Understanding Radon in Homes

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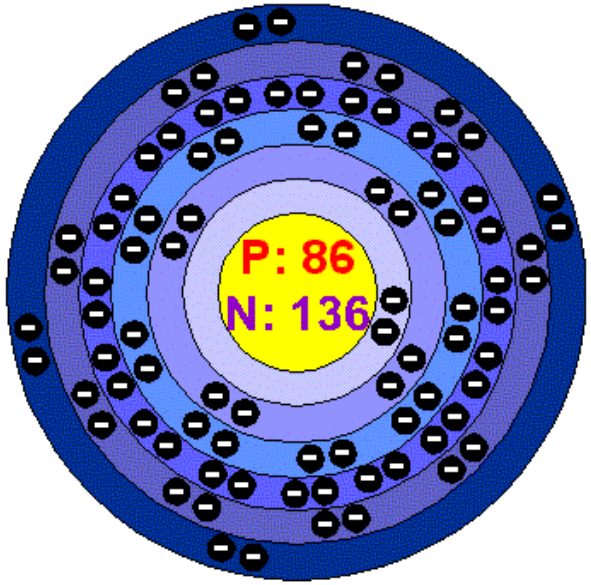
PINCHIN & AFFILIATES

- A leader in engineering, environmental and health & safety consulting solutions
- Multi-disciplinary approach by highly qualified, experienced professionals
- Established in 1981
- Part of the Pinchin Group of Companies, a national network of over 35 offices with over 700 staff

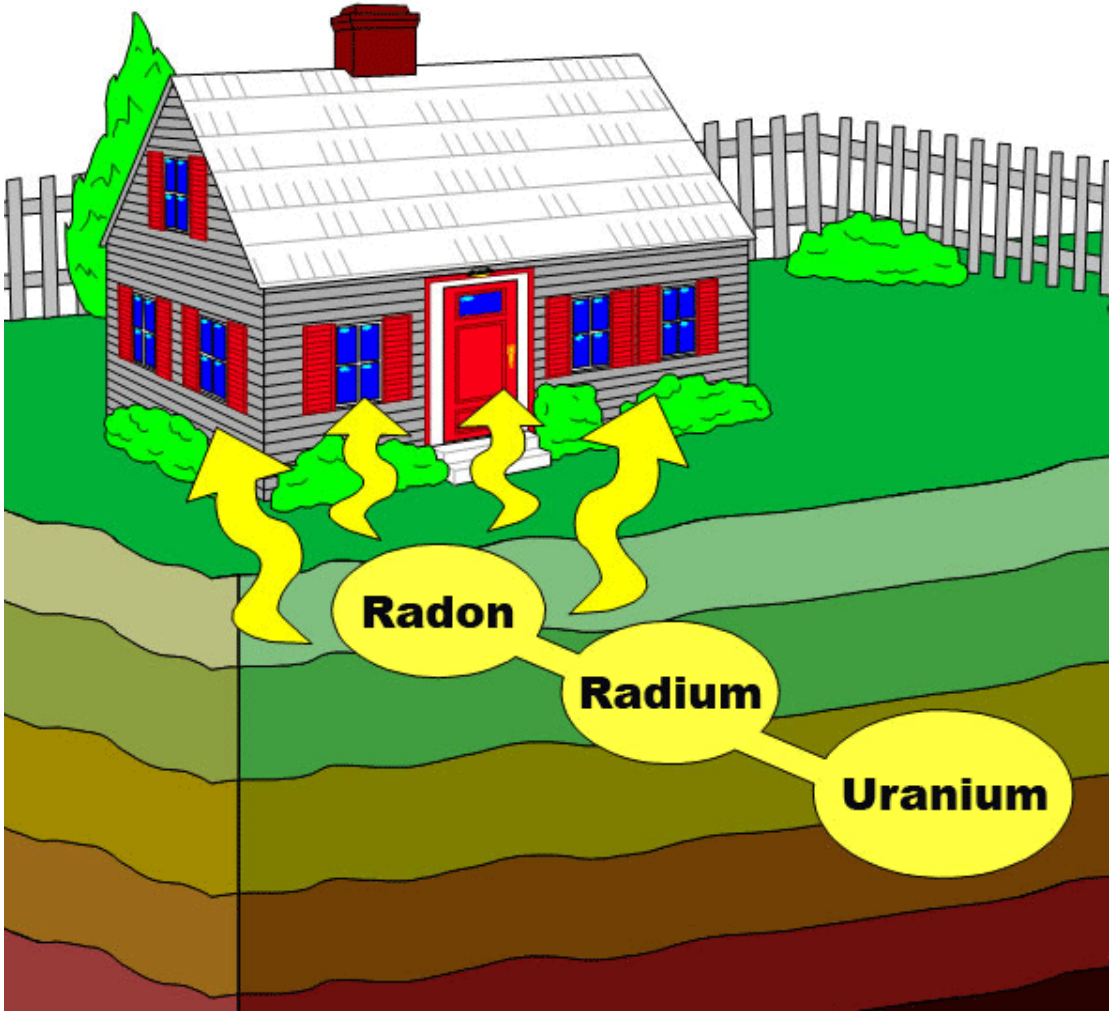
SEMINAR OUTLINE

- What is Radon?
- Health Concerns
- Acceptable levels
- Radon in buildings
- Potential regulation
- Testing for Radon
- Mitigation of Radon



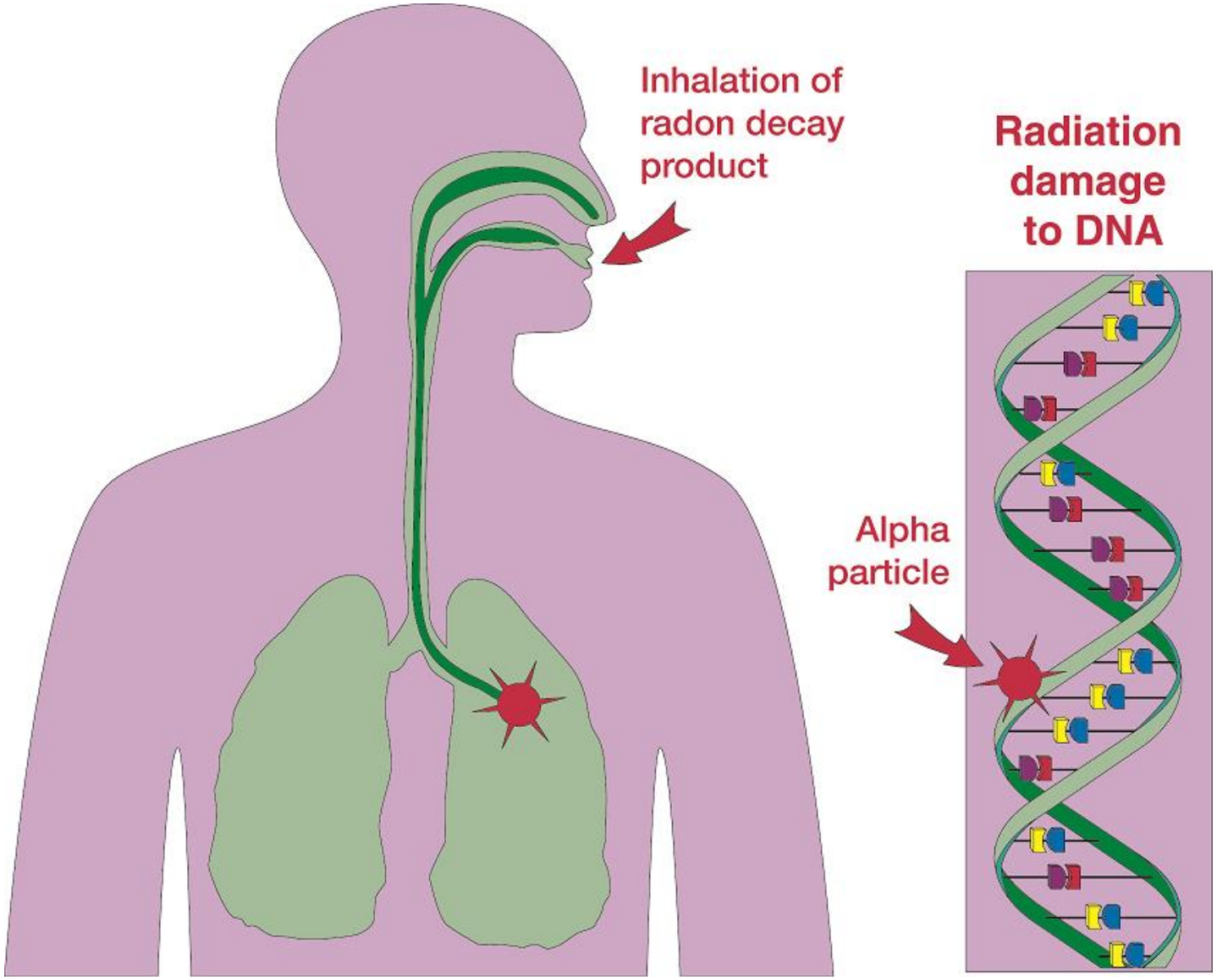
WHAT IS RADON?

- Naturally occurring radioactive gas
- Colorless, Odorless, and Tasteless
- Produced by the decay of uranium in soil, rocks, and water
- Gases move freely through the soil and into the atmosphere



