Cross-Canada Survey of Radon Exposure in the Residential Buildings of Urban and Rural Communities

2024 REPORT

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The Cross-Canada Radon Survey benefits greatly from the comments and suggestions of readers and stakeholders. The members of the *Cross-Canada Survey of Radon Exposure in the Residential Buildings of Urban and Rural Communities* planning and production committee appreciates and welcomes such comments. To offer ideas on how the publication can be improved, or to be notified about future publications, please contact us by email **info@crosscanadaradon.ca**.

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ABOUT THE CROSS CANADA SURVEY OF RADON WORKING GROUP and HOW TO CONTACT US

The Cross Canada Survey of Radon 2024 report working group represents a partnership between the university-based researchers of the Evict Radon National Study (including teams at the University of Calgary, Dalhousie University, University of British Columbia, and University of Saskatchewan), as well as the British Columbia Centre for Disease Control, Carcinogen Exposure (CAREX) Canada, and Health Canada's Radon Technical Operations Section.

The goal of the working group is to assemble source data on residential radon exposure and, from this, generate and disseminate the latest aggregate statistics on residential radon gas exposure in Canada. To achieve this goal, all partner organizations bring together expertise from across the radon testing, exposure science, and public health communication communities in the form of planning and production committee for the *Cross-Canada Survey of Radon Exposure in the Residential Buildings of Urban and Rural Communities*. The individuals involved in the 2024 report working group are listed on page 3 of this report, and please note that the specific persons involved in the working group may change in future updates.

The main products of the Cross Canada Survey of Radon working group are:

- **Full Publication.** To release, at least once per 24 month period (as new data becomes available), a publication that provides updated estimates of Canadian residential radon exposure as a function of area (including nationwide, regional clusters, provincial, and municipal areas as defined by Statistics Canada census divisions and other geographic designations), community across the urban-to-rural paradigm, and the most common residential building type categories defined by Statistics Canada. The 2024 report represents the first edition of this survey (by the team described above), and is the most recent report of this type released since the Final Report of the *Cross-Canada Survey of Radon Concentrations in Homes* published by Health Canada in March 2012. An update of the current report is anticipated in 2025.

- **Case-Studies of Residential Radon Exposure**. Within each annual report, and as the opportunity arises, to release additional information in the context of specialized case studies of importance to public health, building science, and/or radon awareness stakeholder communities. In the 2024 report, these include an early description of radon exposure within multifamily dwellings, a profile of residential radon exposure in the Canadian North, a comparison of radon in the cities of Halifax NS, Montreal QC, and Calgary AB, as well as an examination of trends in Albertan residential radon as a function of year-of-construction, and Canada-wide average radon levels by property floor of testing. Future case studies for the 2025 update are anticipated.

TO CONTACT the working group behind the *Cross-Canada Survey of Radon Exposure in the Residential Buildings of Urban and Rural Communities* please send a message by:

Email to: **info@crosscanadaradon.ca** or click the "contact us" button at **crosscanadaradon.ca**

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LAND ACKNOWLEDGEMENT

The scientists, scholars, and volunteers contributing to the 2024 *Cross-Canada Survey of Radon Exposure in the Residential Buildings of Urban and Rural Communities* reside coast-to-coast-to-coast across all of Canada.

We herein acknowledge our presence on the traditional territories of the indigenous peoples who call this land home, and are thankful for the opportunity to create, collaborate, and work in what is today known as Canada. We recognize that these lands are home to the enduring presence of all First Nations, Métis, and Inuit peoples.

PREFACE

Radon is an important human health hazard. Between 2007 and 2012, Health Canada's National Radon Program undertook an initiative to characterize the problem by measuring radon concentrations in thousands of homes across the country, generating a large national data set to support what was then the most up-to-date and comprehensive assessment of residential radon exposure in Canada. Since that time, we've seen changes in the way people build, renovate, and use their homes, including in response to influences such as climate change and high energy costs. At the same time, commercial radon testing has become widely available, enabling more individuals to test their homes and facilitating research studies.

As new data accumulates, researchers have been seeing a trend towards higher radon levels in many parts of Canada, demonstrating a need to update our understanding of radon within our diverse and developing communities. To this end, Health Canada welcomes this report. The results presented herein represent a major collaborative effort to create and review the largest Canadian radon dataset to date, providing a picture that better reflects the realities of radon exposure in 2024, and providing authorities with data and evidence to more effectively address the challenge of protecting public health.

-Health Canada

EXECUTIVE SUMMARY

The 2024 *Cross-Canada Survey of Radon Exposure in the Residential Buildings of Urban and Rural Communities* summarizes the findings of a multi-year project. This project was led by a consortium of researchers comprised of the Evict Radon National Study team (including researchers at the British Columbia Cancer Agency, University of Calgary, University of Saskatchewan, and Dalhousie University) in collaboration with the staff and researchers at CAREX Canada, the British Columbia Centre for Disease Control, and Health Canada's National Radon Program.

The aims of this project were to (i) estimate the proportion of the Canadian population living in residential properties with radon gas levels above the Canadian guideline level of 200 Bq/m^3 when radon mitigation is recommended, and the World Health Organization (WHO) reference level of 100 Bq/m^3; (ii) understand how radon exposure in Canada differs by region, community, and residential building types; and (iii) empower Canadians to make informed decisions about health and policy, using recent and reliable data that accurately reflects Canada today.

It is important to emphasize that while the health risks from radon exposure below the Canadian Guideline or WHO reference level are small, there is no level that is considered risk-free. It is the choice of each individual to decide what level of radon exposure they are willing to accept. Regardless of radon level, any action taken that reduces an individual's radon exposure corresponds to a decrease in their health risk.

All radon test outcomes included in the 2024 Cross-Canada Radon Survey were from tests carried out by people living in Canada following instructions consistent with best practices for radon testing indicated by Health Canada and the Canadian National Radon Proficiency Program (C-NRPP). All results encompass the outcomes from long-term alpha track radon tests provided by an accredited radon test supplier, with 99.7% of tests occurring between 2009 and 2024. Multiple groups supplied the source data used for this survey, including The Evict Radon National Study, Health Canada, Radonova Inc., the British Columbia Centre for Disease Control, and multiple provincial Lung Associations. All data was assigned to a Statistics Canada census division, and expressed as a function of region, urban-to-rural community type, and building design.

The results from this study indicate that approximately 1 in 5 (17.8%) of people residing in Canada live in buildings with radon levels at or above the current radon guideline of 200 Bq/m^3. An additional 24.2% of people reside in houses with radon levels between 100-199 Bq/m^3. These estimates are greater than the previous Cross-Canada Survey results obtained in the late 2000s, which indicated 6.9% of houses that at the time were at or above 200 Bq/m^3. Overall, 83.6% (245/293) of current Census Divisions had at least one house whose radon level was at or above 200 Bq/m^3. Of the 171 Census Divisions in which we obtained at least 25 radon readings, there were 51 Census Divisions where approximately 25-50% of houses contained radon at or above 200 Bq/m^3.

The average radon level of a Canadian residential building (including single-detached, semi-detached, and row-style residential houses) is 84.7 Bq/m^3, weighted by the distribution of these houses across Canadian regions and urban-to-rural communities, based on data from the 2021 Canada Census. The 2024 survey finds that radon levels vary significantly across regions, urban-to-rural communities, and by building design types. There are areas of Canada where high indoor radon levels are more prevalent, including Atlantic Canada, Prairie Canada, the North, and the British Columbia Interior.

Among different building types, single-detached houses are more likely to be at or above 200 Bq/m^3 relative to semi-detached houses, which are more likely to be at or above 200 Bq/m^3 relative to row-style houses. While limited data was available for multi-family housing (i.e. apartments), current information suggests that some of these property types have high radon exposure. Residential buildings of any type in rural Canadian communities (meaning population centres of 1-29,999 people) generally demonstrated a greater likelihood of being at or above 200 Bq/m^3 relative to urban equivalents.

The percentage of houses with residential radon levels at or above the current radon guideline of 200 Bq/m^3 is generally high across Canadian municipalities, with four of Canada's largest cities with populations exceeding 1 million people (Montreal, Ottawa-Gatineau, Calgary, and Edmonton) demonstrating a 1 in 6 chance and weighted average residential radon levels between approximately 80-110 Bq/m^3.

Based on available data in this report, Canadian towns and cities where at least one quarter to half of residences contain radon at or above 200 Bq/m^3 include Whitehorse (YT), Nelson (BC), Kelowna (BC), Prince George (BC), Vernon (BC), Penticton (BC), Trail (BC), High River (AB), Okotoks (AB), Strathmore (AB), Regina (SK), Brandon (MB), Winnipeg (MB), Thunder Bay (ON), Kingston (ON), Sherbrooke (QC), Bathurst (NB), and Halifax (NS). Many of these municipalities have average residential radon levels greater than 130 Bq/m^3. Therefore, we recommend that public health stakeholders who are active in these communities take particular care to increase the promotion of radon awareness and access to radon reduction resources at this time.

