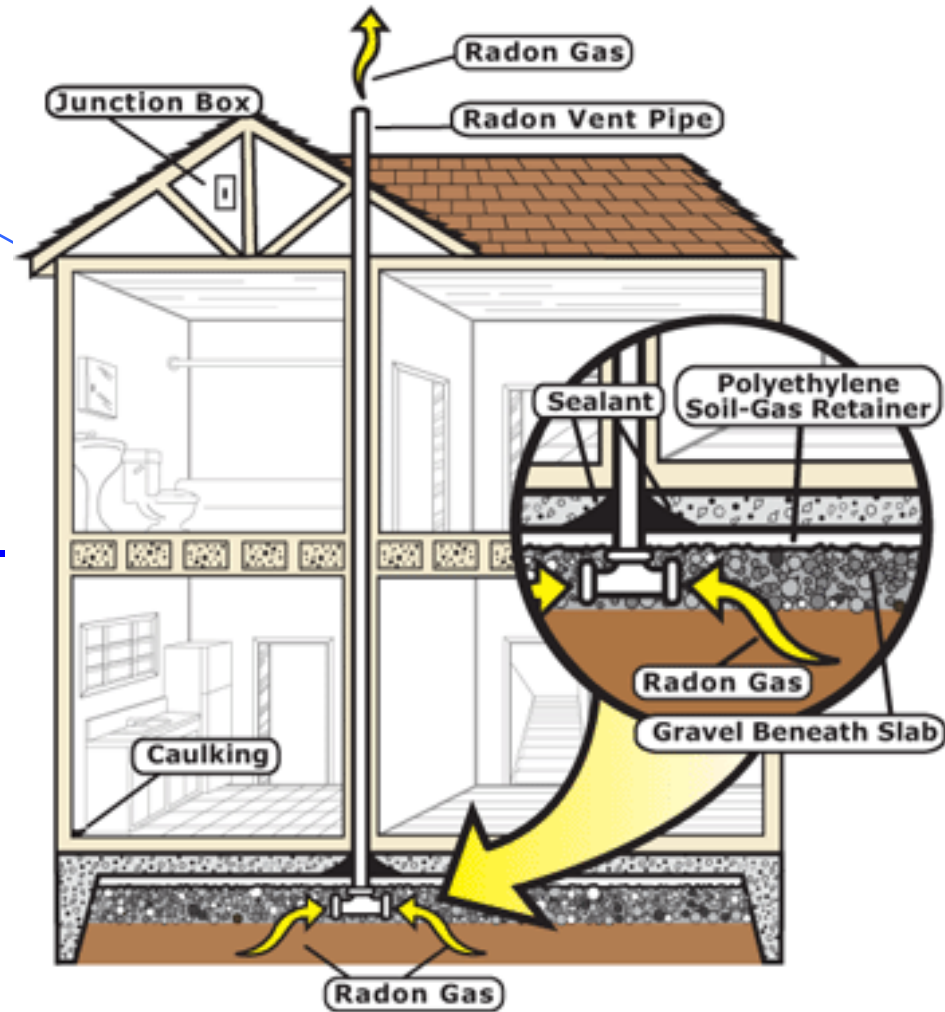


# Radon-Resistant New Construction - Basics for Code Officials



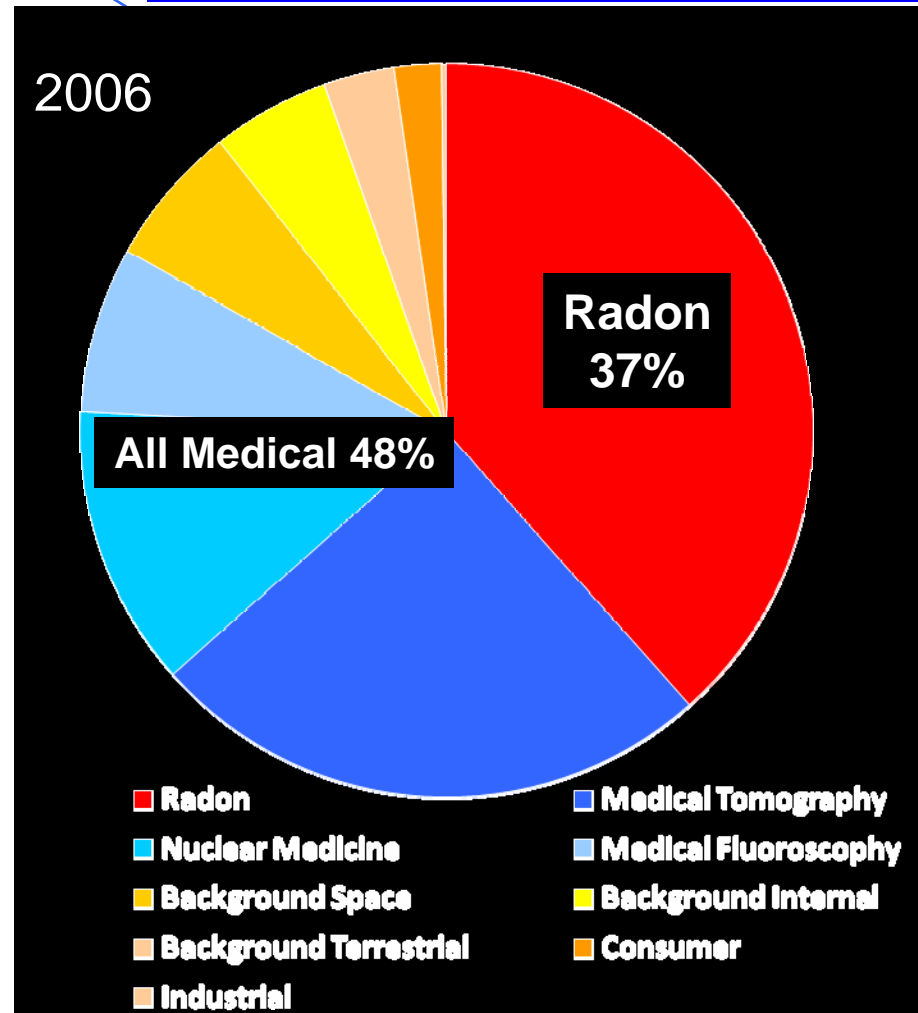
# “Radon is a Serious National Health Problem”

- American Lung Association
- American Medical Association
- Environmental Protection Agency
- National Academy of Sciences
- National Council on Radiation Protection and Measurement
- U.S. Surgeon General
- World Health Organization

# Radon Exposure in Homes Is Significant

Average annual radiation source exposures for US citizens

- Radon 222 - Naturally Occurring Radioactive Gas Element
  - Not Detected by Human Senses
  - Indoor concentrations are created by the way we design, build, and operate buildings where we live, learn, and work



# Basic Facts

- Radon is Everywhere!
- The only way to know the radon level is to test – it can't be predicted
- Your house may be low, your neighbor's may be high
- 95-99 out of 100 high homes can be fixed with fan powered soil suction systems

# Radon Entry and Common Concentrations

## EPA Action Level

4.0 pCi/L

The EPA's action level of 4.0 pCi/L is not a health based number.