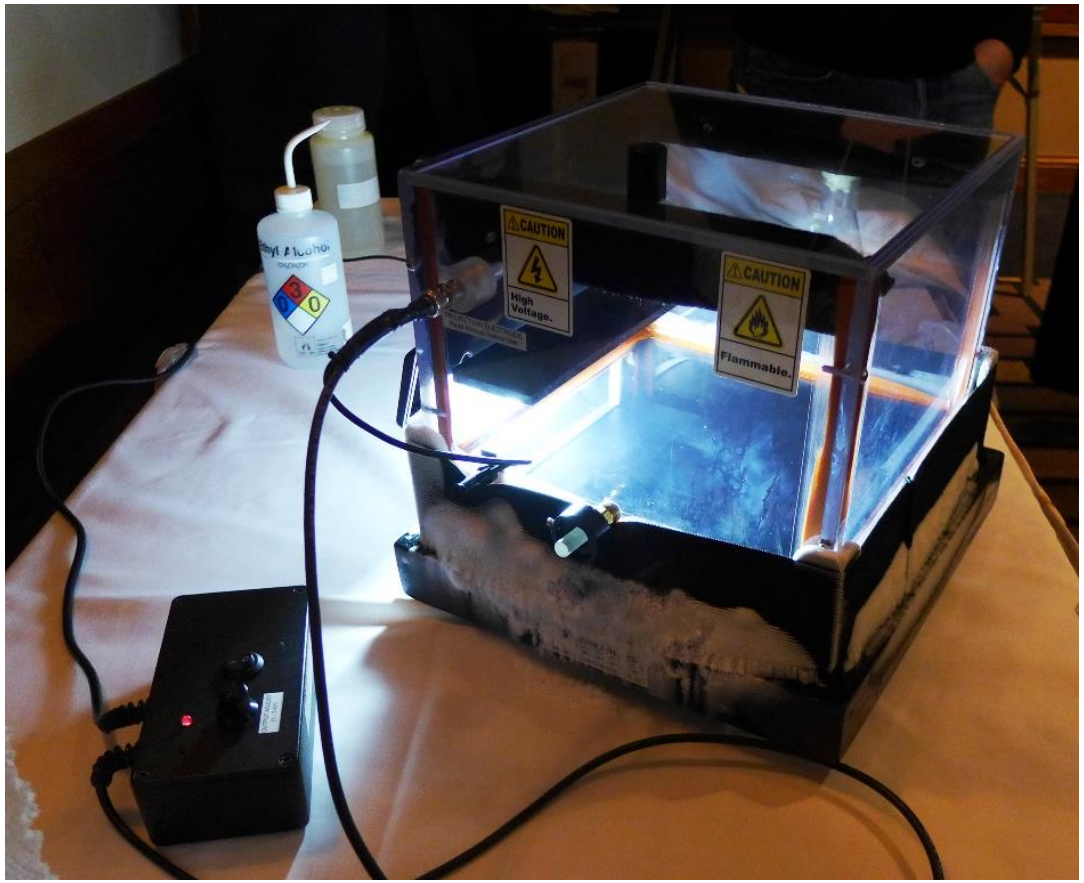
HEALTH CONCERNS

HEATH CONCERNS – RADON DECAY PRODUCTS



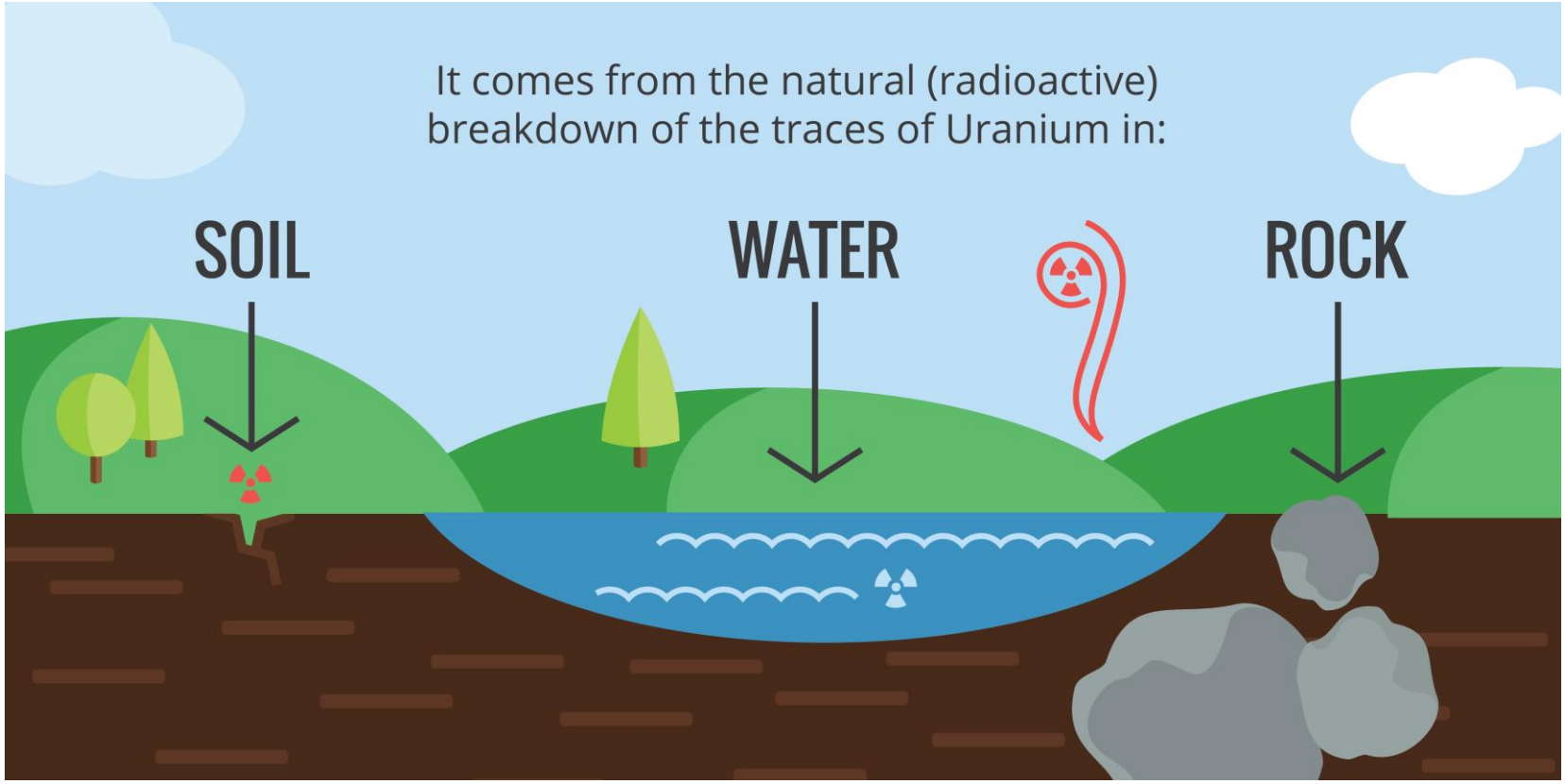
CLOUD CHAMBER

- It allows you to ‘see’ alpha and beta particles
- A closed environment with a supersaturated alcohol atmosphere
- When radon/RDPs decay releasing alpha/beta particles, they react with the atmosphere and ionize it. Mist forms along the new ions in the form of trails



CLOUD CHAMBER

SOURCES OF RADON



- Soil is the major contributor of radon
- Building materials can contribute if contain source materials (uranium or radium)

RADON AND GRANITE

- Natural materials contain some uranium
- Health Canada (2010) study
  - 33 commonly purchased granite types
  - None were found to have significant levels of radon

RADON MEASUREMENT UNITS

- Measuring the radioactivity from radon and its decay products - determines radon levels
- CANADA
  - Units: Becquerel per cubic meter (Bq/m^3)
  - Name after Henri Becquerel, who shared the Nobel Prize with Pierre and Marie Curie for discovering radium and polonium (1903).
- USA
  - Units: Picocurie per litre (pCi/L)
  - 1 pCi/L = 37 Bq/m^3

KEY BENCHMARKS AND GUIDELINES

Benchmarks:

- Outdoors: 10 Bq/m^3
- Indoors (homes): 45 Bq/m^3

Remediation:

- Health Canada:
  200 Bq/m^3 (2 years),
  600 Bq/m^3 (1 year)
- USA: 4 pCi/L (148 Bq/m^3)
- WHO: 100 Bq/m^3

200 Bq/m³
No action required

200 - 600 Bq/m³
Remediate within 2 years

> 600 Bq/m³
Remediate within 1 year

CANADIAN NATIONAL RADON PROGRAM

- 2005 – WHO encouraged Canada to look at its recommended action level for radon gas
  - The existing level was 800 Bq/m^3
- Matter was referred to the Federal Provincial Territorial Radiation Protection Committee
  - Report published in 2007
  - Recommendation was adopted by federal government

MINISTER RECOMMENDATIONS

Department of Health, Canadian Environmental Protection Act, 1999

(updated June 6, 2007)

- Remedial measures should be undertaken in a dwelling whenever the average annual RN concentration exceeds 200 Bq/m^3 in the normal occupancy area
- The higher the radon concentration, the sooner remedial measure should be undertaken
- When remedial action is taken, the RN level should be reduced to a low as practicable

MINISTER RECOMMENDATIONS

Department of Health, Canadian Environmental Protection Act, 1999

(updated June 6, 2007)

- The construction of new dwellings should employ techniques that will minimize radon entry and will facilitate post-construction radon removal, should this subsequently prove necessary
- Recommend that builders employ techniques to achieve a radon concentration less than 100 Bq/m^3

CANADA LABOUR CODE

- The Canada Labour Code (CLC) is the only legally enforceable limit (800 Bq/m³) for occupational exposure to radon in Canada.

- The CLC will be harmonized with Health Canada's radon action level of 200 Bq/m³ in early 2017 (pre-publication - Gazette 1).

RADON IN THE WORKPLACE

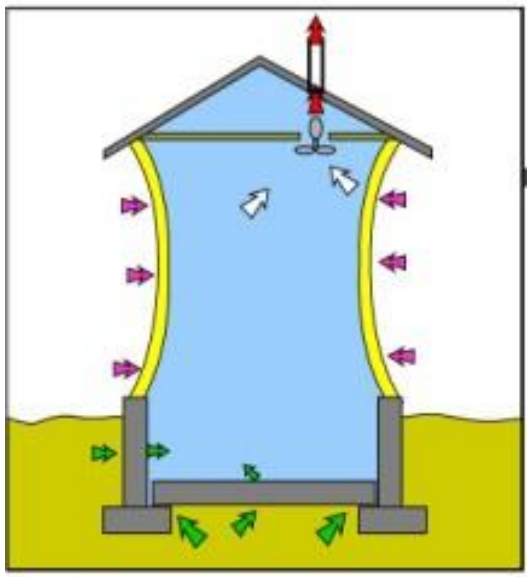
- Federal employees are governed by the Canada Labour Code (CLC)
- Requires the Government of Canada to ensure that its workers are not exposed to high levels of radon (800 Bq/m^3)
- Expected to align with Health Canada's new recommendation (200 Bq/m^3) in the future
- There is no legal requirement for employers to test, however, the only way for an employer to know if they are compliant with the CLC is to test

YUKON – CHILD CARE CENTRES

- Radon testing and mitigation will soon be a licensing requirement
- Will affect all new and existing child care centres
- Not mandated in any other Canadian jurisdiction

HOW RADON ENTERS BUILDINGS

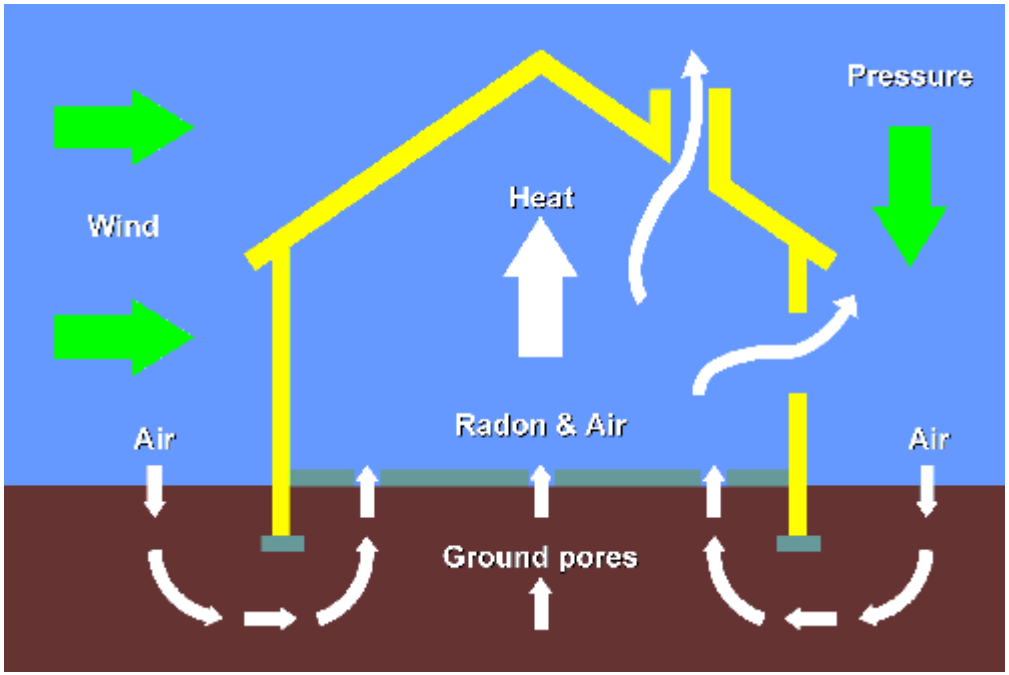
- Stack effect/Vacuums
  - Negative pressures or vacuums in a building draws on radon under the building pulling it inside
- Radon comes from directly beneath and within a few meters of a building
- Some radon can exit through windows and other outside openings



VACUUMS

Causes

- 1. Temperature induced stack effects
  - When outdoor air is colder than indoor air.
  - Why? Cold air is more dense than warm air.
- 2. Mechanical exhaust systems
  - Exhaust fans can also draw soil gas into a building



VACUUMS CONT.