There are no areas of Canada that are 'radon-free'. The results of this study can be used by federal, provincial, and municipal governments as well as health, occupational, and building safety professionals to help prioritize radon outreach and education efforts, and to encourage testing and remediation where necessary.

It is important to note that the outcomes reported in this survey expand upon and validate the results of the previous cross-Canada survey, in that, even for regions where average results indicate a lower incidence of elevated radon, there are houses containing radon at or above Health Canada and/or WHO reference levels for radon action. As such, the results in this report should <u>not</u> be used as a tool to determine <u>personal</u> radon risk potential, or to decide whether to test a specific household for radon.

Since radon levels are influenced by both building features and the behaviour of the people occupying it, the only way to know if a house that people are living in has an elevated level of radon is to test, regardless of region or community.

The 2024 *Cross-Canada Survey of Radon Exposure in the Residential Buildings of Urban and Rural Communities* represents an important new starting point in reporting residential radon exposures in Canada on a more regular timeline, and we are committed to consistent updates of Canadian radon exposure statistics as new data becomes available. We highlight the near-term need to improve radon test information across the Canadian North, especially in the province of Nunavut, and for multifamily housing. Additional radon test information connected with key geographic and building type data is also required for communities in census divisions that we have, as yet, been unable to report radon exposure estimates.

I. AN INTRODUCTION TO RADON and its HEALTH EFFECTS

I.1. What is radon gas, and how is it formed?

Radon is a colourless, odourless radioactive gas that is the second largest contributor to lung cancer worldwide, and the leading cause of lung cancer among people who have had a limited tobacco smoking history or have never smoked tobacco at all[1–3].

Radon gas is produced deep under the ground. It starts when uranium and thorium, which are found in rocks and soil, break down; this process, called "radioactive decay," changes these elements into radium, a solid radioactive metal. Radium then breaks down further into radon gas. This radon gas mixes with other gases in the soil and can quickly move from underground to the Earth's surface as part of what is called "free-phase" gas movement.

Soil gases containing radon constantly migrate to the surface of the Earth, where they escape into outside air and are diluted quickly in the atmosphere. Radon emerging at the Earth's surface may also enter buildings that are in direct contact with the ground, where dilution is limited, and high radon levels can accumulate.

Once formed, radon gas undergoes further decay within only a matter of days, releasing 'alpha' (α) particle radiation and precipitating as solid 'radon decay products.' For any given amount of radon gas entering a building, it takes just under four days for half of that gas to become a solid radon decay product.

I.2. Why is breathing in high amounts of radon gas so harmful?

When radon gas and/or its decay products are inhaled into the lungs, the lung cells are directly exposed to alpha radiation. Exposure to this radiation increases the risk of those lung cells transforming into a cancer, especially if they are exposed over many years and/or to very large amounts of radon.

Alpha radiation is made up of 'alpha particles' that move at 15,000 kilometres per second with enough energy to break apart and damage most molecules they encounter. For example, a single alpha particle emitted by decaying radon has enough energy to produce a microscopic dent in impact-resistant CR39 polycarbonate plastic. Four alpha particles are emitted during the decay of every radon atom and its subsequent short-lived decay

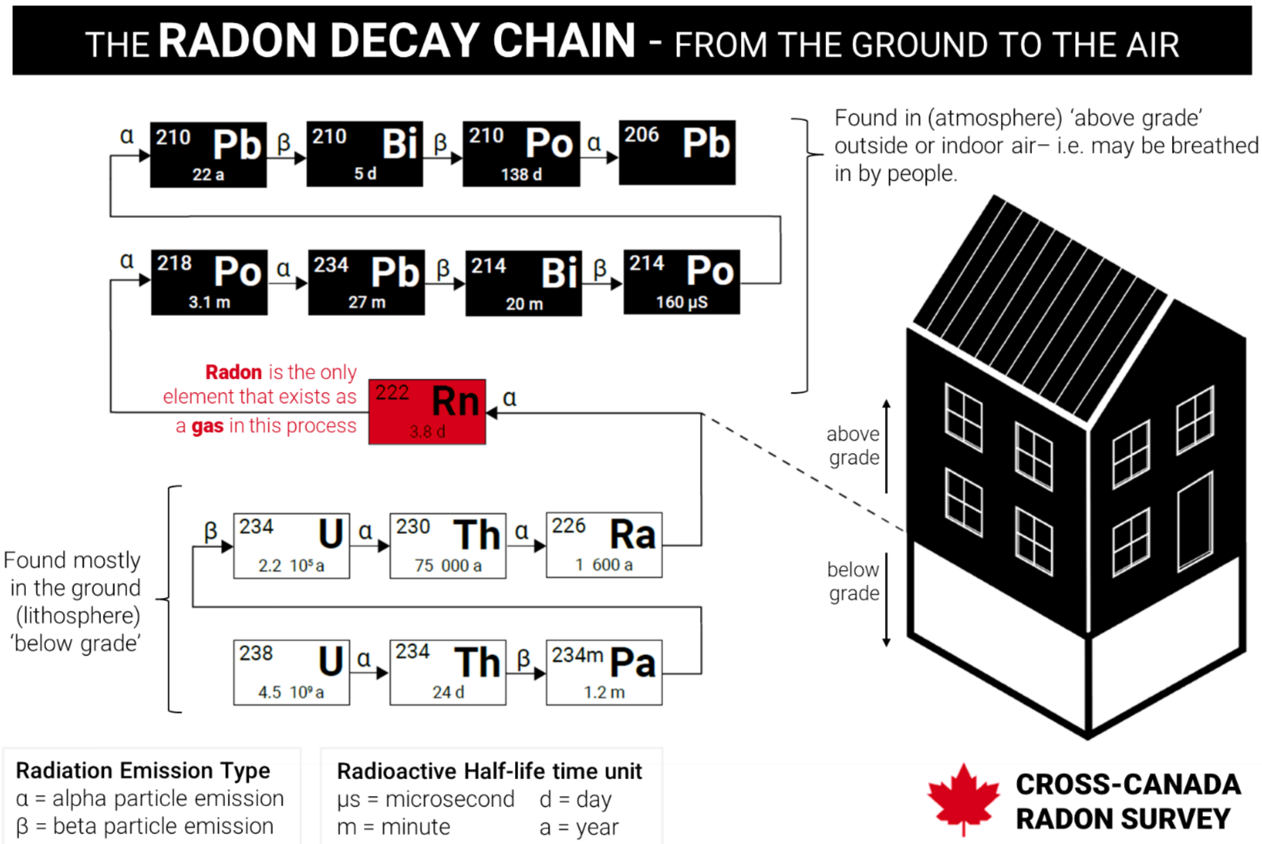
BOX #1. Did You Know? that radon is a noble gas, meaning it does not react chemically with other substances, including underground minerals or water. As such, radon quickly separates from its source and can migrate rapidly towards the surface. While <u>chemically</u> non-reactive, it is still <u>radioactive</u>, meaning it is unstable and emits energy capable of altering molecular structures.

BOX #2. Understanding Units used to Measure Radon. A widely used SI (international system) unit for measuring radiation levels from radon is called the becquerel (Bq). In the case of radon, one Bq represents one alpha particle emission from one radon disintegration event per second of time. For indoor air, Bq values are expressed per volume of air in metres cubed (m^3), so the common unit used to measure how much radiation from radon there is in air is the Bq/m^3. For example, 200 Bq/m^3 indicates that 200 alpha radiation emissions from radon occur every second per cubic metre of air.

BOX #3. Did You Know? Compared with buildings that have very clean air, buildings whose indoor air contains lots of dust or other hard-to-see pollutants such as smoke are more likely to trap radon decay products. In science, the combination of decayed radon and these small particulates become what is called the 'attached fraction'.

These dust and smoke-bound radon decay products can be transported by the dust or smoke particles through a building and into a person's lungs, where they can increase overall radiation exposure in that building.

products (see the infographic below for additional details about radon decay). Thankfully, alpha particles cannot move very far. Inside our lungs, however, radon decay emits alpha particles right next to very sensitive lung cells that absorb oxygen from the air. These particles may hit the cells' DNA—the fundamental building block of all life on Earth.



Infographic showing the radioactive decay series of the substances that lead to the formation of radon gas. Uranium (U) decays to radium (Ra), which are all solids that remain under the ground. Radon – the only gas in this series of events – can move to the surface, entering outside and indoor atmospheres, and then follows a radioactive decay series that transforms it into solid radioisotopes starting with polonium (Po) and progressing into stable lead (Pb) over many decades. Once inhaled, these 'radon decay products' can become embedded in our lungs (and bodies), emitting radiation for prolonged periods.