EPA recommends mitigation at levels between 2.0 pCi/L and 3.9 pCi/L



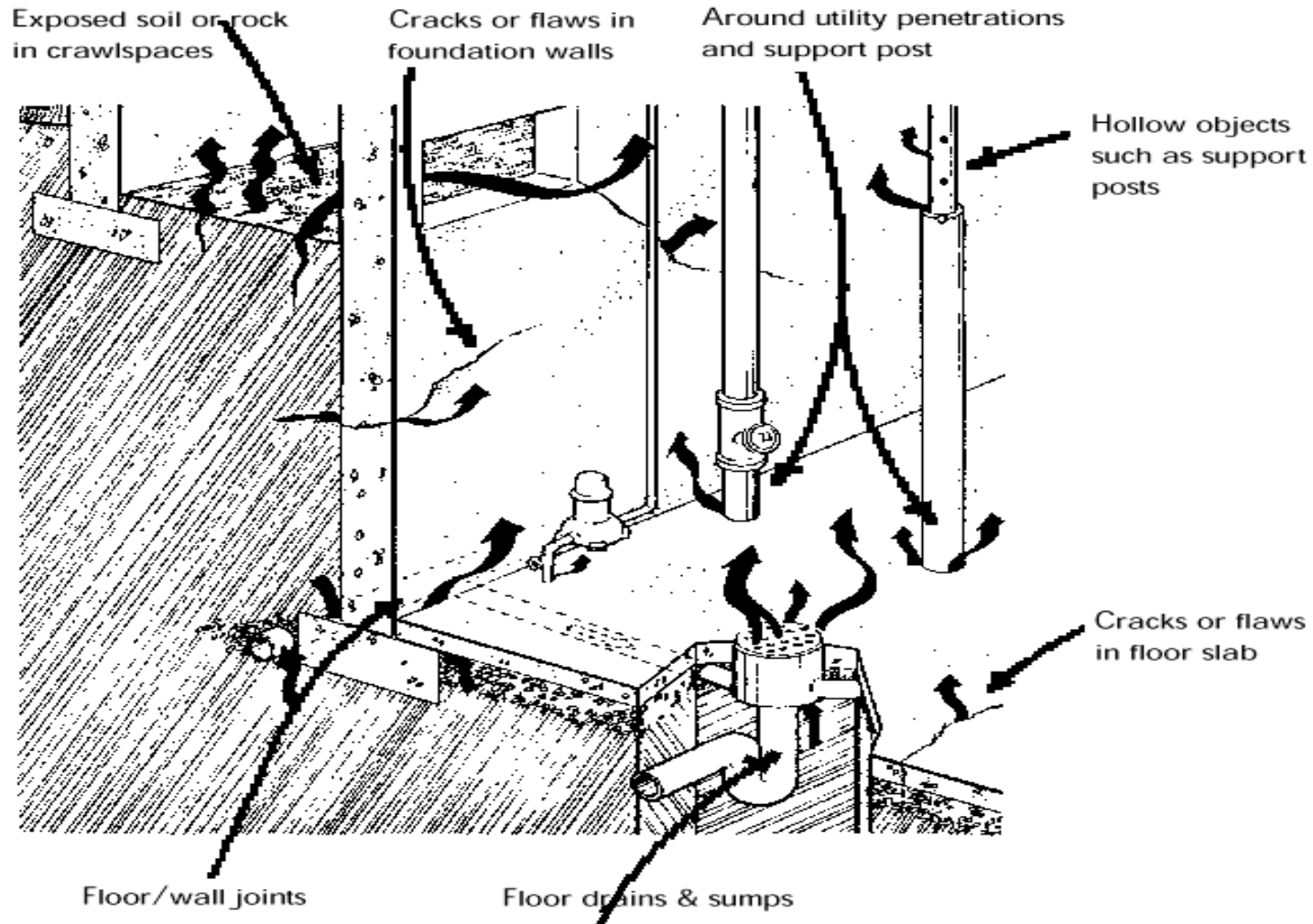
0.4 pCi/L \*U.S. annual average outdoors –

1.3 pCi/L \*-U.S. annual average indoors in homes (living areas) –

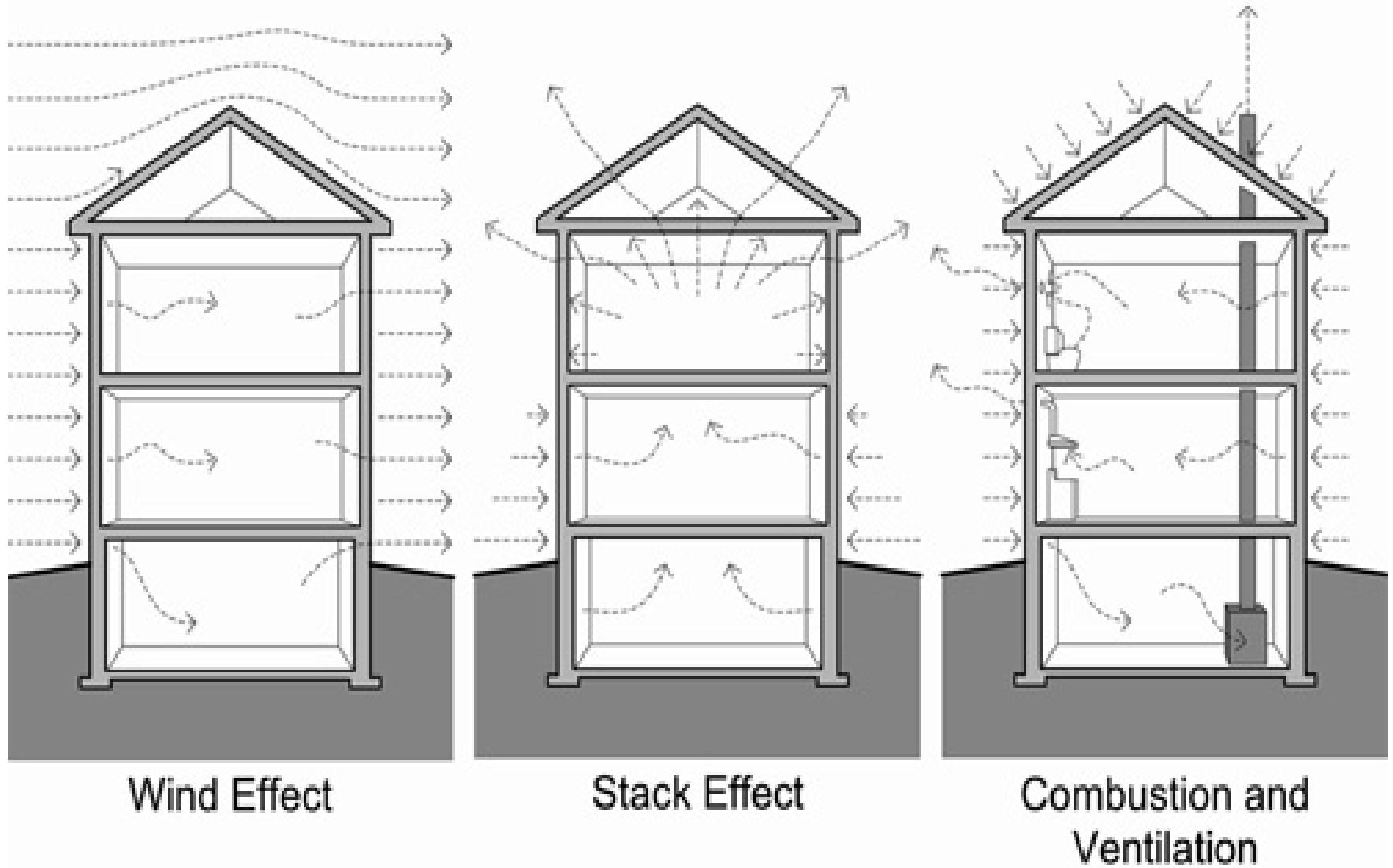
# The Concentration of Radon in a Building Depends Upon:

- Source of radon and its strength
- Air pressure differences
- Air pathways in soil and through foundation
- Air changes per hour – ventilation rate

# How Radon Enters Your Home



# Air Pressure Variables



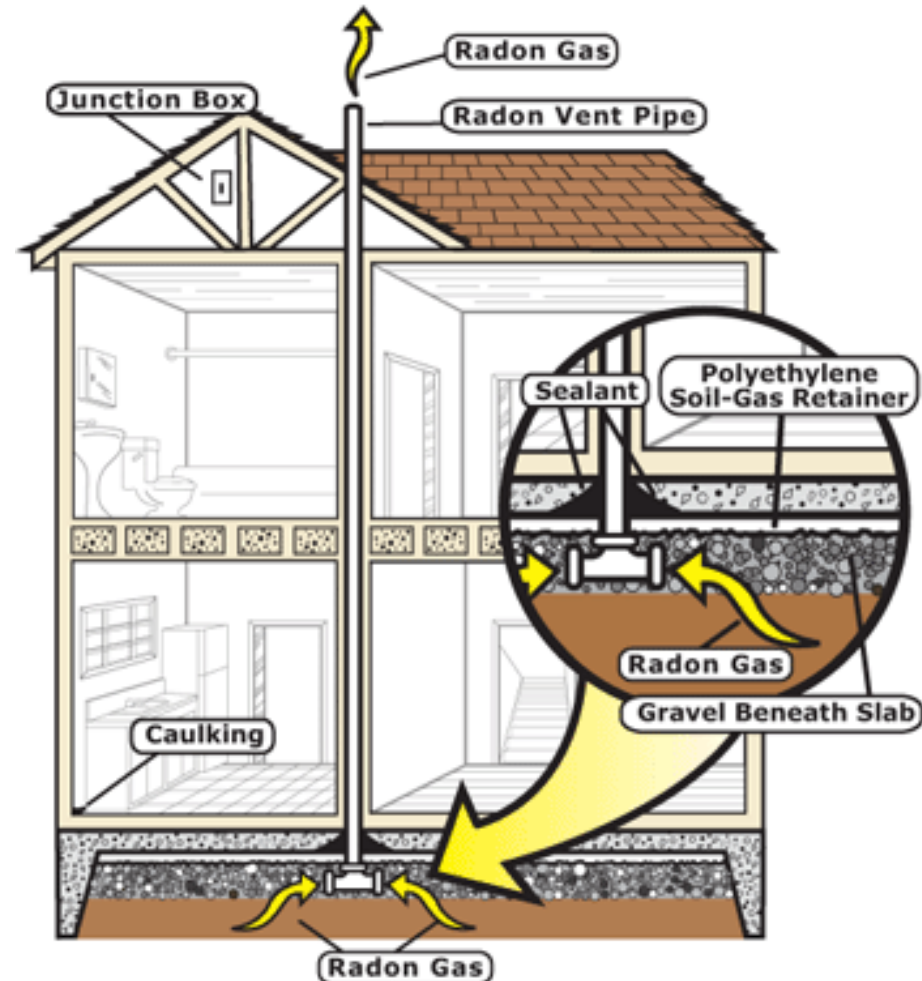


# Effect of Ventilation Rates on Indoor Radon Concentrations

- Just because a house is leaky or tight does not mean it will have low or high radon levels
  - In part, the indoor radon concentrations depend upon:
    - the percentage of air infiltrating that is soil gas (which can range from 1-20% of total infiltration)
    - the radon source strength in that soil gas, and
    - the overall air change rate of the structure
- Making homes tighter can increase the radon concentration due to decreased dilution from outdoor air