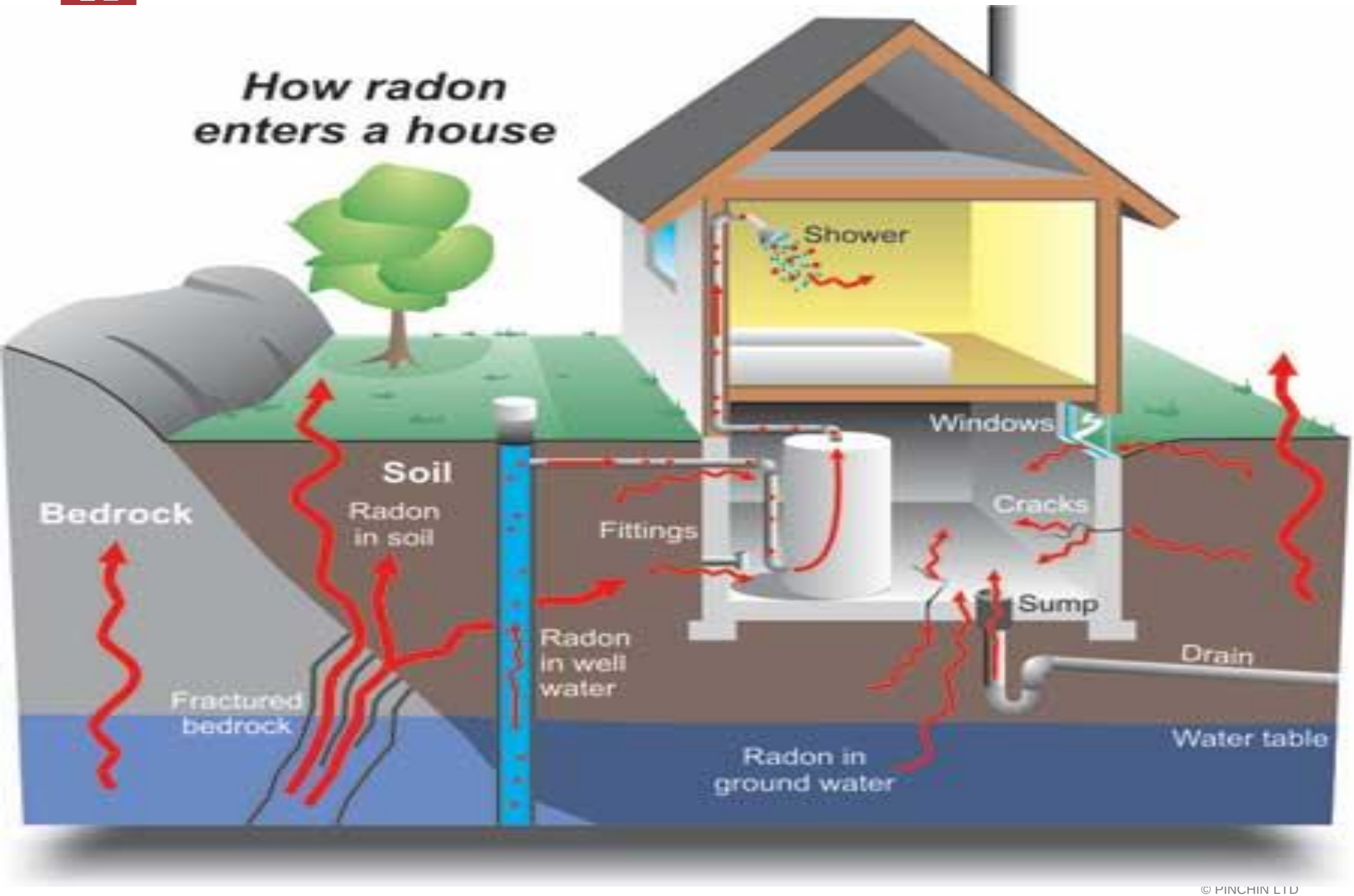
- Changes in negative pressure will change the rate of radon entry. This changes:
  - Hourly
  - Daily
  - Seasonally
- Radon enters through openings in the foundation
- **All foundations have openings. All types are susceptible for radon entry.**
- Question: What type of building DOES NOT have a radon concern?

FORCES THAT DRIVE RADON INTO A BUILDING

Positive pressure under the slab

Negative pressure under the slab

ENTRANCE POINTS



RADON AND BUILDING TYPE

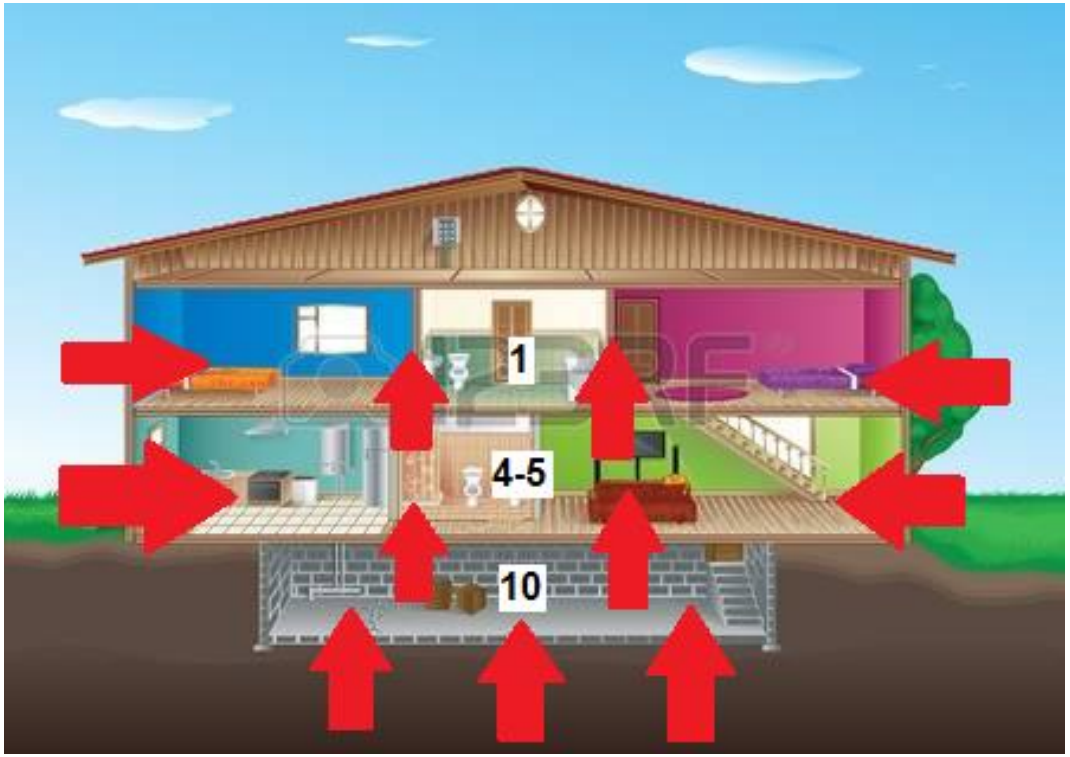
- Just because a building doesn't have a basement doesn't mean radon cannot enter
- Slab on grade buildings and buildings over crawl spaces are also susceptible

WHICH BUILDINGS HAVE A PROBLEM?

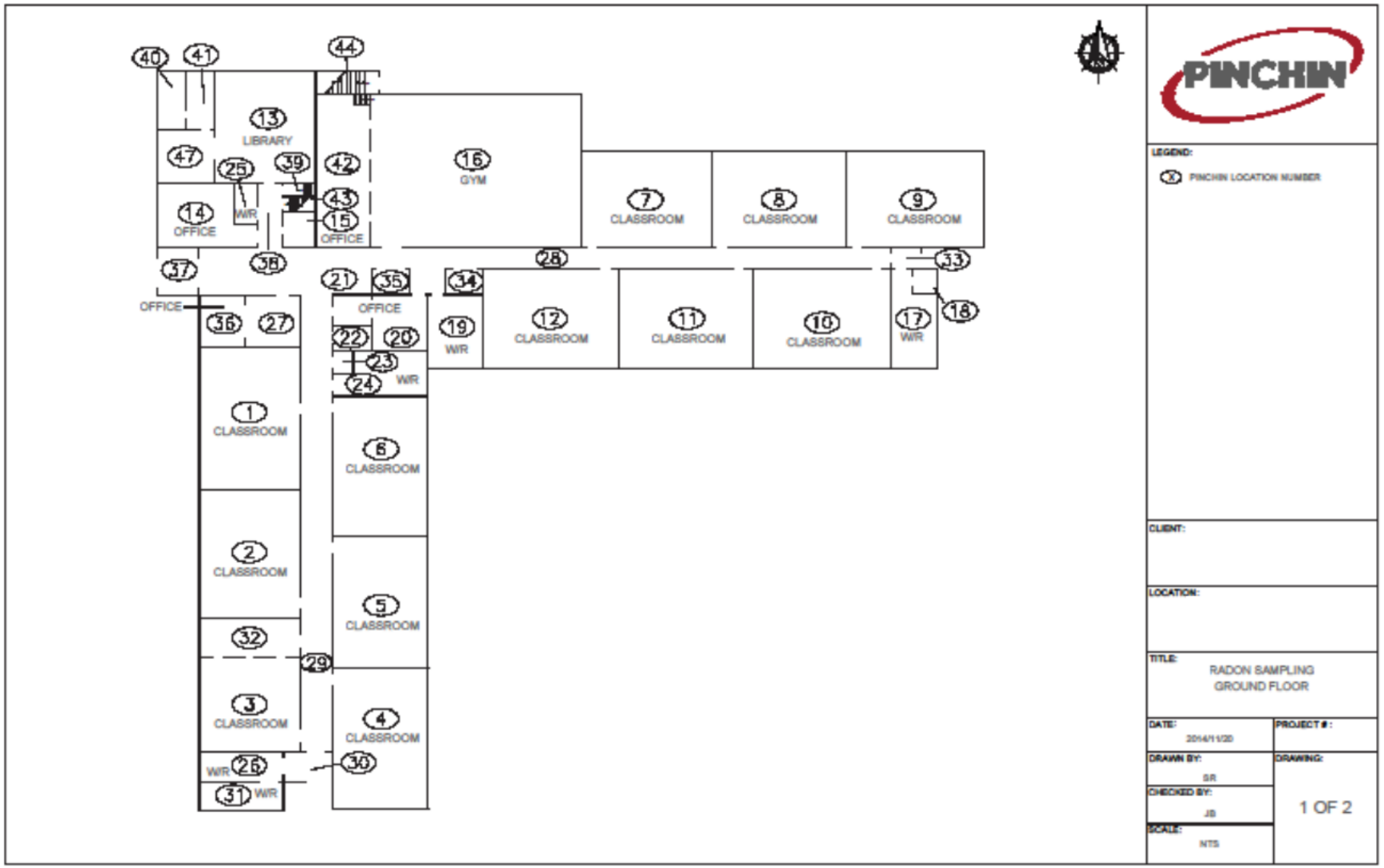
- Levels can vary dramatically between similar homes next-door to each other
- RN in a building will depend on many factors including:
  - Soil Characteristics
  - Construction Type
  - Foundation Condition
  - Occupant Lifestyle
  - Weather

RADON DISTRIBUTION

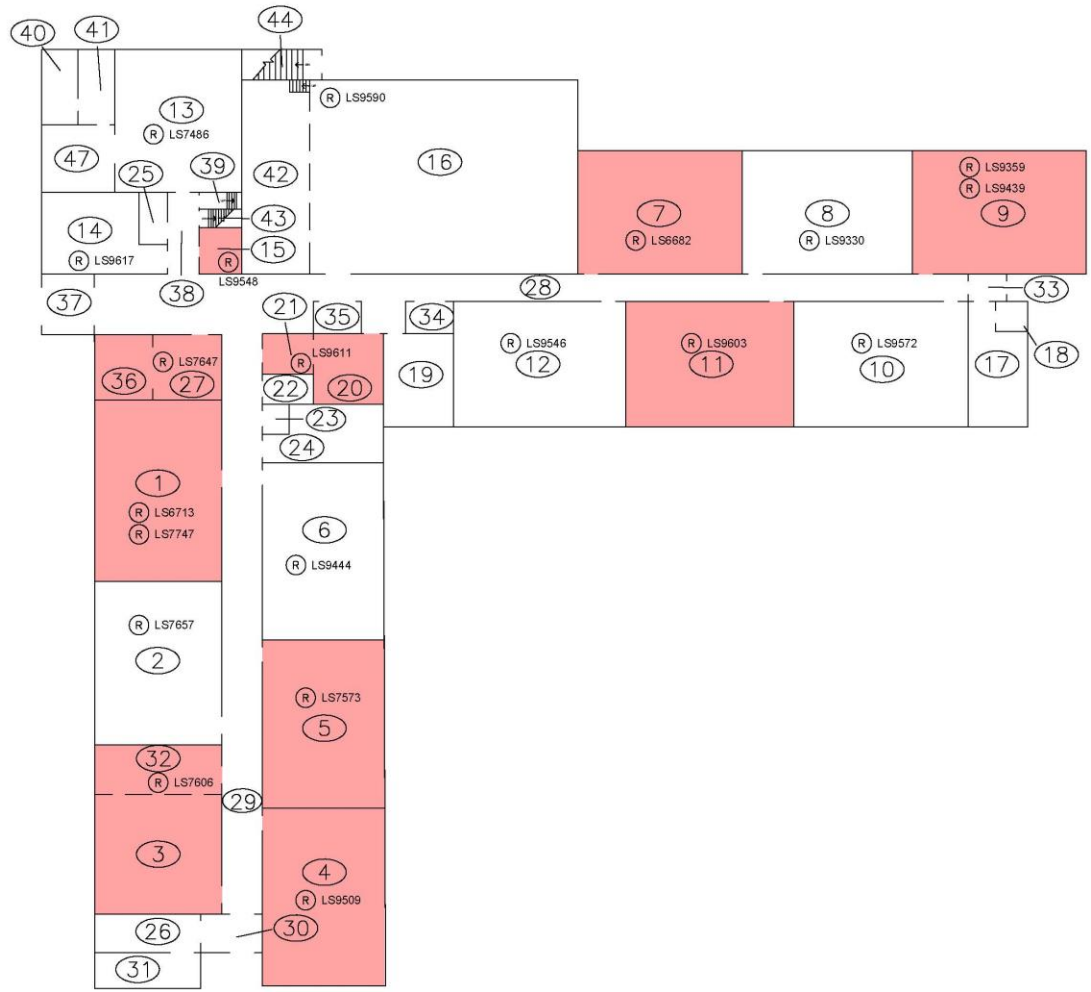
- RN is usually at its highest concentration in the lower level
  - Closest to the source/entry point
- Outdoor air dilutes radon as it moves up the building
  - 1st floor: 40-60% lower
  - 2nd floor: close to outdoor levels