Alpha radiation can damage the DNA in the cells of our lungs, increasing the risk of genetic mutation. Genetic mutations triggered by radon exposure have the potential to alter how lung cells control their growth, increasing the risk of developing lung cancer later in life[4,5].

Radon gas is considered our most significant source of lifetime radiation exposure. Evidence indicates that radon exposure is responsible for 1 in 6 of all lung cancers [6], which equates to about 1 in 50 of all cancer deaths. The high rate of mortality associated with lung cancer is because it remains challenging to treat since it is typically diagnosed very late, at a cancer stage where it has already spread beyond the lungs to other parts of the body.

BOX #4. An Expanded Explanation of Radon Effects on Health. To understand why alpha particles from radon are so harmful to our health, we need to understand more about radiation types. Radiation refers to the energy ‘radiated’ by atoms in the form of electromagnetic waves or atomic particles. Ionizing radiation can 'steal' parts of other molecules (such as electrons), causing those molecules to break or change. Examples of ionizing radiation include X-rays, gamma-rays, and alpha particles.

An important idea when thinking about how damaging a specific type of radiation might be to our bodies is ‘linear energy transfer,’ which describes how much energy the radiation can deposit in any material that it passes through over a specific unit of distance. The different types of ionizing radiation are classified into two categories based on their relative linear energy transfer: low and high. Low linear energy transfer radiation, including gamma and X-rays, does not deposit much energy as it moves through an object[7,8]. In contrast, high linear energy transfer radiation, such as alpha particles emitted by radon, deposits a large amount of energy over a very short distance, creating many more changes in a far smaller area.

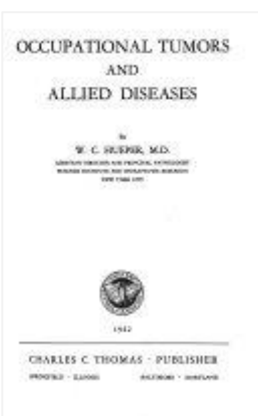
While the cells of our body can withstand and heal the damage that low linear energy transfer radiation can cause fairly well, humans are not well-equipped to heal the damage caused by high linear energy transfer radiation, making exposure to this type of radiation far more serious, dose-for-dose[9]. Alpha particles can lead to severe and complex damage to DNA that is next to impossible for a cell to heal without introducing at least some genetic mutation[10,11].

I.3. A brief history of radon discovery and how we know it impacts human health.

1890-1910s – First Discovery.

While radon was not given its final name until 1923[12], it was first discovered in Canada by scientists Ernest Rutherford and Harriet Brookes (pictured RIGHT) together with Robert Owens, who in 1899, called it ‘the radium emanation’. Their teamwork describing radioactive decay and the discovery of radon emanating from thorium compounds was carried out at McGill University in Quebec, and set the stage for all research into radon and its properties that followed over the next century[12,13].

1940-1970s – Radon exposure in underground miners.



OCCUPATIONAL TUMORS
AND
ALLIED DISEASES

W. C. HUEPER, M.D.

1942

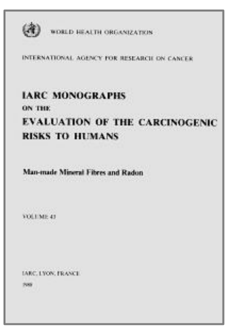
CHARLES C THOMAS · PUBLISHER

In the 1940s, Dr. Wilhelm C. Hueper, a USA National Cancer Institute pathologist, highlighted the potential health risks of radon within an occupational setting. Hueper's research and the subsequent 1942 report “*Occupational Tumors and Allied Diseases*” concluded that radon inhalation was a probable cause of lung cancer[14,15] and that radon was likely responsible for the premature deaths of more than 50% of European miners within 10-20 years of employment. Remarkably, the report had little impact on safety regulations for miners in the workplace at the time but marked the start of a period of a more comprehensive understanding of radon as a public health concern in occupational settings. In time, the link between radon and lung cancer became evident through the larger-scale studies of lung cancers in uranium miners in Canada, East Germany, and Czechoslovakia during the mid-20th century[16–19]. High levels of radon gas were prevalent in early Cold War-era uranium mines, and miners exposed to these conditions showed significantly increased rates of lung cancer. These large epidemiological studies provided the first conclusive evidence of the carcinogenic nature of radon to humans.

1980s – Stanley Watras and the discovery of residential radon exposure.

While awareness of health-damaging radon exposure in an occupational setting (mining) was widely recognized and well-established by the later quarter of the 20th century, radon exposure in the residential built environment (homes) did not emerge until an event that became known as "The Watras Incident" in the mid-1980s. During the winter of 1984, when construction engineer Stanley Watras (pictured RIGHT, with his family) entered the Limerick County nuclear power plant in Pennsylvania, USA, he unexpectedly set off the radiation contamination alarms. The event was considered remarkable as there was no nuclear material on-site because the plant was still under construction, and when Mr. Watras left at the end of the day, the alarms did not sound. Further investigation by authorities found that the indoor air of his nearby residential house contained an astonishing 99,900 Bq/m^3 radon gas and that the source of the radiation that triggered the alarms was likely large quantities of radon decay products attached to his clothing[20]. The incident led to widespread radon testing in residential properties across the United States and other countries, prompted the development of residential radon testing and mitigation technology, and underscored the significance of residential radon exposure as a public health issue[21].

1988 – IARC classification of radon inhalation as cancer-causing exposure.



WORLD HEALTH ORGANIZATION

INTERNATIONAL AGENCY FOR RESEARCH ON CANCER

IARC MONOGRAPHS
ON THE
EVALUATION OF THE CARCINOGENIC
RISKS TO HUMANS

Man-made Mineral Fibres and Radon

VOLUME 43

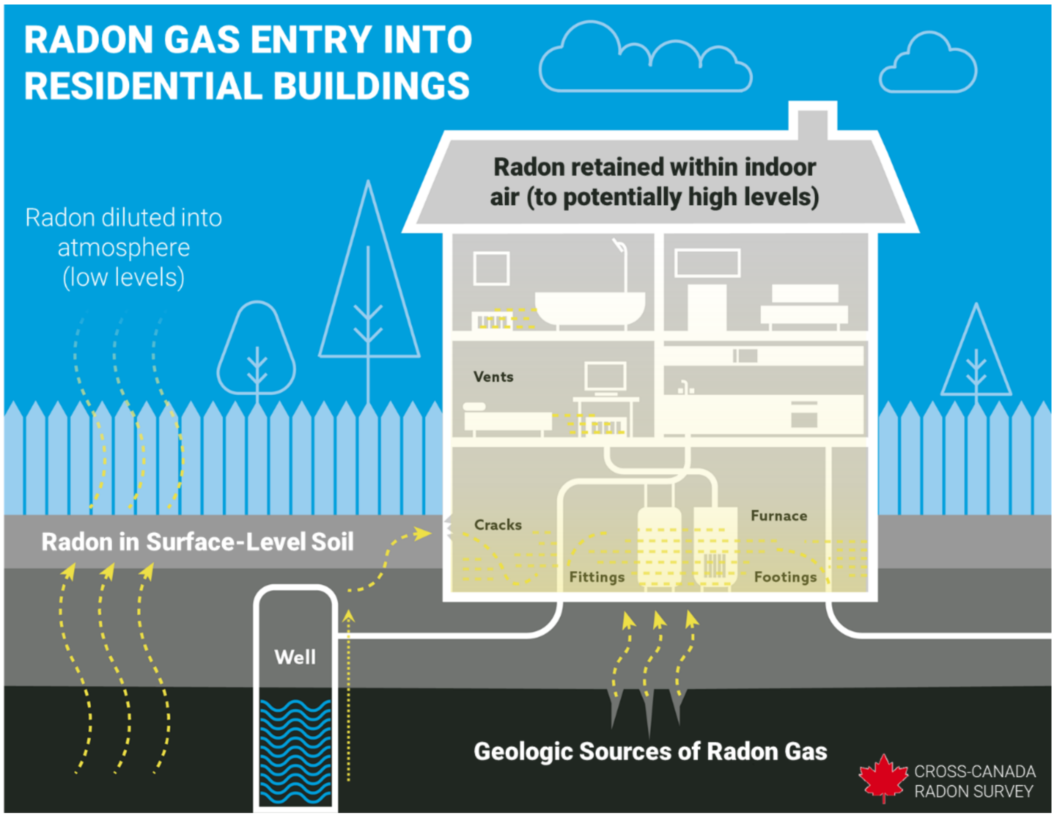
IARC, LYON, FRANCE

The International Agency for Research on Cancer (IARC) is the specialized cancer agency and part of the World Health Organization (WHO). Their main objective is to coordinate and conduct research on the causes and prevention of cancer globally. One of the agency's key roles is to assess the cancer-causing (carcinogenic) risks of various substances and exposures and classify these risks accordingly. A Group 1 carcinogen is, based on all available evidence, a substance that is conclusively cancer-causing in humans. Ultimately, in 1988, the IARC categorized radon and radon decay products as an IARC Group 1 carcinogen[22]

1990s-2000s – Linking residential radon exposure to lung cancer.