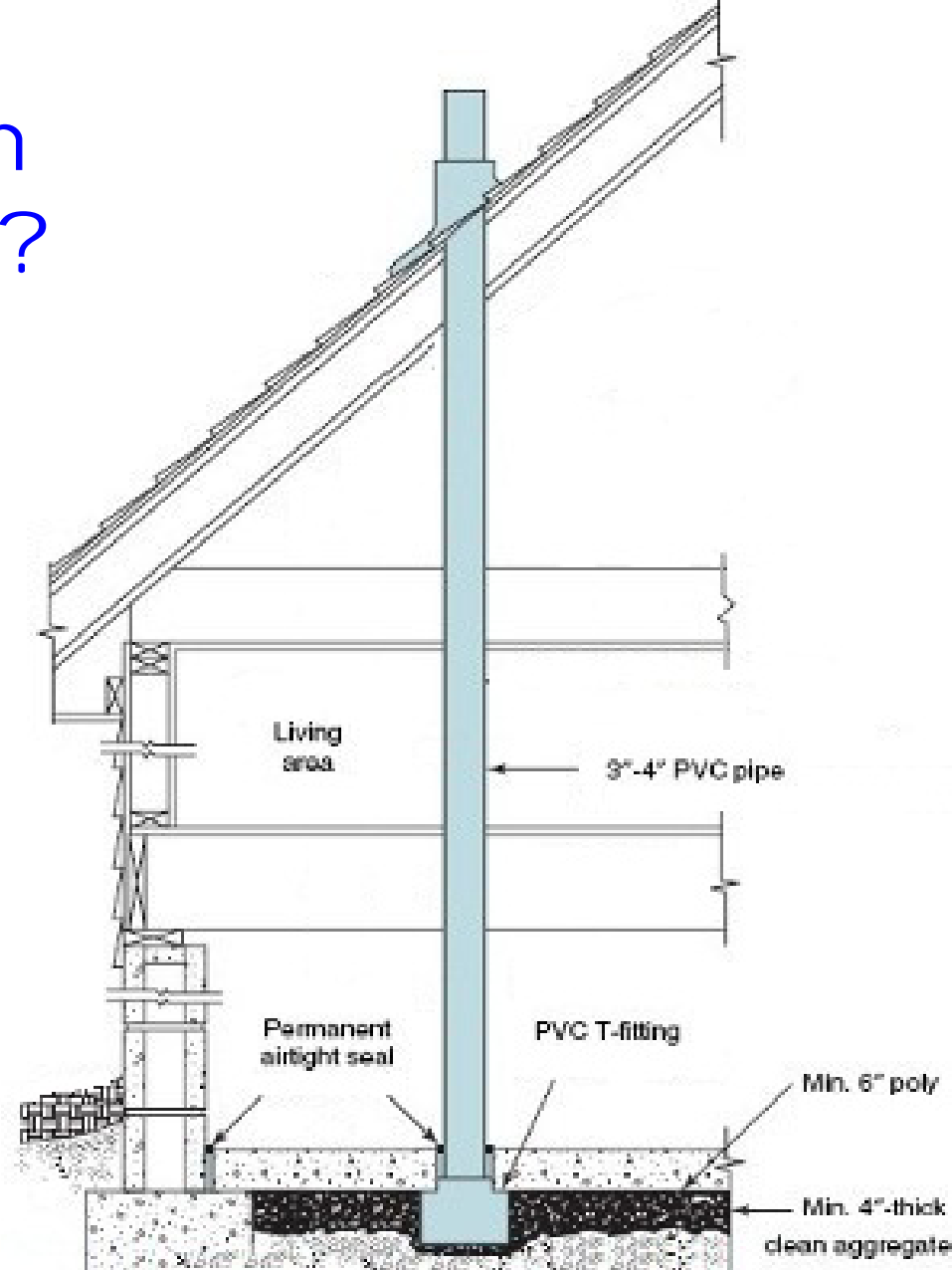
# What Does It Take to Build the House Radon Resistant?

- Foundation gas collection system
- Pipe to convey gas through roof
- A closed barrier between soil gas and indoor air
- Provision to add fan if needed



# How Is the System Supposed to Work?

- It is designed to vent radon from beneath the structure by use of a vent pipe routed through the conditioned space of a building, connecting the sub-slab area with outdoor air.
- When air in the pipe is more buoyant than outside air, the air escaping the pipe creates a slight vacuum (pressure differential) to pull soil gas towards the outside.
- Known as Passive Soil Depressurization - PSD

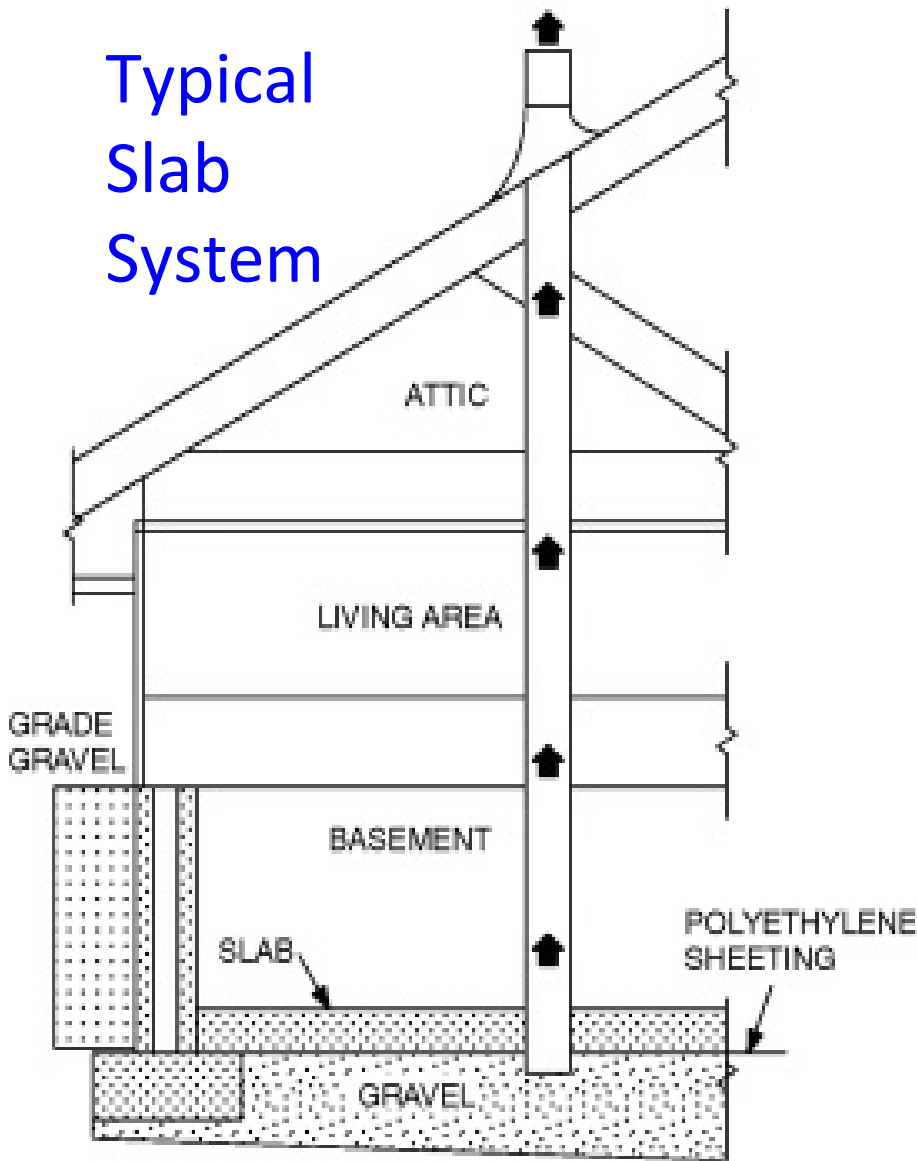


# Two Major Reasons Passive Soil Depressurization is Used

1. To reduce indoor radon concentrations
  - In general, about 50% reduction over the course of a year is expected if properly installed
2. To make the house easy to fix if further radon reduction is needed
  - By activation with a fan
    - Stack must easily accessible outside conditioned space for fan installation
    - Power must be available near fan
    - Major openings between soil and occupied space must be sealed