RADON VARIABILITY IN BUILDINGS



RADON VARIABILITY IN BUILDINGS



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LEGEND:

- (X) PINCHIN LOCATION NUMBER
- (R) RADON SAMPLE LOCATION
- LEVELS ABOVE 200 Bq/m³

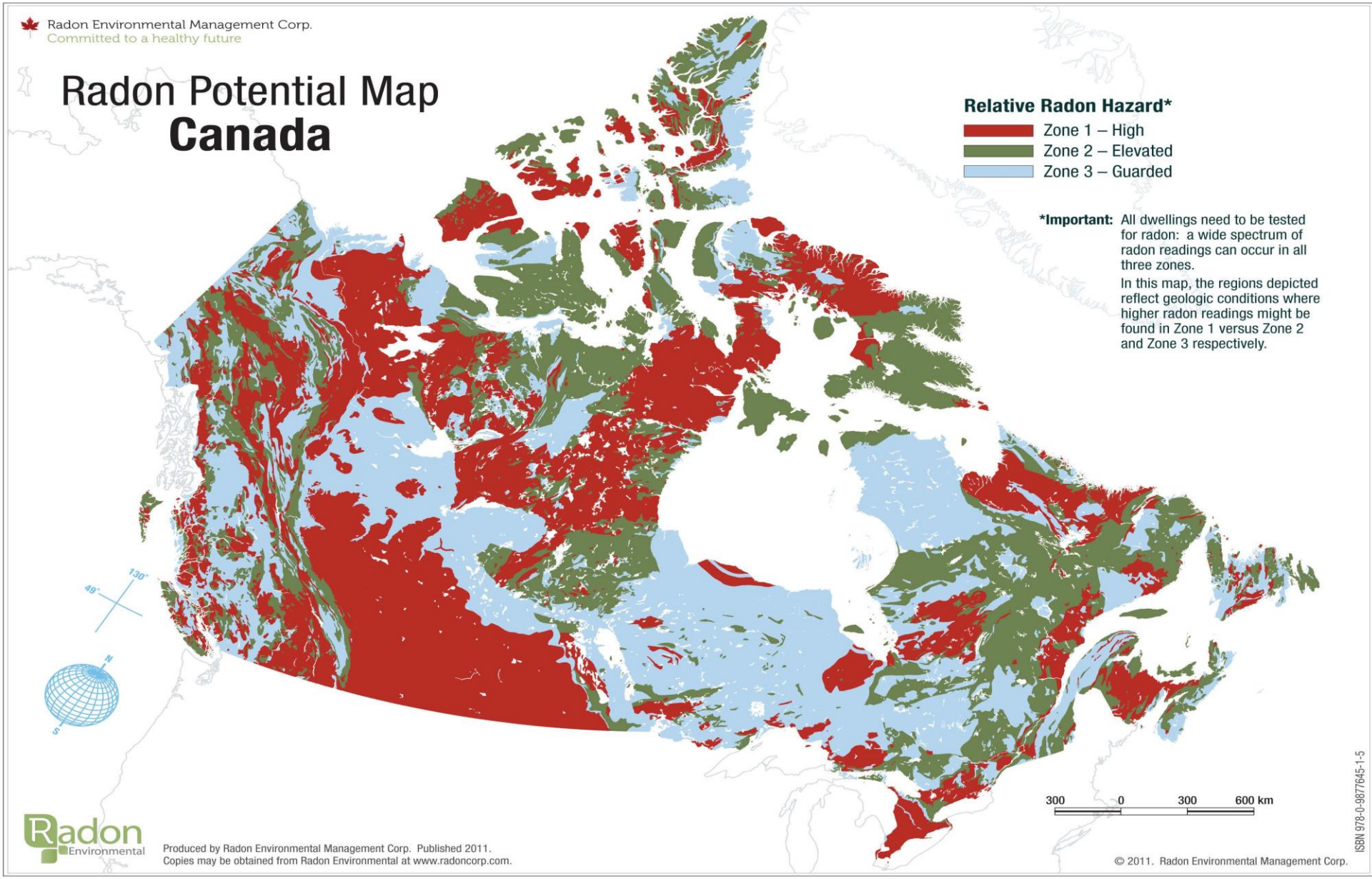
CLIENT:

LOCATION:

TITLE:
RADON SAMPLING
GROUND FLOOR

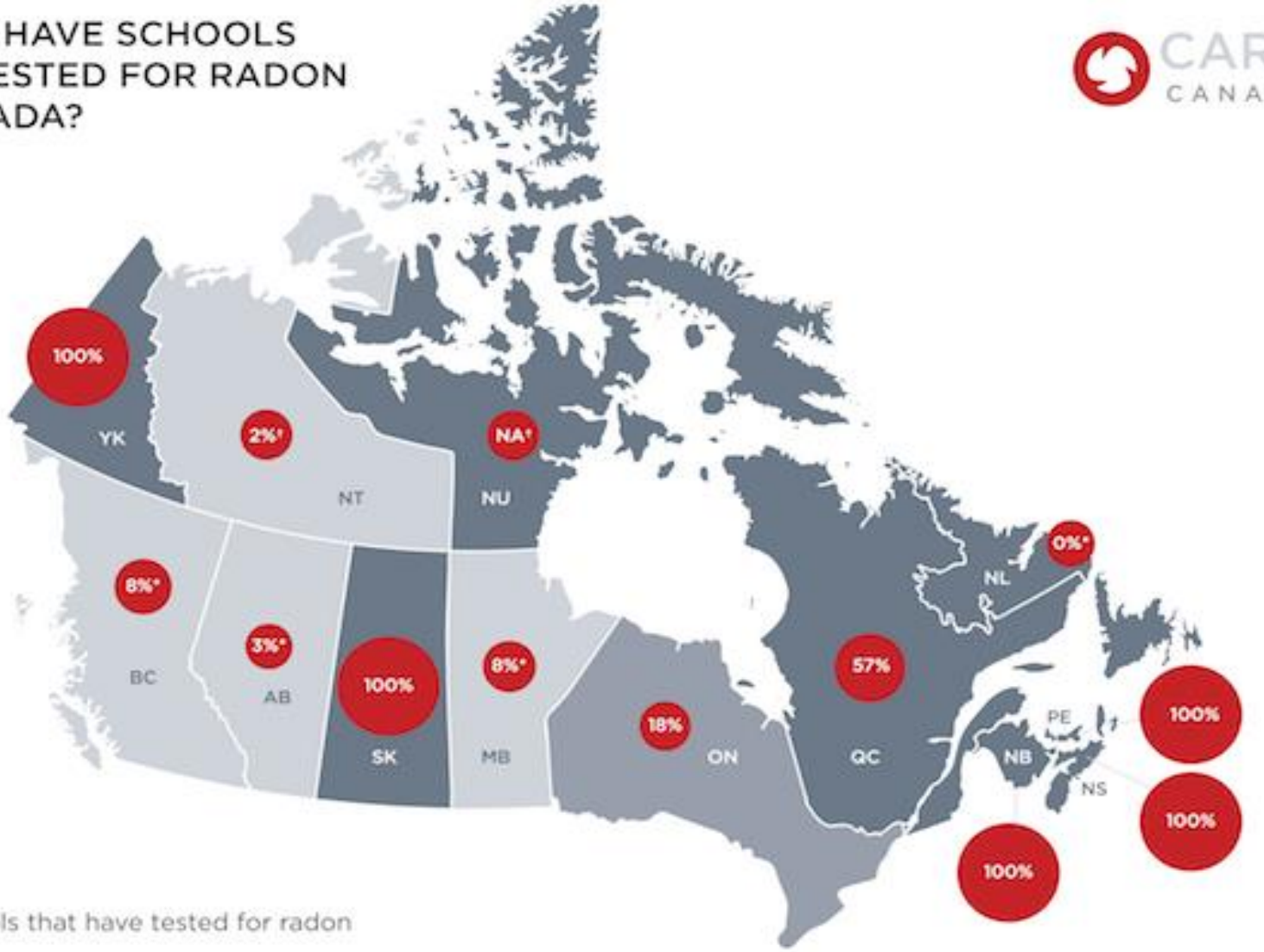
DATE:	PROJECT # :
DRAWN BY:	DRAWING:
CHECKED BY:	1 OF 1
SCALE: NTS	

GEOLOGIC RADON POTENTIAL MAP (2011)



WHERE HAVE SCHOOLS BEEN TESTED FOR RADON IN CANADA?

CAREX CANADA



% of schools that have tested for radon

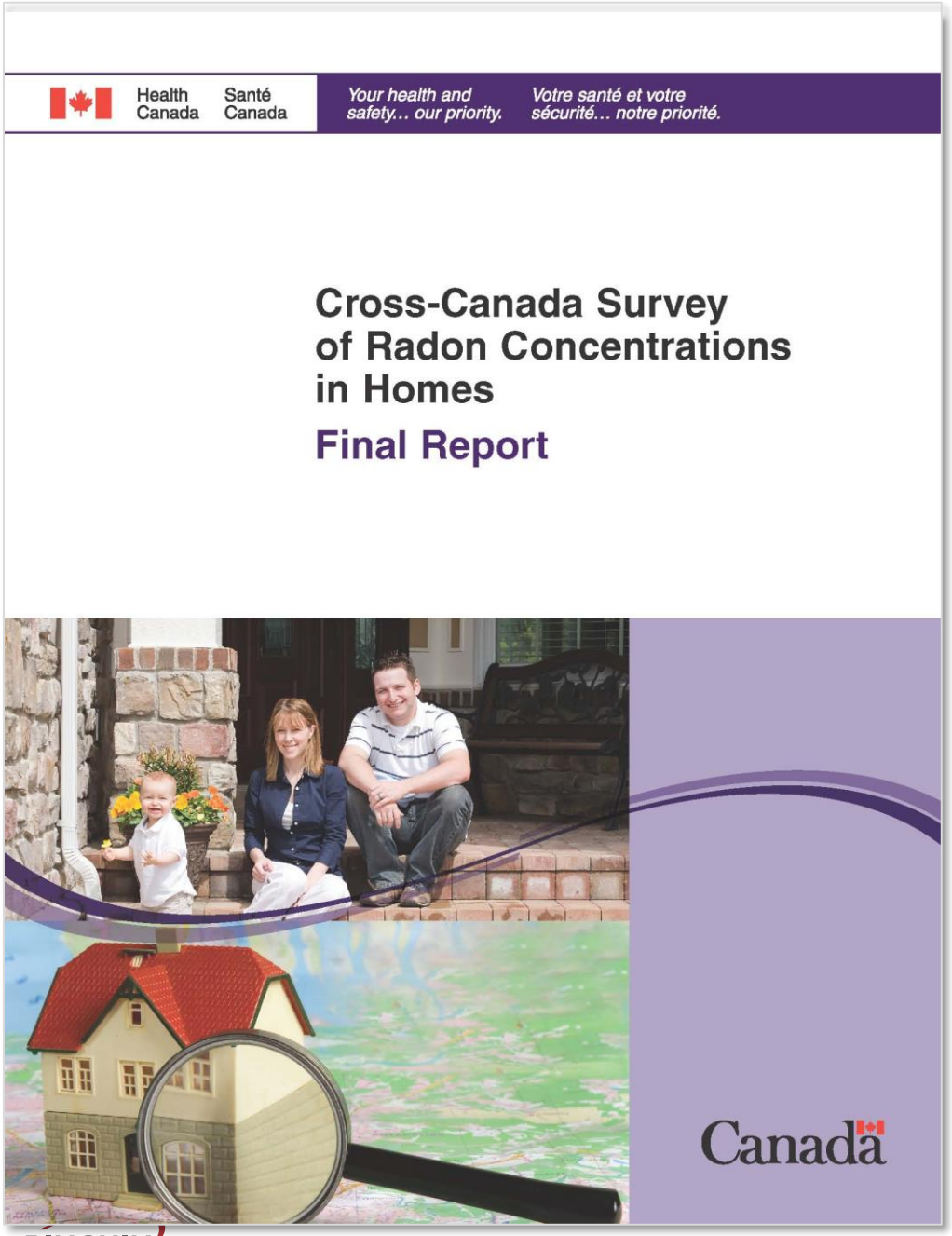
% of schools reporting testing data:

- 0-33%
- 34-66%
- 67-100%

This map is based on information collected in 2017 for publicly funded schools in Canada

*Some schools in these provinces have expressed interest or developed plans to test for radon in the future but are not included in this total. Please see supplemental table for more information.