The epidemiological study of how radon exposure within the residential built environment (homes) relates to lung cancer in large populations was carried out throughout the 1990s-2000s. Like the earlier work on underground uranium miners, these very large studies were crucial to understanding whether long-term exposure to residential radon increased the risk of developing lung cancer. By 2005, three major studies on this were released, including (i) a pan-European study where collaborative analysis combined data from thirteen separate European studies, encompassing 7,148 people experiencing lung cancer and 14,208 healthy volunteer controls[17]; (ii) seven pooled North American case-control studies involving 3,662 people experiencing lung cancer and 4,966 health volunteer controls[23]; and (iii) two large case-control studies conducted in China, which included a total of 1,050 people experiencing lung cancer and 1,996 health volunteer controls[24]. Collectively, all these studies found that the average radon concentration in the homes of people diagnosed with lung cancer was higher than that of the healthy volunteer control groups and consistently showed that population centres with higher residential radon levels have higher lung cancer rates. Overall, there was a statistically significant increase in excess relative risk of lung cancer of 16% per 100 Bq/m³ increase in long-term average radon exposure.

I.4. Understanding indoor air radon exposure in Canadian Buildings.



Radon is a gas that comes from minerals like uranium, thorium, and radium in the Earth's crust. It is constantly being made and released into the air. Outside, radon levels are usually low and not harmful. However, inside buildings, radon can build up to high levels that are dangerous. This can happen in places like schools, houses, and workplaces[25–31]. So, even though radon is naturally made, the high levels we see indoors are a human-made problem. Radon can get into buildings in different ways, with the amount that enters and the amount that is retained inside the building depending on location and design.

REGION. Radon gas can move easily through cracks, faults, and openings in the ground. It rises to the surface at a rate dictated by the geology of a given location. In Canada, all regions have some radon-generating geologic source material, with most regions displaying average indoor air radon levels at the high end of those documented for other global regions[32]. In part, high indoor radon occurs in Canada because our geology has some of the world's most abundant reserves of uranium-containing (and thus radon-generating) minerals. ***Therefore, when thinking about radon risk in a given household, it is important to consider region.***

COMMUNITY. Both earth and atmospheric factors influence the movement of radon upwards and into buildings, as well as ground-penetrating human infrastructure such as groundwater wells. Recent research[33] indicates that rural communities relying on groundwater wells have properties with higher radon levels compared to nearby urban communities. The higher radon trend for more rural (lower population density) communities has been demonstrated across

Canadian regions, so ***when accounting for factors contributing to the risk of radon exposure within a given household, it is important to consider community type.***

BUILDING DESIGN. Over the past decade, a variety of research studies have shown that Canadian buildings are experiencing high and increasing levels of radon gas. The design, construction, and ventilation systems of a building are key factors that impact indoor radon levels[33–35]. For example, recent research indicates a trend of higher radon levels in newer residential buildings in Canada[34]. It is important to recognize that how our properties are built is a function of continuously evolving build practices and regulatory codes and that not all new residential properties in the world necessarily contain higher radon. For example, in Sweden – a comparable cold-climate nation to Canada – indoor air radon levels have decreased in new buildings over time. ***Thus, when accounting for factors contributing to the risk of radon exposure within a given household, it is important to consider a building's design type, age, and other property metrics.***

I.5 Radon testing and reduction (mitigation of a building to reduce radon entry)

Residential radon exposure is highly variable between populations and individuals but is also highly modifiable and, therefore, preventable. To understand whether a given building contains sufficient radon levels to be of concern, it is first recommended that Canadians test all residential properties which they occupy for substantial periods of time. For most people, this will be their primary place of residence. As radon is invisible to human senses, performing a long-term radon test is the only way to determine if a given building has high radon levels.

Testing a residential building for radon is relatively easy and widely accessible to the public through commercial and non-profit sector radon testing options. One of the most effective and reliable tests is called an 'alpha track' device, which requires no electricity and is often in the shape of a small hockey puck or ant trap. The general advice is 'to test the air you breathe' so the radon test devices should be placed in the lowest level of the home, where an occupant spends four or more hours on average each day. A long-term radon test is required to obtain a reliable outcome, with test period recommendations typically being 90 or more days to reduce the chances of an undesirable false-low or false-high outcome [36].

Taking action to reduce radon levels at or greater than 100 Bq/m^3 is recommended by various health organizations, including the World Health Organization [1], to reduce the risk to individuals living in high radon-containing built environments. The Canadian Radon Guideline I level is 200 Bq/m^3 and is considered the actionable threshold [6], with specific advice to reduce exposure to as low as reasonably achievable. Action to reduce radon levels above the guideline is strongly advised, and the level of urgency increases as radon levels rise. While the health risk from radon exposure below the Canadian Guideline is small, there is no level that is considered risk-free. It is the choice of each individual to decide what level of radon exposure they are willing to accept. Regardless of radon level, any action taken that reduces an individual's radon exposure corresponds to a decrease in their health risk.

If a radon test outcome is considered high (at or exceeding 100-200 Bq/m^3) or otherwise unacceptable by the occupants, then a radon reduction retrofit (commonly called radon mitigation) can be done. Thankfully, the technology needed to retrofit a residential building to permanently reduce radon entry is well-established, highly effective in Canada, and relatively quick to install.

II. SURVEYING RESIDENTIAL RADON IN 21st CENTURY CANADA

II.1. The purpose of the 2024 Cross-Canada Survey of Radon

The purpose of the 2024 "*Cross-Canada Survey of Radon Exposure in the Residential Buildings of Urban and Rural Communities*" is to gather long-term (three months or longer) indoor radon test results that have been carried out in a large number of residential buildings from across diverse Canadian communities ranging from the most densely populated urban areas to the least populated rural regions, in order to:

- Estimate the proportion of the Canadian population living in residential properties with radon gas levels above the Canadian guideline level of 200 Bq/m^3 and WHO recommended level of 100 Bq/m^3.
- Understand how radon exposure in Canada differs by region, community, and residential building types.
- Empower Canadians to make informed decisions about health and policy, using recent and reliable data that accurately reflects Canada today.

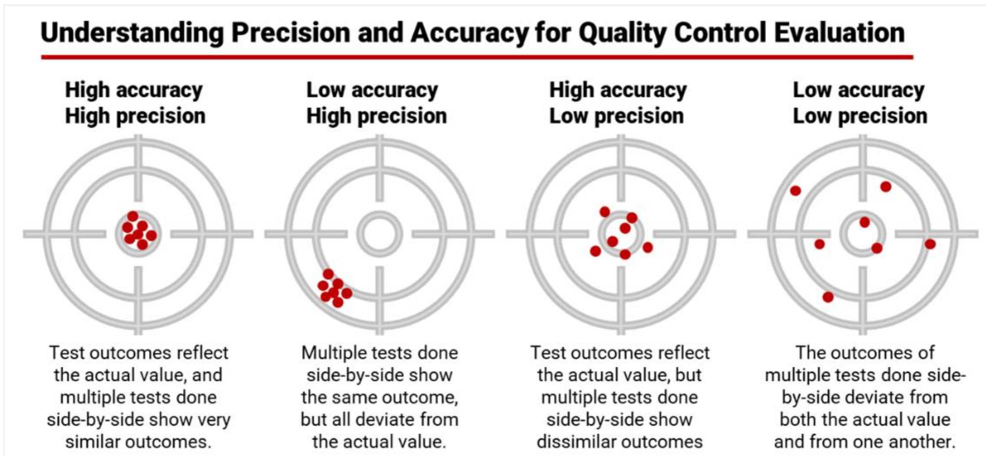
II.2. Survey Design

The following list summarizes important-to-understand features of the 2024 survey:

- All radon results are from long-term alpha track tests (of 90 days or more in duration) performed by people living in Canada advised to place their test on the lowest floor (storey) of a residential property in which a person spends an average of four or more hours per day.
- The majority of radon testing took place in winter heating months, with any outcomes based on radon testing periods that included a summer month being primarily in the context of a longer radon testing period of six months to a year.
- Both homeowners and renters were eligible to participate in radon testing for this survey. Similarly, people living in multi-story buildings, Indigenous reserves, or any other type of property or community were eligible to participate.
- Participants were recruited through a combination of geographically targeted direct invitation, convenience sampling, and/or arbitrary invitation administered by a wide variety of organizations and in English and/or French, depending on the organization. No quotas were used.
- In terms of communication, participants were informed of the opportunity to perform a radon test in their house via a combination of in-person radon awareness events, social media, paid online advertising, direct phone calls, and/or word-of-mouth.
- A mixture of paid-for, cost-subsidized, and at-cost radon test kits were deployed, depending on the specific group or organization administering the radon tests to participants.
- Data is associated with basic information regarding general location, test period, and other property type data, with a majority of data points also linked to exact geographic location and precise property metrics.
- Radon results are sorted into census divisions, as defined by Statistics Canada, rather than other potential units, such as provincial health regions. Where possible, household radon results within a census division were further linked to a smaller census sub-division, and/or metropolitan area, and/or designated place.