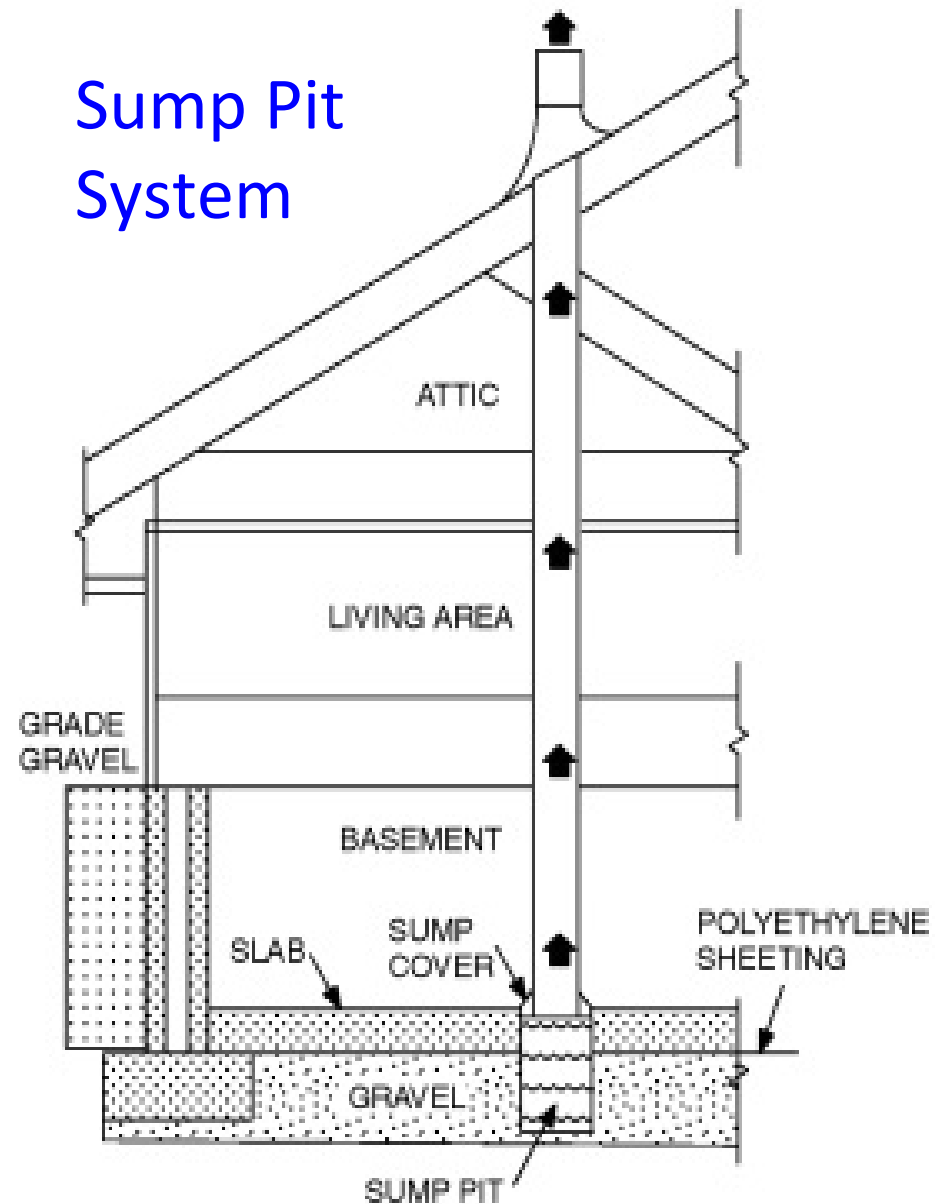
TYPICAL SUBSLAB DEPRESSURIZATION  
PASSIVE RADON SYSTEM

Typical  
Slab  
System



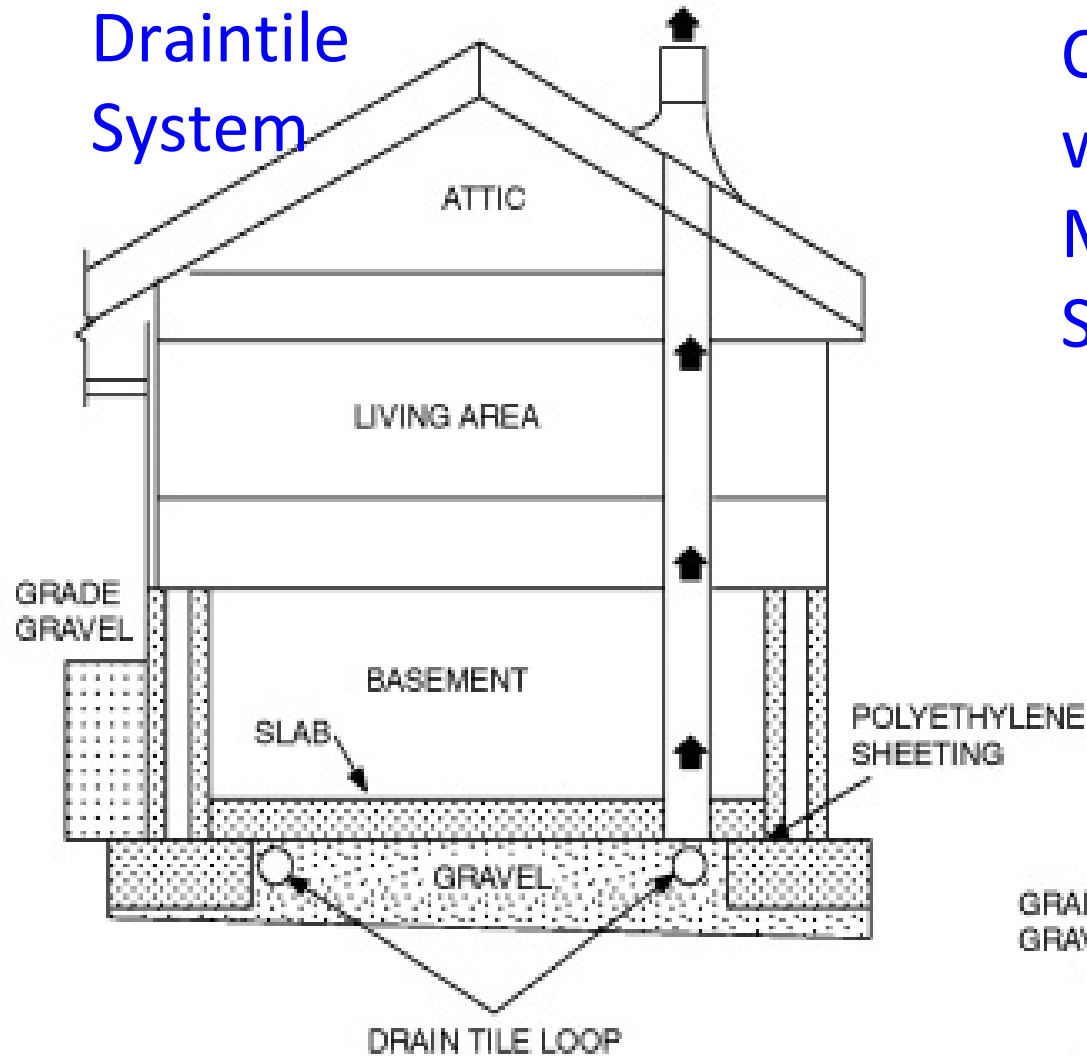
PASSIVE RADON SYSTEM VENTED  
THROUGH SUMP

Sump Pit  
System



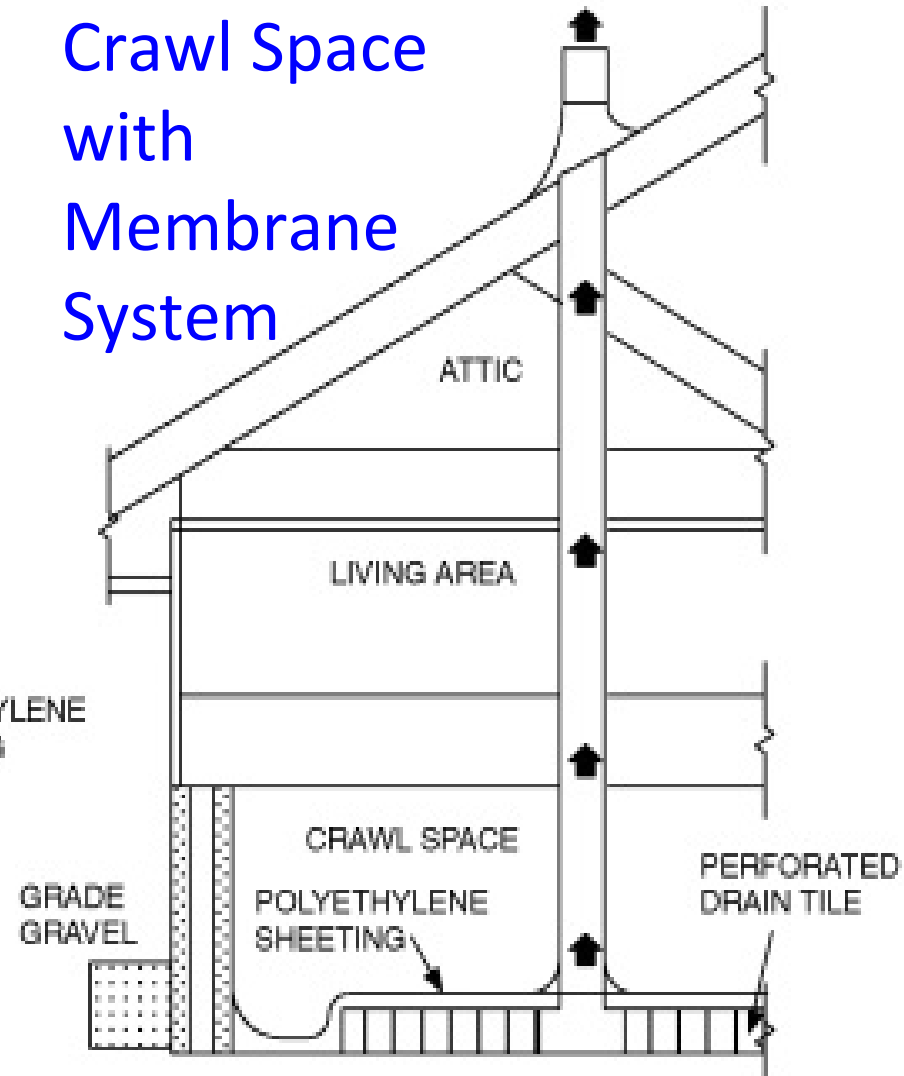