†All school buildings in Nunavut and some in the Northwest Territories are constructed above ground on piles and may not require radon testing.



(2012)
Health Canada Survey results from testing 14,000 homes across Canada ~ 7% of homes have radon concentrations above the guideline

HEALTH CANADA RADON DATA

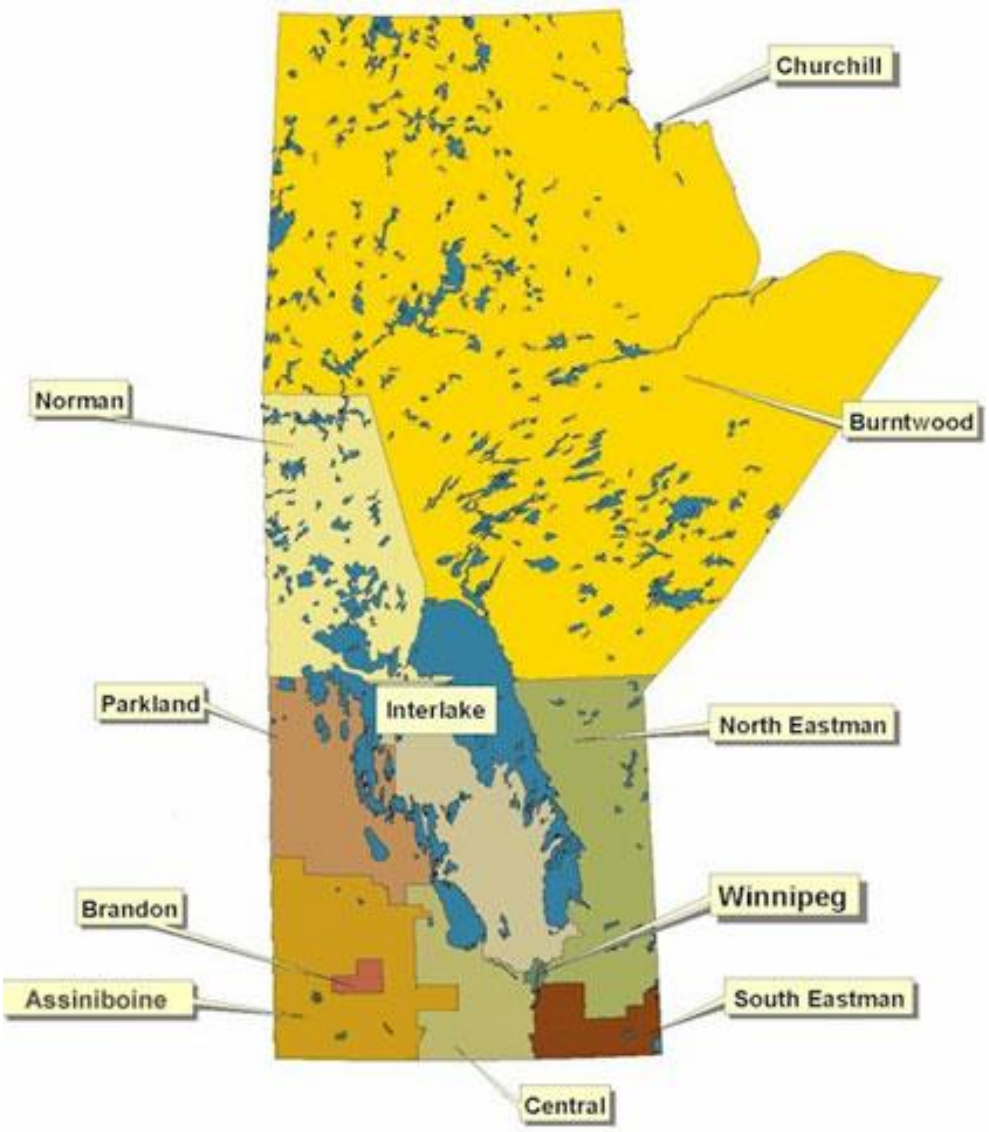
Table 2: Percentage of Homes Tested with Radon Concentrations Below 200 Bq/m^3, Between 200 and 600 Bq/m^3, Above 600 Bq/m^3 and Above 200 Bq/m^3 for Each Province and Territory

	"Raw" Percentage of Homes with Radon Concentrations:			
Province/Territory	**% Below 200 Bq/m^3**	**% 200 to 600 Bq/m^3**	**% Above 600 Bq/m^3**	**% Above 200 Bq/m^3**
Alberta (AB)	93.4	6.0	0.6	6.6
British Columbia (BC)	92.1	6.7	1.2	7.9
Manitoba (MB)	76.3	21.1	2.6	23.7
New Brunswick (NB)	75.2	18.7	6.1	24.8
Newfoundland and Labrador (NL)	94.1	4.6	1.3	5.9
Nova Scotia (NS)	91.2	6.3	2.5	8.8
Northwest Territories (NT)	94.6	4.9	0.5	5.4
Nunavut (NU)	100.0	0.0	0.0	0.0
Ontario (ON)	91.8	7.3	0.9	8.2
Prince Edward Island (PE)	96.5	3.5	0.0	3.5
Quebec (QC)	89.9	9.0	1.1	10.1
Saskatchewan (SK)	83.7	15.3	1.0	16.3
Yukon (YT)	80.4	13.8	5.8	19.6

HEALTH CANADA MANITOBA RADON RESULTS BY HEALTH REGION

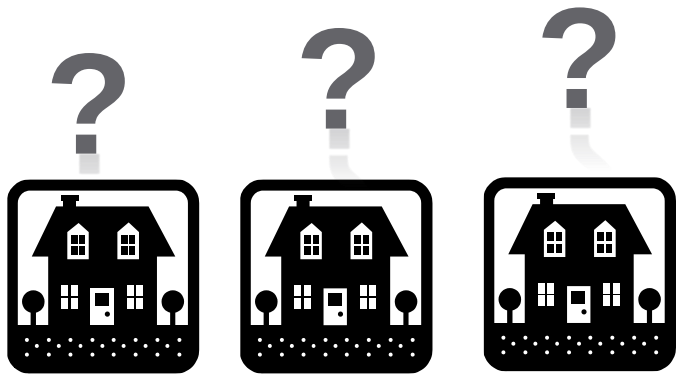
Health Region	# of Participants	% Above 200 Bq/m^3	% 200 to 600 Bq/m^3	% Above 600 Bq/m^3
Winnipeg RHA	66	12.1	12.1	0
Brandon RHA	79	44.3	40.5	3.8
N. Eastman RHA	100	21.0	20	1.0
S. Eastman RHA	113	9.7	9.7	0
Interlake RHA	121	24.8	24.8	0
Central RHA	108	42.6	35.2	7.4
Assiniboine RHA	110	34.5	32.7	1.8
Parkland RHA	122	43.4	31.9	11.5
Nor-Man RHA	212	12.3	11.8	0.5
Burntwood/ Churchill	152	7.9	7.2	0.7

MANITOBA RADON HEALTH REGIONS



RADON LEVELS IN BUILDINGS

- Some known ‘hotspots’ with increased potential for elevated radon levels
- Radon levels can vary greatly between adjacent buildings
- The **ONLY!** way to know what the radon levels are in a building is to test



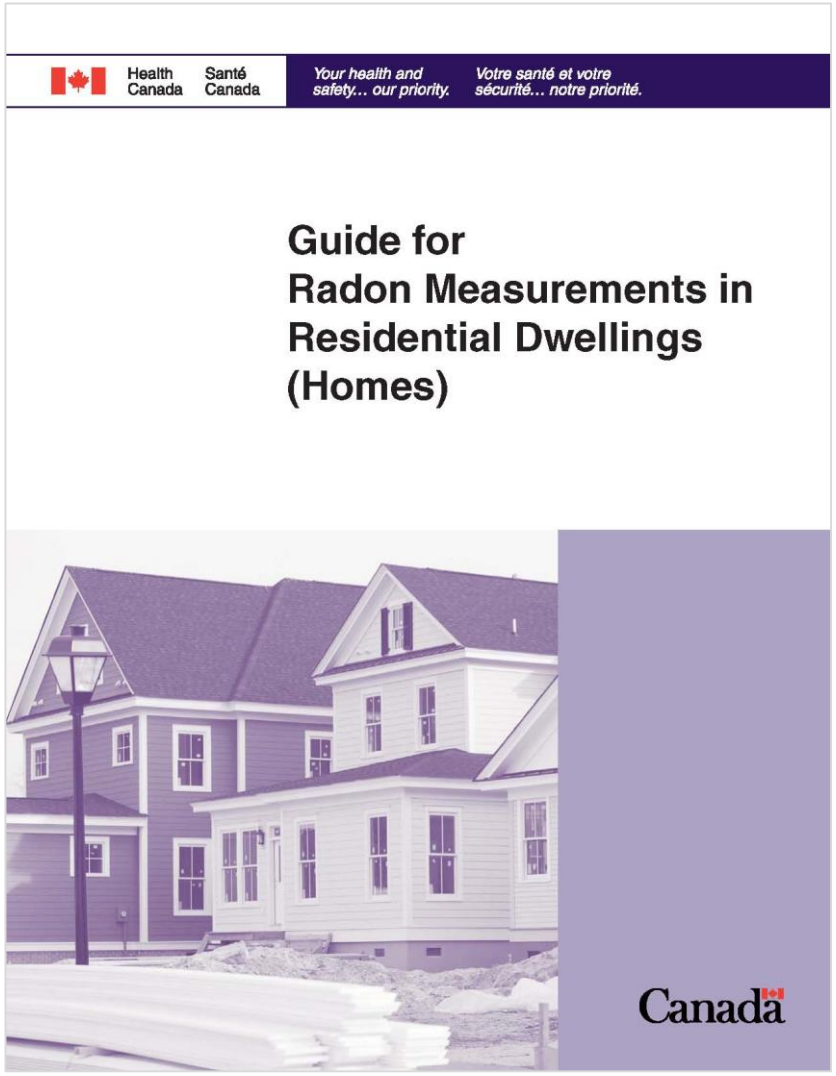
RADON TESTING

- How to find out how much radon is in the air?
- **THE ONLY WAY TO KNOW IS TO TEST!**

<u>2 Types of testing:</u>

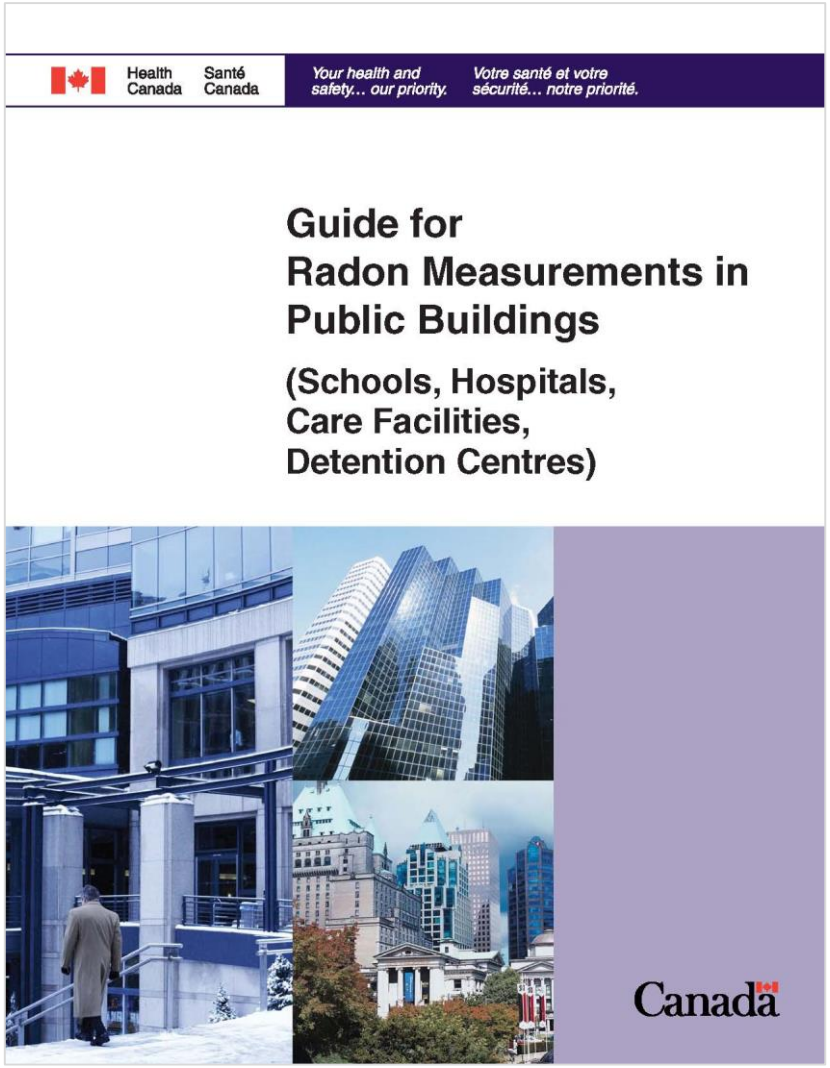
- Short term (typically 2 – 7 days)
- Long term (minimum 91 days to 1 year).