II.3. Quality controls during radon testing

To our knowledge, all data included in the 2024 Cross-Canada Radon Survey was carried out according to the best practices for radon testing advised by Health Canada and indicated by the Canadian National Radon Proficiency Program (C-NRPP). At a minimum, data are from long-term alpha track radon test devices provided by an accredited supplier who also performed internal quality controls during device production, test analyses, and provided participants (and/or groups administering the radon testing programs for a community) with a certified radon test outcome. *Please see the methodology section (XV) for more details.*

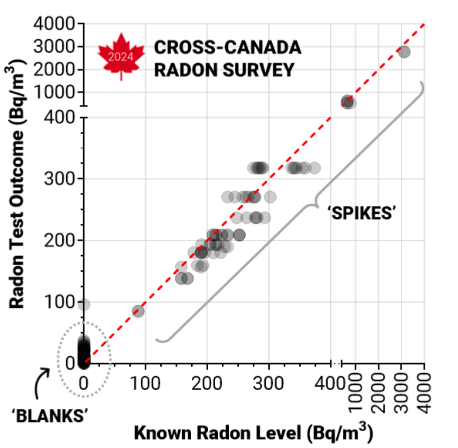


For all radon test programs administered by agencies such as Health Canada or the Evict Radon National Study teams, the radon testing process is verified to have included quality controls to determine the reliability of results in terms of **accuracy** and **precision**, which are explained in the graphic above. *To illustrate quality controls used to assess accuracy and precision, data from radon tests conducted by the Evict Radon National Study team are shown in the examples below.*

To assess radon test **ACCURACY** (how close a given set of measurements are to their true value), we deployed 'blanks,' which are tests put through the postal system without being deployed in a house, to control for test quality and background signal, as well as 'spikes,' which are tests exposed to a known amount of radon in a certified radon chamber, as an independent check of the laboratory analysis results.

Quality Controls: BLANKS and SPIKES

Based on a total of n = 265 blanks (tests opened and immediately sent for testing without exposure to a household) and a total of n = 75 spikes (tests opened and exposed to known amounts of radon gas within a controlled chamber).



For this graph, the 'coefficient of determination' value (r^2) is 0.995, which is considered an extremely strong indication of accuracy.

Quality Controls to Determine Radon Test ACCURACY.

In this graph, we evaluate how closely the outcomes of an alpha track radon test fits with the known amount of radon that the test was exposed to.

For "blanks", which are alpha track radon tests that were opened and immediately sent through the postal system to the testing laboratory, the assumed amount of radon exposure is assumed to be negligible – that is, 0 Bq/m^3. In reality, a small amount of radon exposure might occur during transit, hence these values are often come back with readings just slightly above zero.

For "spikes", the alpha track radon tests are opened and placed within a controlled chamber containing a known amount of radon gas for a period of ~90 days, similar to the test duration of a household. Tests are then sent to the testing laboratory to be evaluated.

For both blanks and spikes, the testing laboratories are not made aware of what these tests represent, to avoid any potential for bias.

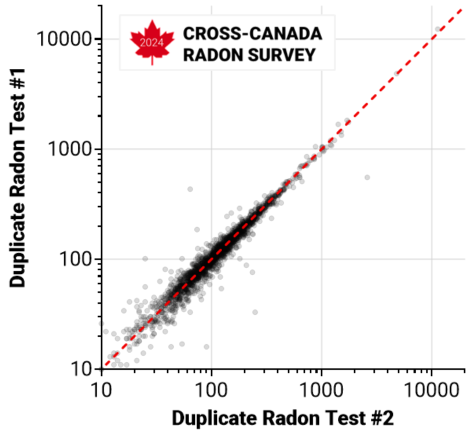
To confirm **PRECISION**, which is how close otherwise identically performed measurements are to each other, duplicate radon tests were provided at no cost to randomly selected participants, and then deployed at the same time and in the same place.

For these true duplicates (illustrated in panel A of the figure to the right), identical radon tests were placed no more than 10 cm apart and carried out at the same time in the same room within a house.

We also examined tests that were conducted by participants in the same house and at the same time, but in different rooms on the same floor, or in different rooms on different floors (see panels B and C of figure to the right). While these are not true duplicates, they provide a good idea about similarities and differences in radon testing performed within different locations within the same house.

(A) Quality Controls: TRUE DUPLICATES (TESTS AT IDENTICAL LOCATION)

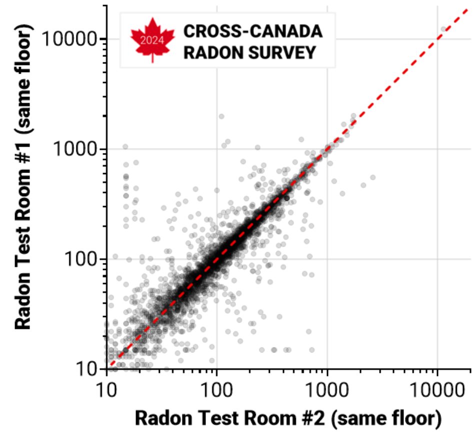
Based on n = 2,014 duplicate radon test performed at the same time and placed ≤10 cm from one another.



For this graph, the 'coefficient of determination' value (r^2) is 0.97, which is considered an extremely strong indication of precision.

(B) Quality Controls: TEST IN DIFFERENT ROOM ON SAME FLOOR of same house

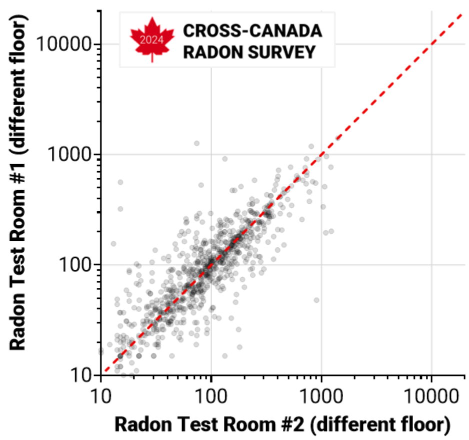
Based on n = 3,119 performed at the same time in the same house, in different rooms on the same floor.



For this graph, the 'coefficient of determination' value (r^2) is 0.86, which (despite known differences in radon between rooms) is a very strong indicator of precision.

(C) Quality Controls: TEST PLACED ON DIFFERENT FLOOR of same house

Based on n = 854 radon tests performed at the same time in the same house, but in rooms on different floors.



For this graph, the 'coefficient of determination' value (r^2) is 0.58, which (despite known differences in radon by floor) is still a moderate indicator of precision.

Quality Controls to Determine Radon Test PRECISION.

Panel A: In this graph, we compare the outcome of two long term radon tests performed at the same time and in the same room of the house, placed less than 10 cm apart. Panel B: In this graph, we compare the outcome of two long term radon tests performed at the same time but in different rooms on the same floor of the house. Panel C: In this graph, we compare the outcome of two long term radon tests performed at the same time but in different rooms on different floors of the house.

In all graphs, the semi-transparent dots represent the duplicated radon test outcomes from one house, while the dashed red line represents the point where two tests would have identical outcomes. The more that the duplicate radon tests outcomes (dots) align with the red line, the higher the precision.

IN SUMMARY, we have a high degree of confidence in the radon test outcomes that form the basis of this survey, as the accuracy controls indicate that tests reflect known amounts of radon 99.5% of the time. The precision controls (true duplicates) indicate that two tests performed together obtain the same outcome 97% of the time.

II.4. Achieving a balanced representation of Canadian residential radon levels

By linking all residential radon test results with a specific *Statistics Canada* 'census division' (please see section II.5 for definitions), the radon test outcomes for different building design types in this survey could be reported as a function of geographic region, and/or urban-to-rural community type.

Why was it important to do this?