PASSIVE RADON SYSTEM USING DRAIN TILE LOOP

## Drain Tile System



SUBMEMBRANE DEPRESSURIZATION SYSTEM FOR CRAWL SPACE

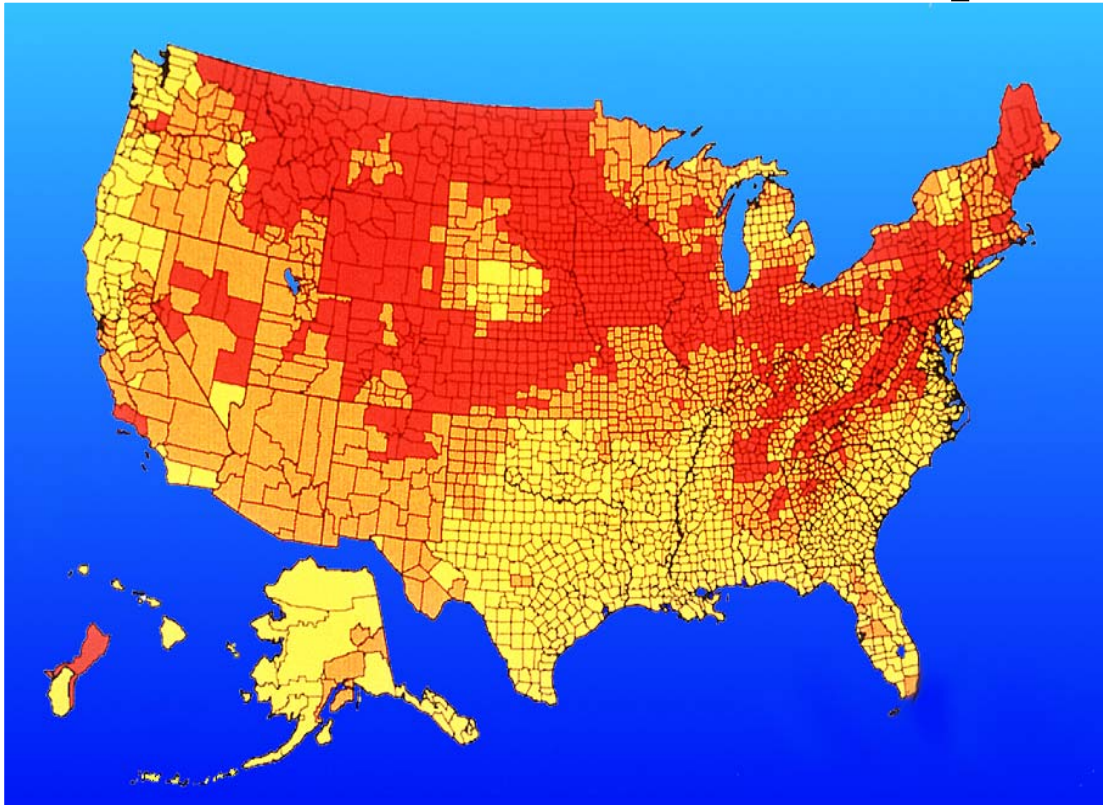
## Crawl Space with Membrane System



# International Residential Code (IRC) Appendix F: RRNC

(Initially intended for Zone 1)