HEALTH CANADA MEASUREMENT GUIDELINES (2008)



- test in the lowest occupied area of the house (i.e. occupied for at least 4 hours per day
- Recommends testing during the heating season
- Does not recommend short-term testing

HEALTH CANADA MEASUREMENT GUIDELINES (2008)



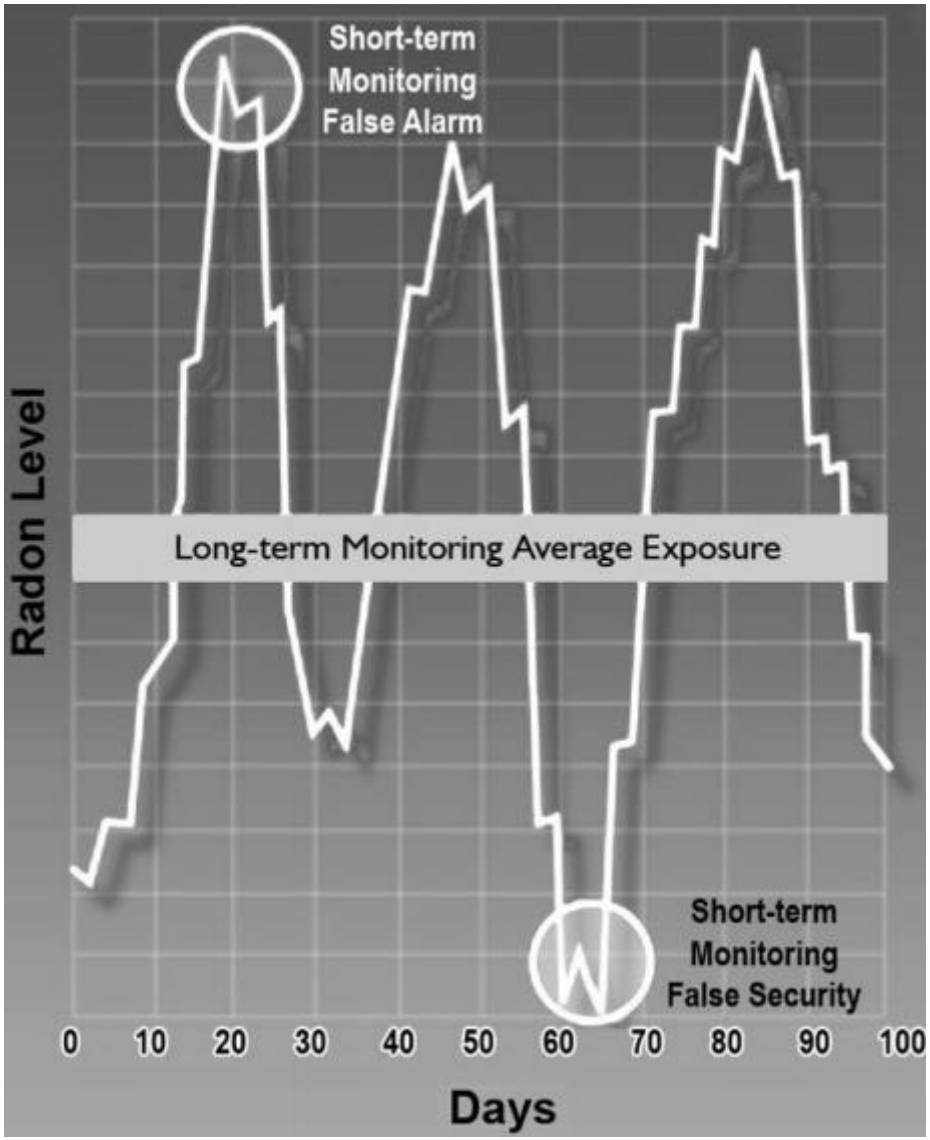
- Test in each room occupied for 4 hours/day in the lowest occupied level (basement or slab-on-grade)
- Testing required on upper floors as well

SHORT TERM TESTING

- Testing is generally for 2 – 7 days
- Closed building conditions
- Lowest occupied, or occupiable level
- Used for short turnaround (e.g. real estate transactions)
- Provides an indication (snapshot) of radon potential
- Not recognized as a basis for mitigation by Health Canada
- Follow-up with long term testing

SHORT TERM TESTING

- 24 – 72 hr test only
- Variability over 5 days
- Too short for more than ‘potential’



COMMON SHORT TERM TEST DEVICES

ELECTRET ION CHAMBER (E-PERM)

- Voltage of electret on bottom of device is measured before & after testing
- Reported radon is a function of voltage drop & duration of deployment
- Can be used for short and long term testing

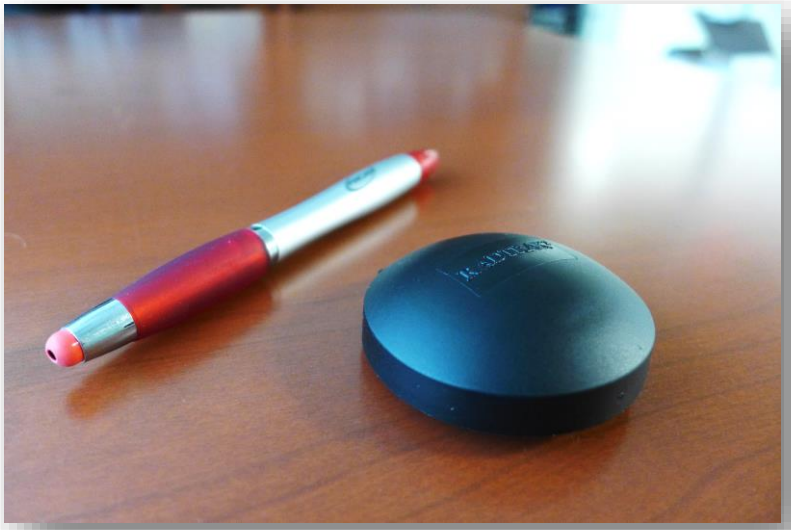
CONTINUOUS RADON MONITORS

CONTINUOUS RADON MONITORS

- Radon results calculated at hourly intervals
- Lock-out/tamper resistant
- Diagnostic testing

CONTINUOUS RADON MONITORS

LONG-TERM TESTING



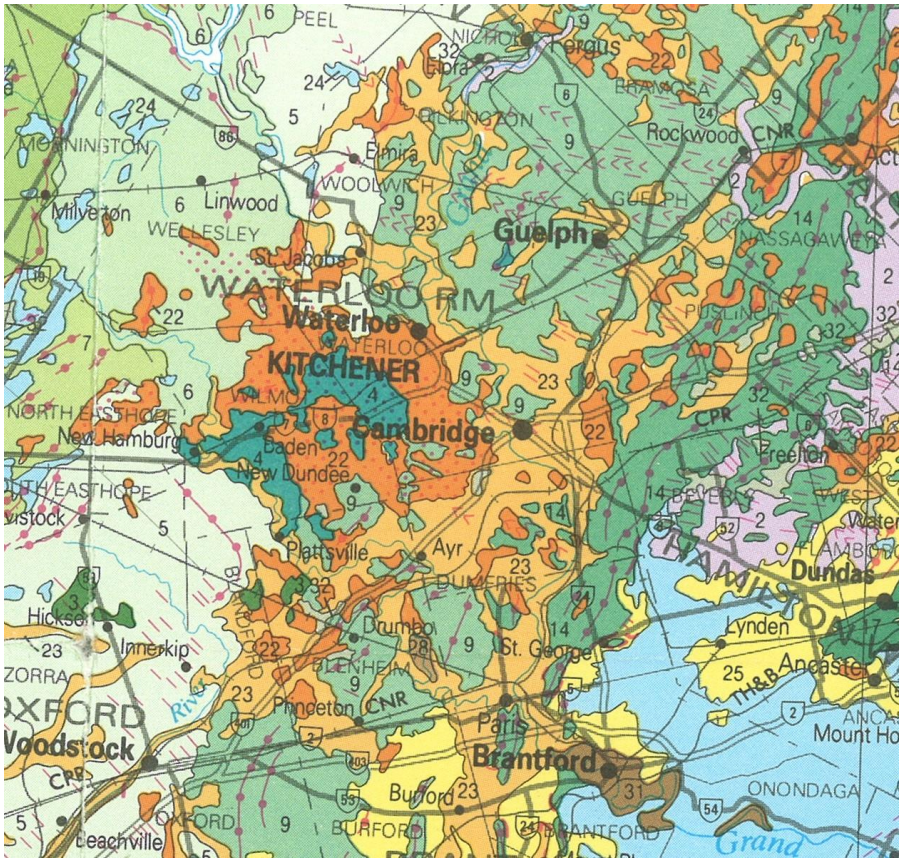
- Recommended by Health Canada
- 91 days to 1 year
- Under normal living conditions – doesn't inconvenience anyone
- Can base mitigation decisions on long-term test results

COMMON LONG TERM TEST DEVICES

- Electret Ion Chamber (E-Perm)

- Alpha Track Detector
  - Records alpha particle strike damage on plastic sheet from radon and RDPs with the device.
  - Lab counts ‘alpha tracks’ on the plastic