Grouping the readings in this way allowed us to use all three of these specific categories to ensure the average radon outcomes reported in this survey were appropriately weighted, meaning that they better represent how residential houses in Canada actually exist, as opposed to just those households who performed a radon test.

By applying statistical weighting of all data to calculate average radon levels, we aimed to ensure that results are as representative as possible of the current distribution of Canadian housing stock as it has been measured by the most recent (2021) Canada Census (for more details, see BOX #5).

In short, the 2024 Cross-Canada Radon Survey was designed so that radon information about indoor radon concentrations reflects the mix of residential housing that exists in Canada today. In the following sections, we define the categories of data classification used in this report.

BOX #5. Achieving Representative Data and Minimizing Error. All techniques for recruiting people to perform a radon test (these are known as "sampling methods") have the potential to introduce an imbalance in how representative the final data is. For example, a data imbalance could be too many radon measurements from one specific type of house (and too few from the others) for a given region of Canada, potentially skewing the overall radon outcomes higher or lower than the true value for that region. These imbalances are generally unavoidable and must be accounted for whether or not sampling happens by random or semi-random direct invitation, by convenience sampling (i.e. anyone who asks to participate is permitted to), or by combinations of both these approaches.

In the context of radon testing in Canada and elsewhere, it has been observed that convenience sampling tends to recruit a greater percentage of people living in single-family detached houses than actually exist in a given community. By contrast, telephoning numbers associated with a property (especially landlines) during the 2020s will, by nature, over-sample populations who are more likely to either have a landline at all, or answer a telephone caller from an unknown number – a behaviour innately biased as a function of age, and therefore property type and location, as demonstrated by research into the demographics of Canadian property ownership. These issues do not mean each of these different approaches are incorrect, just that the imbalances in outcomes they can produce need to be addressed. We note that the data that was used as the basis for this report represents a combination of sampling techniques, as described in Section II.2.

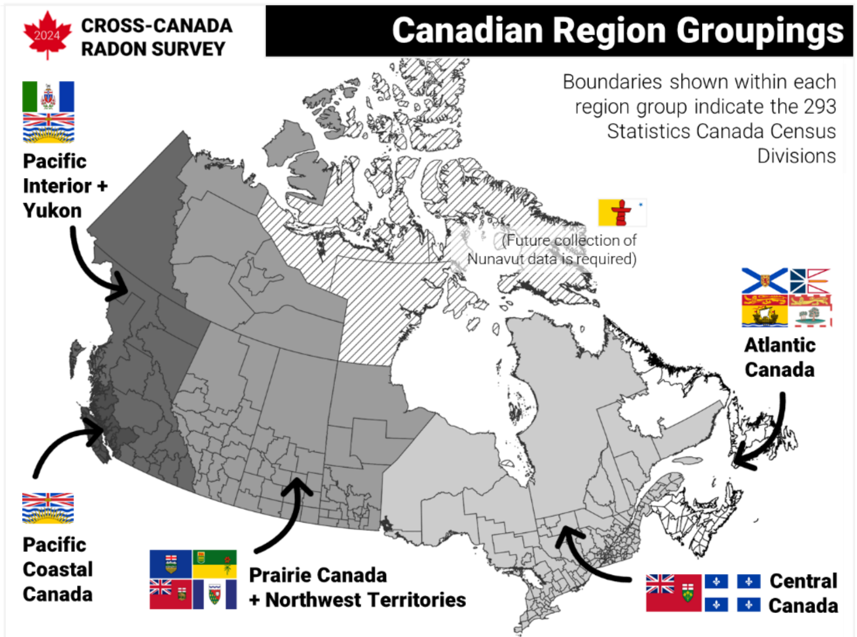
In practical terms, as no one sampling method will produce a set of radon results with a perfect reflection of what exists in Canada today, there is always a need to apply a data weighting or a 'normalization' process to improve data representation. More specifically, this process means adjusting the balance between radon test values of a given group (region, community, building type) to a commonly understood scale or point of reference, prior to averaging.

Statistics Canada provided us with highly detailed information from the 2021 Canada Census to understand where Canadian houses are, what they are (in terms of single-detached houses versus row houses, etc.), and the general distribution that exists between the most urban (densely populated) and most rural (sparsely populated) communities. Using this census information as the commonly understood reference scale, we adjusted radon data for a given region, community, and building type to be numerically representative of the current 'reality' of the Canadian housing stock.

Defining Region Type Categories

It is important to note that, for statistical purposes of preparing the data for this report, we were required to group the provinces of Canada into five larger regions that either include multiple provincial jurisdictions grouped together or, in one case, part of a provincial split between two regions. *Please see the Box #6 for a more detailed explanation.*

These five regions reflect areas of Canada where indoor air radon levels demonstrate a degree of consistency (for example, Ontario and Quebec), or acknowledge large differences within a province (for example, the BC coast versus BC interior), and/or are already commonly understood geographical groups (for example, Prairie or Atlantic Canada).



The five regions are:

- Atlantic (NL, PE, NS, NB)
- Central (ON and QC)
- Prairies and NWT (AB, SK, MB, NT)
- Pacific Interior and Yukon Territory (Northern and Interior BC, eastern Fraser Valley from Chilliwack onwards, and YT)
- Pacific Coastal BC and Island (Vancouver Island, Sea-to-Sky Corridor, Sunshine Coast, the northern BC coast, Lower Mainland and western Fraser Valley up to Chilliwack)

BOX #6. How the five Canadian Regions for this report were grouped. Based on the data we had access to for this report, reporting regional data using five larger groups was a necessity for the statistical analysis needed to achieve balance in the reported outcomes as a function of community and building design type, which requires a minimum number of readings per region.

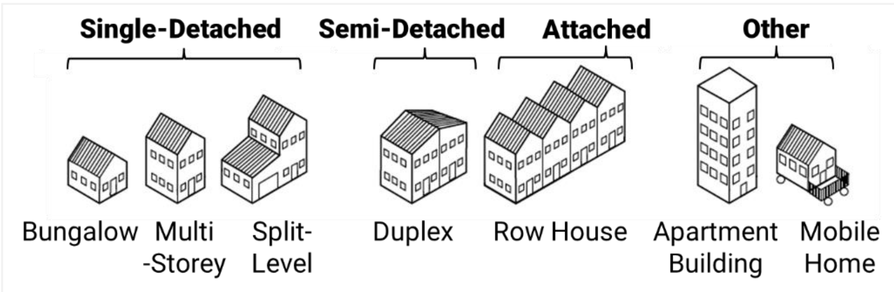
Altogether, we chose to group the Maritime provinces of Nova Scotia (NS), Newfoundland (NL), New Brunswick (NB) and Prince Edward Island (PE) together as a single Atlantic Canadian region, to group Ontario (ON) and Quebec (QC) together as 'Central Canada' (a region where a majority of each province rests on the Canadian Shield geological formation), and to group the Prairie provinces of Alberta (AB), Saskatchewan (SK), and Manitoba (MB) together with the Northwest Territory (NT) as 'Prairie and NT'.

In the case of British Columbia (BC), where very large differences in indoor air radon levels were observed between the interior and coastal areas, we split this province into two regions, with the 'Pacific Coastal and Island' region encompassing Vancouver Island and the lower mainland, etc., and the rest of BC being grouped together with Yukon Territory (YT), as these areas demonstrated very comparable radon outcomes.

Recognizing that the Canadian North is a unique area with its own special considerations, at the end of this report, we provide a special section where all outcomes collected for Yukon and NT are reported together. At this time, our teams did not have access to any indoor air radon test outcomes from Nunavut, and we highlight the near-term need to ensure that radon levels in this important area of Canada are explored and reported on within an updated version of this survey.

Defining Building Design Type Categories

The four major building design type categories we used are:

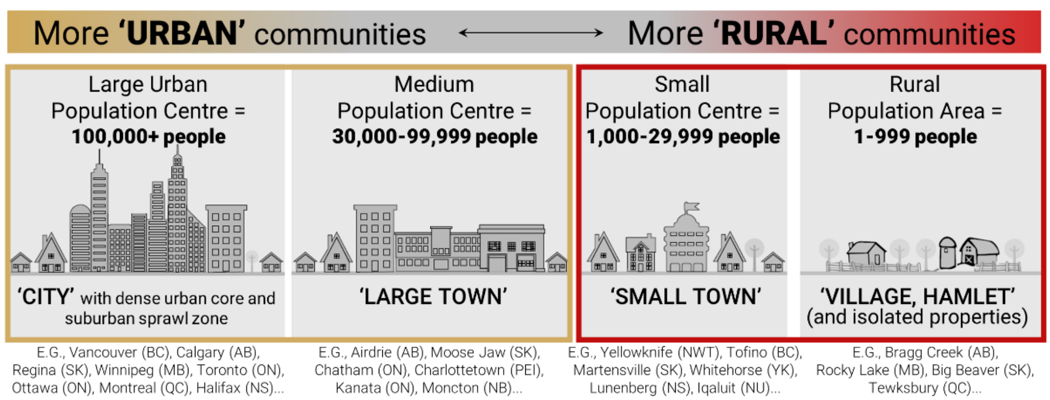


- Single-detached Properties
- Semi-detached (Duplex) Properties
- Row (Attached) Properties
- Other (including Multi-Family Dwellings, Cabins, Mobile Homes, etc.)