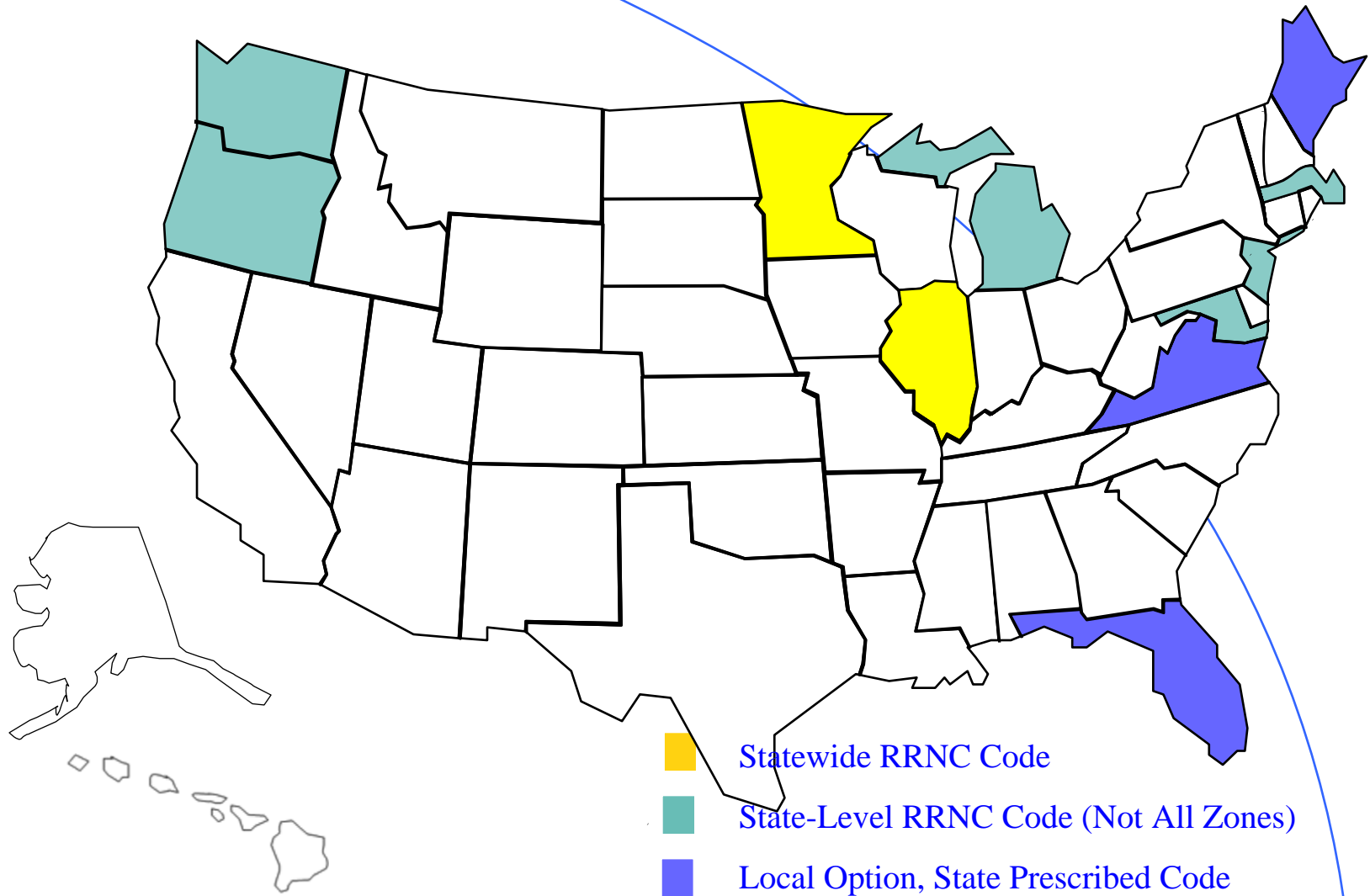
## 1993 EPA Radon Zone Map



- Adoption is encouraged for all zones as risk has increased since 1993
- EPA Radon Zones
  - Red = High potential  
Zone 1 > 4.0 ave.
  - Orange = Medium potential  
Zone 2, 2.0 to 4.0 ave.
  - Yellow = Low potential  
Zone 3 < 2.0 ave.



# RRNC Adoptions at the State Level





# Jurisdictions with Radon Control Building Code Requirements

- States (statewide or zone 1 only)
  - Illinois (statewide)
  - Maryland
  - Michigan
  - New Jersey
  - Washington
  - Oregon
  - Minnesota (statewide)
  - Massachusetts
- States (statewide but need local adoption)
  - Florida
  - Maine
  - Rhode Island
  - Virginia
- States (where local jurisdictions have adopted)
  - Alabama
  - Colorado
  - Georgia
  - Idaho
  - Iowa
  - Kansas
  - Montana
  - Maryland
  - Nebraska
  - New Mexico
  - New York
  - Ohio
  - Oklahoma
  - Pennsylvania
  - South Carolina
  - Tennessee
  - West Virginia
  - Wisconsin
  - Wyoming

# IRC Appendix F: Section 103 Requirements (Overview)

1. General
2. Subfloor Preparation
3. Soil-Gas Retarder
4. Entry Routes
5. Passive Submembrane Depressurization (PSD) Systems: Crawlspace
6. PSD Systems: Basements and Crawlspace
7. Vent Pipe Drainage
8. Vent Pipe Access
9. Vent Pipe Identification
10. Combination Foundations
11. Building Depressurization
12. Power Source

# Summary of PSD Effectiveness Testing

Study	# Homes	Average Rn Capped	Average Rn Uncapped	Average % Rn Reduced	Comments
NAHB 1994	45	5.9	2.5	<b>57%</b>	Most built ~ EPA standards, some no poly, some no sealing; inspected during construction
East Moline, IL 1998	21	9.2	3.7	<b>59%</b>	Built ~ EPA standards but un-finished basements w/o poly; inspected during construction
Monroe Co., NY 2002	20	2.9	2.5	<b>12%</b>	<u>Vent stacks NOT through conditioned space, no poly under slab</u>
Muscatine, IA 2002	13	9.3	7.5	<b>20%</b>	12 homes had <u>sub-slab sand NOT permeable layer</u> , 1 home with sub-slab gravel had 51% radon reduction
Dane Co., WI 2003	7	11.1	4.7	<b>42%</b>	Built ~ EPA standards and inspected during construction; <u>1 house at 12 pCi/L with PSD had large leaks</u>
Manhattan, KS 2002-2005	19			<b>31 - 37%</b>	<u>Unsealed sump pits, vent stack NOT through conditioned space (1)</u>

# PSD Can Work But ... It Needs To Be Done Correctly

- If not done correctly . . .
  - May not provide much, if any, radon reduction
  - Can make future activation, if needed, difficult, impractical, or impossible
- It is *highly important* to test all new homes for radon, even those with PSD
  - PSD does not guarantee  $< 4$  pCi/l but . . .
    - It does reduce indoor radon and it provides a system ready for activation if needed

# Testing Reveals Performance!

- Installing RRNC properly enhances the potential that radon levels will be low.
- The only way to know if the system is successful is to test.
- Testing can occur when ready for occupancy.
- If the house tests above 4 pCi/L the system should be activated with a fan and system pressure indicator added to the pipe.