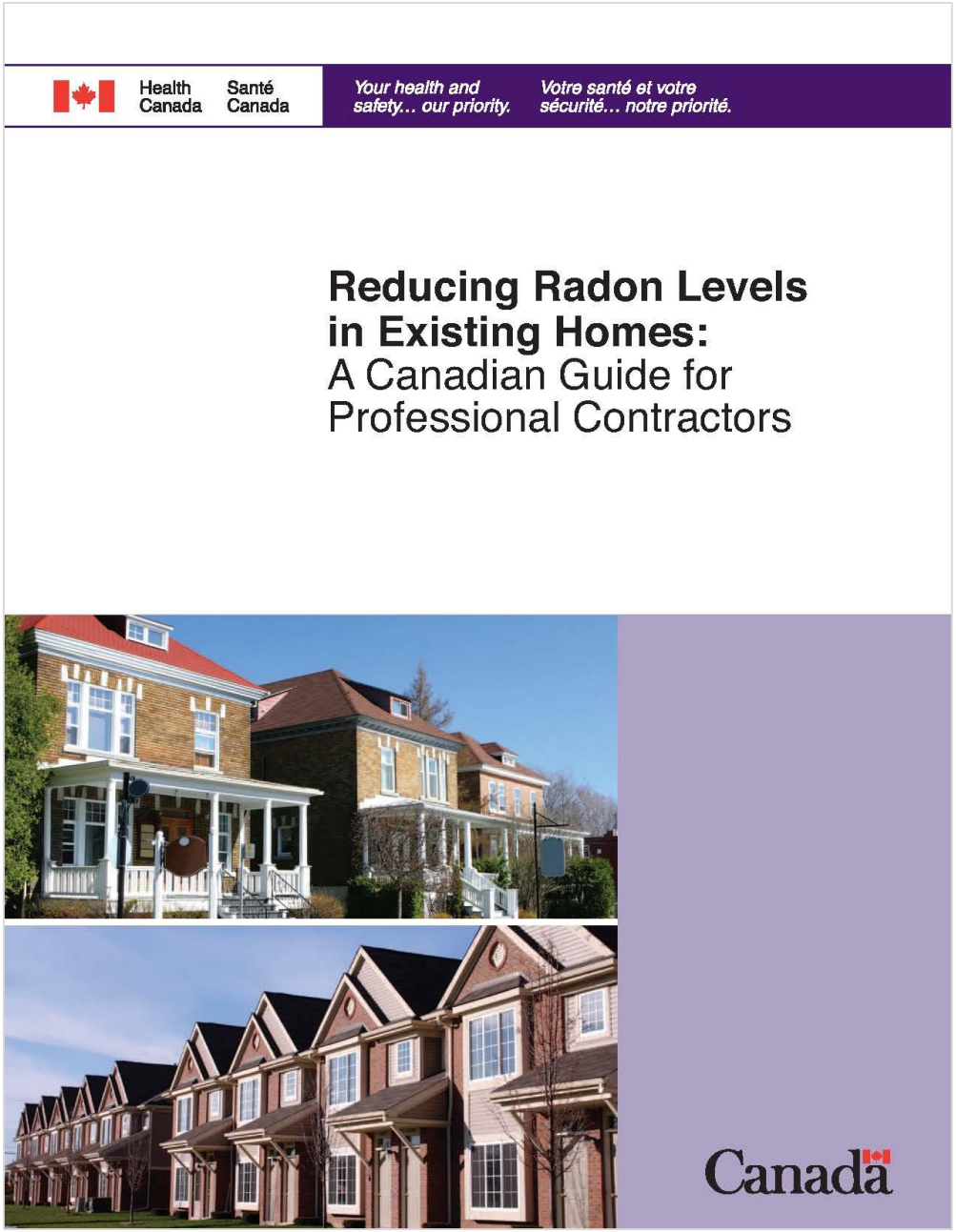
PORTFOLIO RADON TESTING PROGRAMS



- Radon geologic potential maps
- Glacial geology maps
- Existing radon data
- Information on buildings in the portfolio
  - HVAC?
  - Basements?
  - Age
  - Building configuration

HEALTH CANADA MITIGATION GUIDELINE (2010)

- Covers virtually all mitigation techniques



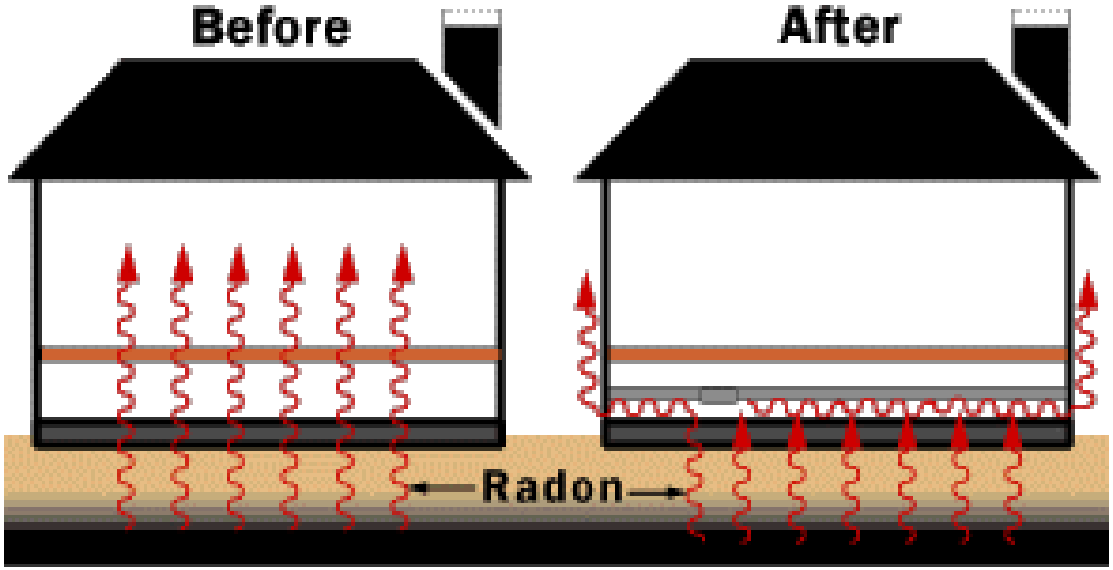
HEALTH CANADA MITIGATION GUIDELINE

Time Frame to Remediate

Radon Concentration	Recommended Remedial Action Time
> 600 Bq/m^3	In less than 1 year
200 – 600 Bq/m^3	In less than 2 years
< 200 Bq/m^3	No action required

MITIGATION TECHNIQUES

- The most effective approach to mitigate homes is by active soil depressurization
- **Mitigations should always be conducted by a C-NRPP approved mitigator**
- **Indoor radon should be reduced to as low as practical!**



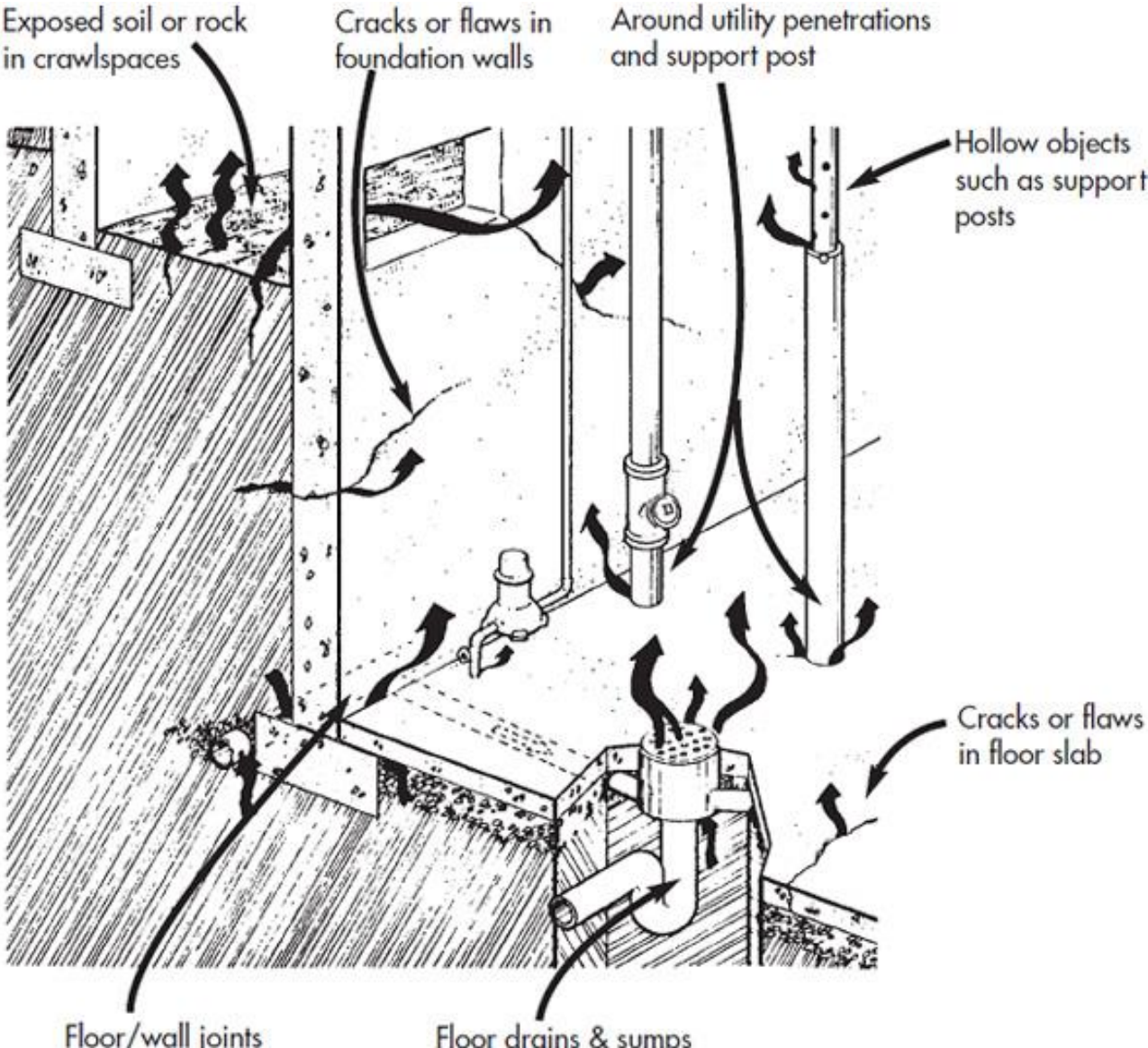
SUB-SLAB DEPRESSURIZATION

- Suction created in a pit under the slab
- Radon collected and exhausted outdoors
- Runs 24/7
- Highly effective

SUB SLAB DEPRESSURIZATION (SSD)

Poured concrete basements

- **Creating a lower pressure in the sub-slab fill than the pressure in the building will change the airflow**
  - Air will move from the building to the sub-slab fill through the openings



FORCES THAT DRIVE RADON INTO A BUILDING

Positive pressure under the slab

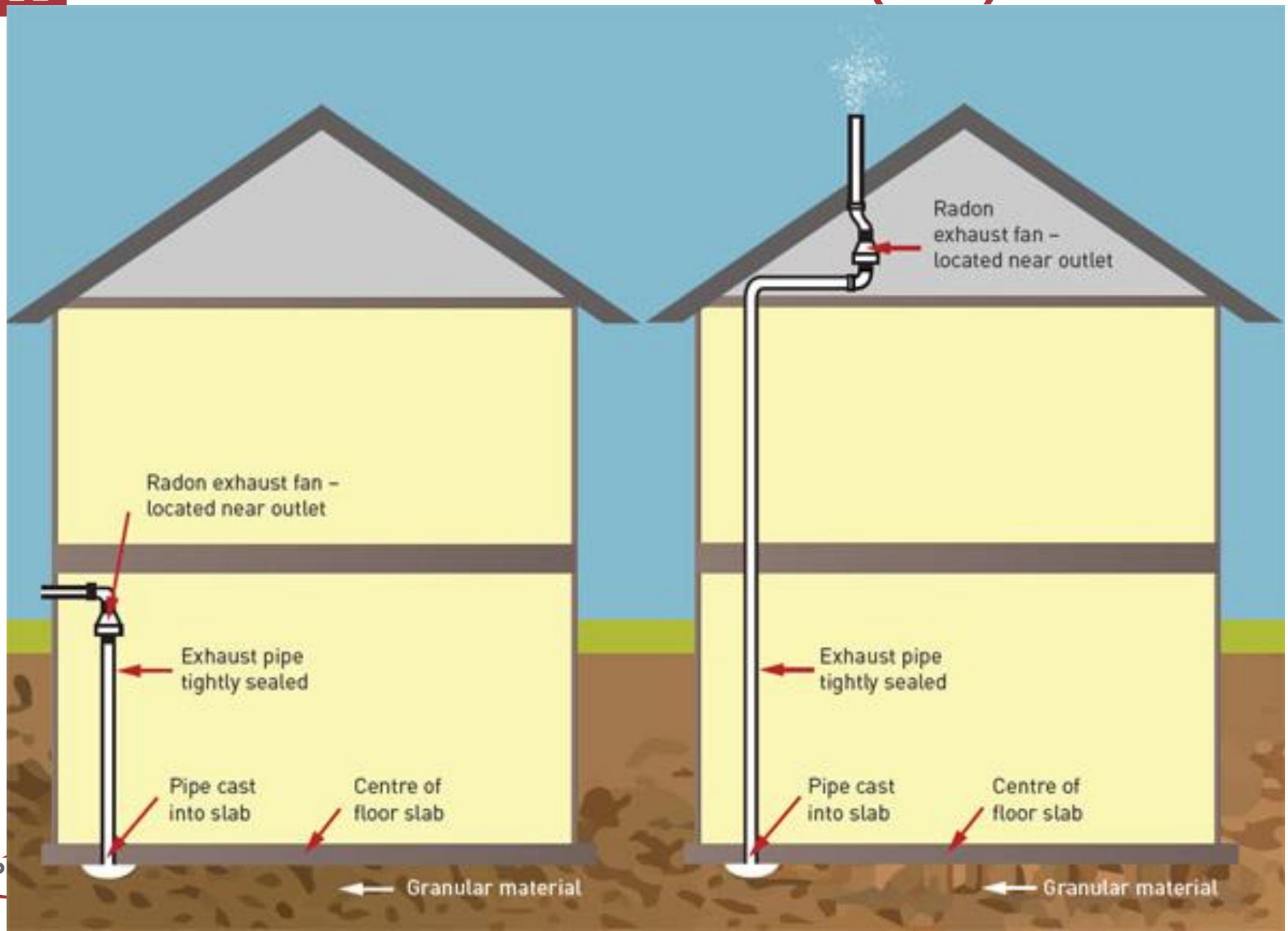
Negative pressure under the slab

SUB SLAB DEPRESSURIZATION (SSD)

Most common mitigation method!