Of these, we had access to only limited data for the 'other' category that included multi-family dwellings such as apartments. As such, a majority of radon test outcomes discussed in the 2024 report will be restricted to the first three categories, with a special section (XIII.1) that discusses preliminary outcomes for multifamily residential buildings.

Defining Community Type Categories

Using Statistics Canada's definitions of Population Centres and Designated Places that include census metropolitan and rural areas, all household radon readings were assigned to these two community group categories.



- More <u>"Urban" communities</u>, which are a combination of cities and large towns. Specifically, large towns are formally classified as communities that have a population of 30,000-99,999 people, while cities are communities with a population greater than 100,000 people. The grouping acknowledges that the infrastructure of these more urban communities (and the experiences of the people living there) are generally distinct from those of lower population densities. ***For simplicity, moving forward, we will refer to all city and large town communities as "urban".***
- More <u>"Rural" communities</u>, which are a combination of small towns and rural areas. Specifically, rural areas refer to communities/isolated residences with a population of 1-999 people, while small towns are communities with a population of 1000-29,999 people. The grouping acknowledges that the infrastructure of these more rural communities (and the experiences of the people living there) are generally distinct from those of higher population densities. ***For simplicity, moving forward, we will refer to all small towns and rural/isolated communities as "rural".***

II.5. Glossary and definitions of other important terms

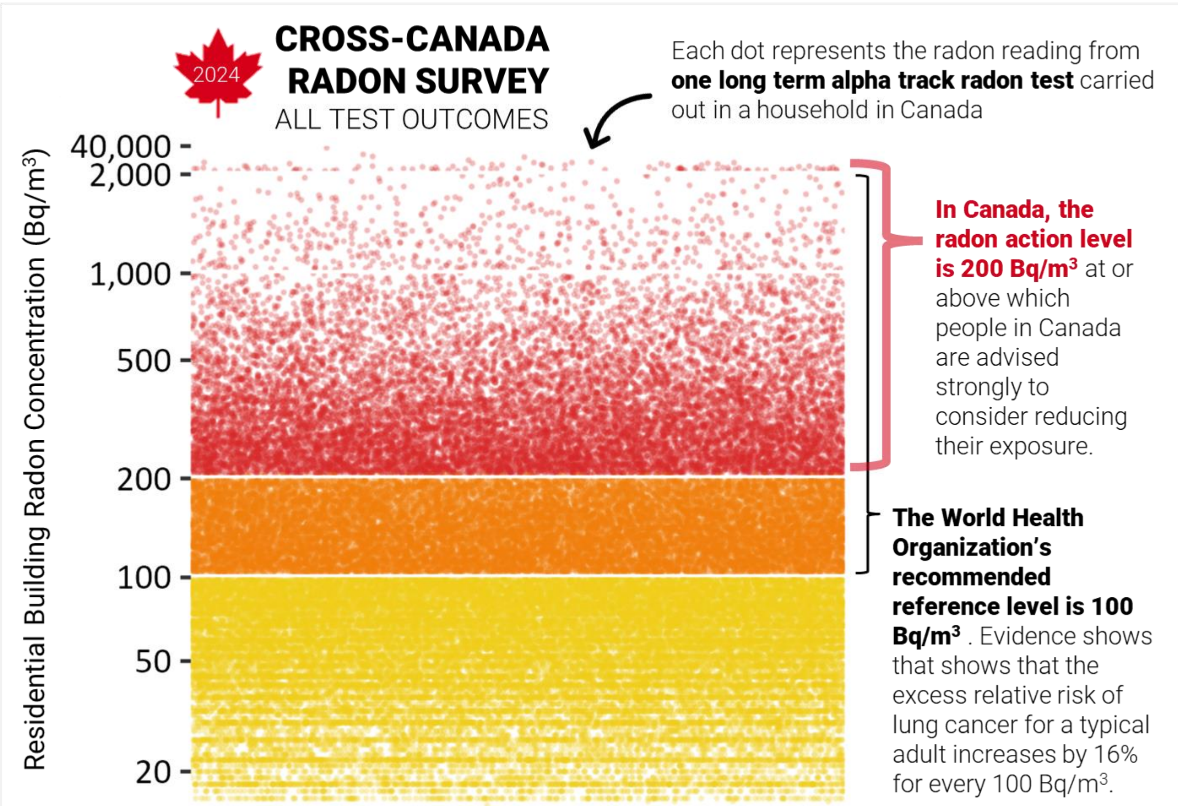
As discussed above, *Statistics Canada* 2021 census data was used to re-weight our radon data so that it best reflected the "reality" of radon exposure in Canada in the 2020s. To achieve this, all household radon results were first sorted into Census Divisions (with other units including Census Subdivisions, Census Agglomerations, Census Metropolitan Areas (urban areas), and Designated Places (rural areas)).

The glossary below will help the reader understand what is meant by all these terms **(and for more details, please see Statistics Canada):**

- **Census Agglomeration:** An area formed by one or more nearby municipalities with a core population (i.e. the population of the largest municipality in the group) of at least 10,000 people. All areas within a Census Agglomeration that are not within the border of a population centre or designated place are considered rural areas.
- **Census Division:** are one of the most stable administrative areas of intermediate geographic size, between the provincial/territory and municipality levels. They are most often used in long-term studies. Census divisions are used for regional planning and managing common services, and are established by provincial law, or in cooperation with Statistics Canada and provincial/territorial authorities.
- **Census Metropolitan Area:** An area formed by one or more nearby municipalities with a total population of at least 100,000 people and the core population of at least 50,000 (i.e. the population of the largest municipality in the group). All areas within a Census Metropolitan Area that are not within the border of a population centre or designated place, are considered as rural areas.
- **Census Subdivision:** A geographic area that is provincially or territorially legislated as a municipality, or areas that are treated as a municipal equivalent for statistical purposes.
- **Designated Place:** An area that does not meet the criteria of a population centre but is a small community or place of importance. If a designated place has a population of fewer than 1,000, it is considered a rural area.
- **Population Centre:** A geographic area centred on a municipality with a population of at least 1,000 and a population density of at least 400 people per square kilometre. If an area falls outside the population centre, and is not a designated place, for the purposes of this report, it is considered a rural area.
- **"Urban":** Communities that are large towns and cities with populations of 30,000 people or greater
- **"Rural":** Includes small towns, villages, hamlets and isolated properties where the population ranges from 1 person to 29,999 people in the community.

III. RADON LEVELS FOR CANADA AS A WHOLE, AND BY BUILDING TYPE

A total of 69,478 unique long-term radon test outcomes were assembled for this survey, with 68% having been completed in a basement or cellar (below grade floor of property), 30% completed on the ground floor or walkout level (floor or property entirely or partly level with the ground), and 2% on an upper floor at least one storey above ground level. The average radon test duration was a geometric mean of 126 days (approximately 4 months), with 99.7% of tests carried out between calendar years 2009-2024. The complete 'raw' outcomes of the data collected for the 2024 Cross-Canada Radon Survey are shown below.



Residential radon across Canada, weighted by region, community, and building type.

When all Canadian data (for all regions, communities, and building types) are combined in a manner that is balanced by distribution of these factors as established by the 2021 Canada Census, the geometric average household radon level was 84.7 Bq/m^3, with just under 1 in 5 (17.8%) of single-detached, semi-detached, and row-type residential buildings containing radon levels that are at or over 200 Bq/m^3.