# Liability Concerns

- This is a life safety system
- Buyer commonly assumes performance is assured just by presence of a system
- Untrained contractors doing work – no one to assume liability
- Lawsuits against builders for incorrectly installed systems

# Costs and Cost Saving

- No RRNC can lead to systems being installed on the exterior
- Poor installation means redoing the work
- Poor installation means poor performance leading to more activations
- Electrical costs are less when run during construction
- Poor performance means more testing to clear the property
- Failed tests can delay closing on the property

# Performance Issues

- Pipes Blocked by Construction Debris
- Pipes Blocked by Soil
- Stack Pipe too Small
- Pipe Routed Through Unheated Space
- Pipe does not Discharge Above Roof



# Performance Issues

- Pipe Joints Note Sealed
- Pipe installed at 45 degree angle in attic. No room for fan
- Pipe installed directly next to truss member not allowing space for fan
- System Labels Lacking
- Radon Performance Tests not Done

# Mitigator Comments About Activating Builder Installed PSD

- My experience has been that about 25% of activations of builder installed systems work fine, and 75% must be altered or abandoned.
- The most common fixes needed are cleaning out the suction pit, correcting the pitch of the piping, filling holes under tubs and sealing wall/floor joints, altering piping to allow room for a fan, completing roof penetrations, and installing electrical service.

# Why Build Using Radon Resistant Techniques

- Radon-resistant new construction (RRNC) typically costs a builder between \$250 and \$750.
- RRNC could cost less than \$250 if the builder already uses some of the same techniques for moisture control.
- Energy and moisture reduction benefits
- To reduce incidence of lung cancer
- To reduce potential liability

# RRNC – Barriers to Adoption

## Technical Issues

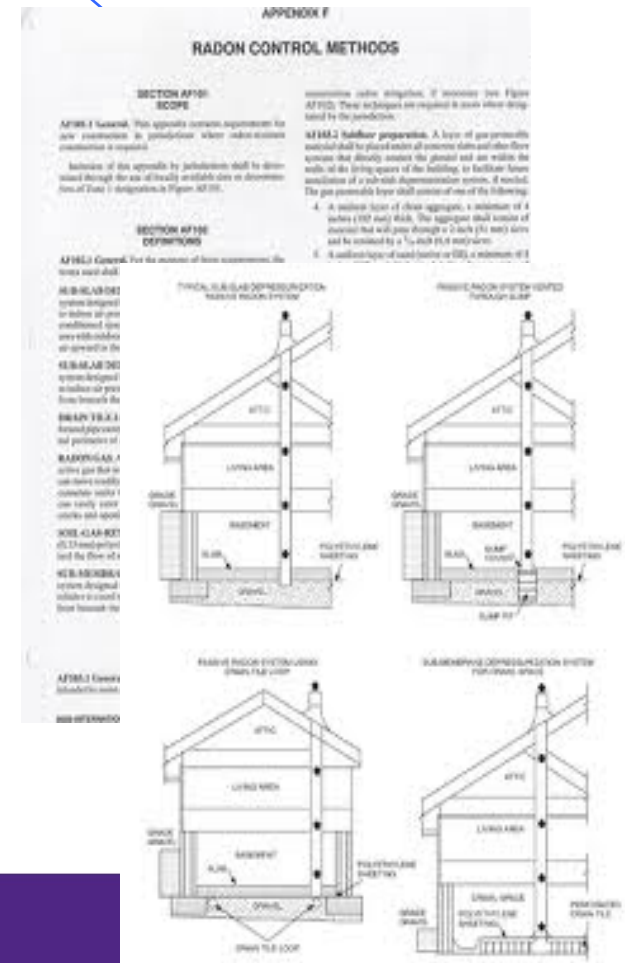
- Appendix F not credible
  - Radon & Building professionals
- Appendix F inept
  - Pipe connection
  - Space for fan
  - Submembrane sealing
  - Duplicative of some code provisions
  - Overall clarity
- Builders need training/guidance
- Plumbers need direction
  - Plumbing code?

## Systems Issues

- ICC Paralysis
  - Code updates occur place by place
- Appendix tradition
  - Local “can opt” to save lives
  - NAHB opposed to requirement
- Zone map tradition
- Environmental issues ban (ICC)
- Not incremental cost

# Status of Changes to IRC Appendix F

- AARST team
  - Proposed changes to clarify
    - Connection, discharge, fan installation
    - Eliminate duplicate code provisions
    - Delete control joint sealing requirement
    - Support from NAHB staff
  - Proposed new section in code (still optional)
    - AARST withdrew its support as compromise
- Lost at hearing due to unrelated wording issue
- Future talks will ensure Appendix F cleanup
- Changes can be promoted w/new adoptions
- Update to CCAH under consideration
- Training



# RRNC Landscape

- State and local codes can require RRNC for homes in high radon-prone areas - but most don't
- IBC needs an RRNC appendix
- IRC needs a better RRNC appendix
- Everyone who touches housing - homeowners, tenants, realtors, builders, code officials, radon professionals - has a self interest in RRNC done right the first time

# Questions/Discussion

# Resources/ Handout for You

<http://sosradon.org/rrnc>

## Radon Resistant New Construction (RRNC)

- Why Consider RRNC?
- Installing Radon-Resistant Features
- RRNC What Do I Give My Builder? - RRNC Codes and Standards
- RRNC Fact Sheets

<https://www.epa.gov/radon/building-codes-radon-resistant-new-construction-rrnc>

<http://www.nehacert.org/CDPHE/ColoRRNCVideo.html>

## Building In Radon Control

Radon is a tasteless, colorless and odorless gas

occurring naturally in soil and rock. Radon is a leading cause of lung cancer, second only to cigarette smoking.

Installing a radon system during construction of a structure doesn't cost a lot, and enhances the value of the property.

**How a radon system works.**

Crushed stone under the house provides an

easy pathway for the radon to migrate towards the vent piping, where it is drawn upwards and released safely into the atmosphere.

The mitigation system will lower radon levels even without a fan, but it may not be enough. A fan may be required. A simple radon test will provide the answer.



A radon test should be performed immediately after the house is occupied, and a fan installed if results are greater than 4 pCi/L.

For further information: IRC 2006 Appendix F, or Pa. Dept. of Environmental Protection, Radon Division, or [www.state.pa.us](http://www.state.pa.us) PA Keyword: radon or 1-800-23RADON



# Contacts

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[gary@air.com](mailto:gary@air.com)