- “This method involves installing a pipe through the foundation floor slab and attaching a fan that runs continuously to draw the radon gas from below the home and release it into the outdoors where it is quickly diluted.” Health Canada (2013). Radon – Reduction Guide for Canadians.
- What does it do?
  - 1. The system reverses the air pressure difference between the house and the soil
  - 2. RN gas is released outdoors

SUB SLAB DEPRESSURIZATION (SSD)



SUB SLAB DEPRESSURIZATION (SSD)

Cold climates

- **Tips for colder climates:**
- Fan and pipe placed inside the home (almost entire system located indoors)
  - Reduces condensation/ice up that can occur if the fan is located outside the living space (i.e. attic)
- Ground level discharge
  - Exhaust with a shorter pipe near ground level at right angles to the wall

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SUB SLAB DEPRESSURIZATION (SSD)

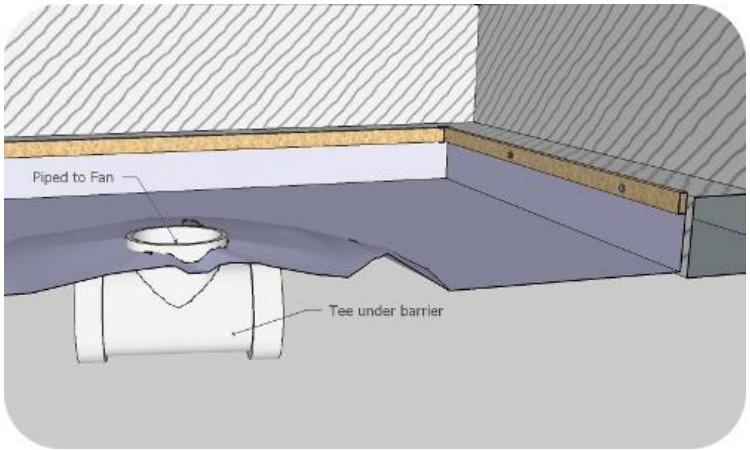
SUB-SLAB DEPRESSURIZATION DESIGN

- Communication test conducted to determine best placement of suction point(s) and what type of fan to use

SUB MEMBRANE DEPRESSURIZATION (SMD)

Crawlspaces, exposed soil/rock

- The soil in a crawlspace can be vented using a similar technique called active sub-membrane depressurization
- A thick plastic sheet (i.e. poly membrane) is laid over the soil and runs about 100-300 mm up each wall
- The poly is caulked and secured in place with battens fixed with masonry fasteners
- A pipe with fan draws the radon from under the plastic sheet and vents it to the outdoors
- Perforated piping or porous material is placed on the soil to ensure the fan suction is distributed to the edges of the membrane and acts as a gas collector



SUB MEMBRANE DEPRESSURIZATION (SMD)

Crawlspaces, exposed soil/rock

- Pay special attention to properly seal around the pipe penetration
- Reliable long-term material is necessary (adhesives, poly, etc.)

PRICING - SSD AND SMD

- SSD and SMD systems typically range from ~$1,500 - $3,000
- The operating cost for electricity for the fan is ~$50 - $75/year
- Active soil depressurization is almost always the recommended approach for large radon reductions (50%+)

HEAT RECOVERY VENTILATORS (HRV)

- Radon can be diluted by using a HRV
- A HRV increases ventilation by introducing outdoor air as it uses the heated or cooled air being exhausted to warm or cool the incoming air
- It is important to ensure that this type of system has balanced intake and exhaust
    - If the house is depressurized it can draw more RN in

MODIFICATION OF AIR HANDLING SYSTEMS

- HVAC can dilute radon levels and pressurize buildings to keep radon out
- HRV/ERVs requires regular maintenance to be effective – typically lower radon by ~25- 50%
- HRV/ERVs have ongoing energy penalties

HEAT RECOVERY VENTILATORS (HRV)

- Only appropriate for situations where only low/modest reductions are needed
  - Reduces radon levels by 25 - 50%
- HRVs will be most successful in houses that are more airtight and have low natural ventilation rates (not drafty)
- A HRV system will cost between ~$1,500 - $3,500
- The operating cost can be high for the electricity and the increase in heating/cooling costs with increased ventilation in the home

SUMP HOLE AND DRAIN TILE DEPRESSURIZATION

- The sump can be capped and sealed so that it can continue to drain water and also serve as the location for a radon suction pipe
- This will collect soil gas from the weeping tile system
- Install water traps in the floor drains to prevent house air from entering the sump through the drain
- Sump covers are usually made with durable plastic
- Rubber grommets or silicone caulk is used for discharge pipe/electrical
    - Needs to be air tight!

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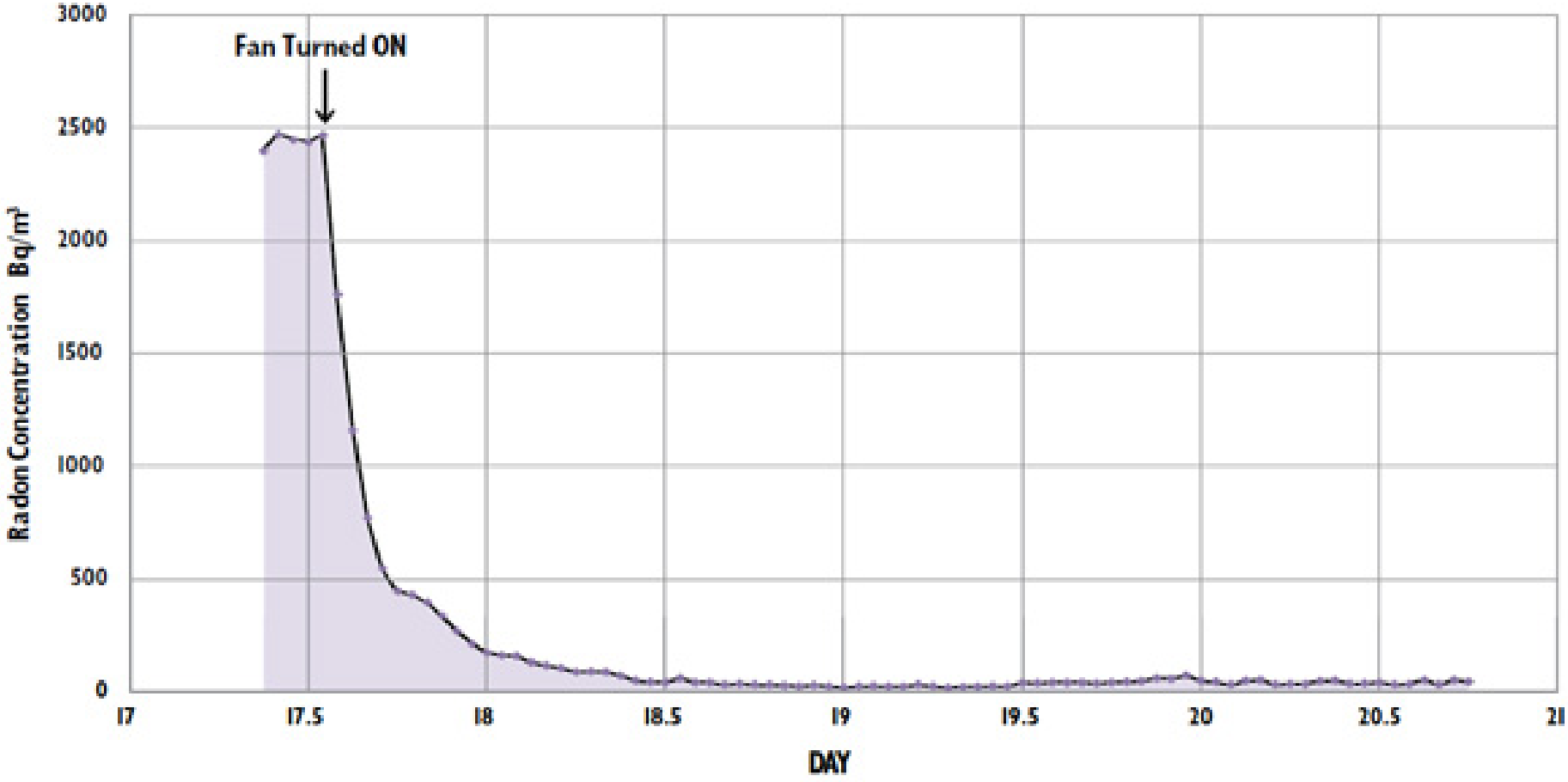
SUMP-HOLE AND DRAIN TILE DEPRESSURIZATION

- Many complications make this an unpopular system!
- Complications:
  - Air may be coming in from downspouts or window wells drained to the weeping tile
  - If there are surface connections the sump depressurization will draw cold air down in the winter and can freeze the ground
- Prevention:
  - Reroute downspouts to discharge at ground level away from the house and the connections closed
  - Window well drains cant be closed without risk of basement flooding – may be possible to attach a trap to the window well drainpipe

TESTING AFTER RADON MITIGATION

- Conduct follow-up sampling to ensure radon concentration has decreased
- Retest within 2 years and every 5 years after that time or when major renovation occurs affecting slab/basement walls

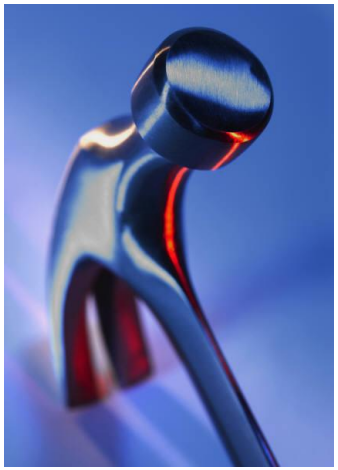
FOLLOW UP TESTING



REMOVAL OF RADON FROM WELL WATER

- **Aeration** – water goes into a tank and is aerated. Radon stripped out of the water and exhausted outside.
- **Carbon Adsorption** – water run through tank with granular activated carbon. RDPs adsorbed onto carbon which is disposed of. Gamma radiation buildup in the carbon filter.

RADON RESISTANT CONSTRUCTION TECHNIQUES



- Similar to mitigation measures
- Passive systems (vs. active)
- In conjunction with various measures
- e.g. caulking and sealing joints/openings
- Addressed in Building Codes

NATIONAL BUILDING CODE & RADON (2010)

- Allows for basic protection of all buildings (residential and non-residential). Specific provisions to address radon mitigation in new residential homes and small residential buildings
- Sump pit cover required to be airtight
- Caulking slab perimeter and penetrations
- Granular fill under slab and soil gas membrane between fill and slab
- Inspections
- Roughed-in piping for SSD systems
- Owner to test following occupancy

BUILD FOR TOMORROW

www.nationalcodes.ca

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CERTIFICATION

- Health Canada recognizes the Canadian National Radon Proficiency Program (C-NRPP)
- C-NRPP is a certification program designed to establish guidelines for training professionals in radon services
- www.c-nrpp.ca

CANADIAN ASSOCIATION OF RADON SCIENTISTS & TECHNOLOGISTS (CARST)

- A Canadian association dedicated to:
  - Ensuring quality standards are developed
  - Educate Canadians on identifying and managing radon in dwellings and workplaces
  - Provide a bridge between radon professionals and public and private organizations
- www.carst.ca

MOVING FORWARD

- Have your building(s) tested by a C-NRPP certified measurement professional
- Test your home too!
- If you have elevated radon levels, ensure that a C-NRPP mitigation professional is there to help you to reduce your risk

QUESTIONS?

For more information or for newsletters, please visit www.pinchin.com

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