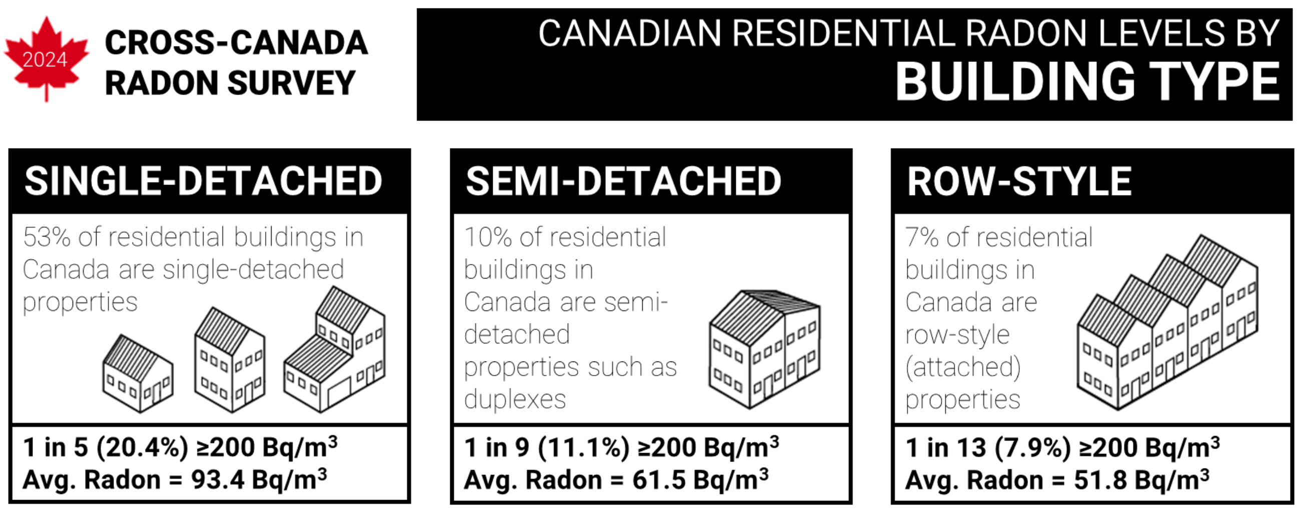
KEY FINDING = Nearly 1 in 5 Canadian single-detached, semi-detached, and row-type residential buildings are at or above 200 Bq/m^3 radon

Overall, 83.6% (245/293) of Census Divisions had at least one house whose radon level was at or above 200 Bq/m^3. Of the 171 Census Divisions in which we obtained at least 25 radon readings, there were 51 Census Divisions where approximately 25-50% of houses contained radon at or above 200 Bq/m^3. The highest Canadian residential radon level observed within this dataset was 32,321 Bq/m^3. ***Please see Section XVI for tables containing average radon test outcomes (and associated data) for all Canada Census Divisions.***

These outcomes emphasize that Canadian radon exposure in residential buildings is a serious public health concern. Based on the total number of single-detached, semi-detached, and row-type residential buildings and the average number of occupants per house in Canada at this time, the observation that nearly 1 in 5 houses contain radon levels that are at or exceed 200 Bq/m^3 equates to an estimated 4.6 million out of 25.7 million people (living in these home types) who would benefit most from radon reduction to lower their exposure below current radon action guidelines. Further to this, an additional 1 in 4 (24.2%) of Canadian houses record radon levels between 100 and 199 Bq/m^3, which is important to note as 100 Bq/m^3 is the WHO reference level [17,23,24]. Thus, 42% of the Canadian house types we report on will contain radon that is at or exceeds 100 Bq/m^3.

Radon levels across different Canadian residential building types

Radon levels in a building can vary significantly depending on various factors, including how that building is designed. To understand how differing building structures influence radon concentrations in Canada, household radon levels were sorted to allow a detailed examination of trends of high radon by building type. The three building type categories listed below encompass 69.6% (25.7 million people) of the total population of Canada (36.99 million people in the 2021 Census), with multifamily dwellings (such as apartments) making up the remaining 30.4%. ***Please see Section XIII.1 for a preliminary analysis of radon levels in multifamily residential buildings.***



Single-detached houses: Single-detached houses, which encompass 53% of Canadian residences, exhibit the highest average indoor radon levels at 93.4 Bq/m^3. In Canada, 1 in 5 (20.4%) Single-detached houses contain radon at or over 200 Bq/m^3. 1 in 4 (26.4%) of these dwellings record levels between 100 and 199 Bq/m^3.

- **1 in 5** Single-detached properties are at or above 200 Bq/m^3 radon

Semi-detached houses: Semi-detached houses represent 10% of all Canadian residences, and show average radon levels of 61.5 Bq/m^3. On average, semi-detached houses contain lower levels of indoor radon than detached houses. In Canada, 1 in 9 (11.1%) semi-detached houses contain radon at or over 200 Bq/m^3. 1 in 5 (18.8%) semi-detached houses record levels between 100 and 199 Bq/m^3.

- **1 in 9** Semi-detached properties are at or above 200 Bq/m^3 radon

Row-style (attached) houses: Row-type houses represent 7% of all Canadian residences and show average radon levels of 51.8 Bq/m^3. On average, row houses contain lower levels of indoor radon than detached or semi-detached houses, but these levels are still considered high in a global context. In Canada, 1 in 13 (7.9%) row houses contain radon at or over 200 Bq/m^3. 1 in 6 (15.6%) row houses record levels between 100 and 199 Bq/m^3.

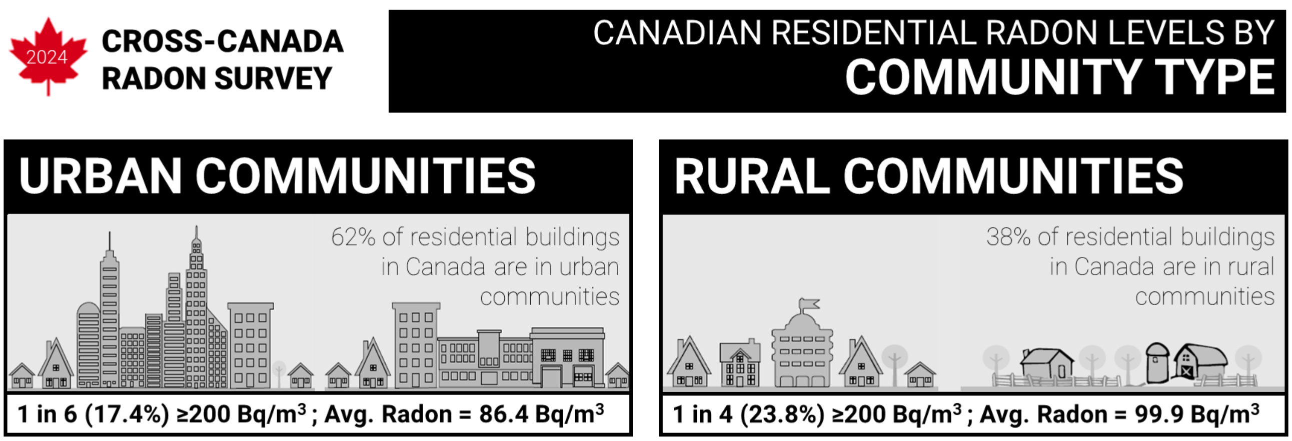
- **1 in 13** Row-style properties are at or above 200 Bq/m^3 radon

The pan-Canadian data underscores significant differences across residential building types that impact indoor radon levels. These outcomes also emphasize that assessing the probability of high radon in the Canadian residential built environment needs to carefully consider housing type wherever possible.

BOX #7. A Call to Action!
All Canadian building types can potentially contain high household radon. Testing where you live for radon is important. If the radon results are high, installing an effective radon mitigation system could significantly reduce your lifetime risk of developing lung cancer.

IV. RADON LEVELS IN CANADA, BY URBAN TO RURAL COMMUNITY

As many different factors influence indoor radon levels, the analysis of household radon in Canada can be broken down further into separate variables such as community type. In this section, we report Canadian residential radon data for two distinct types of communities, those that are considered (i) 'Urban' and (ii) 'Rural' based on community population size.



- **1 in 6** Urban community properties are at or above 200 Bq/m^3
- **1 in 4** Rural community properties are at or above 200 Bq/m^3

IMPORTANT: As a reminder, whether a community is considered more "Urban" versus more "Rural" is entirely dependent on population size. Our rural community group includes small towns, villages, hamlets and isolated properties where the population ranges from 1 person to 29,999 people in the community. By contrast, communities that are large towns and cities with populations of 30,000 people or greater are classed under the urban community group.

Urban communities: 62% of Canadian detached, semi-detached, and attached residences are found in more urban communities. Of these, 53% are in cities of 100,000 or more people, and 9% live in large towns of 30,000-99,999 people.

The average urban household radon levels were found to be 86.3 Bq/m^3, with 1 in 6 (17.4%) of these buildings containing radon levels at or above 200 Bq/m^3, while 1 in 4 (26.4%) were between 100 and 199 Bq/m^3. Within more urban communities, radon levels across building types were:

- **1 in 6** Urban Single-detached properties are at or above 200 Bq/m^3
- **1 in 8** Urban Semi-detached properties are at or above 200 Bq/m^3
- **1 in 11** Urban Row-style properties are at or above 200 Bq/m^3

The highest average radon levels in urban communities were observed in single-detached houses, with an average radon level of 86.3 Bq/m^3. 1 in 6 (17.4%) urban single-detached houses contained radon levels greater than 200 Bq/m^3, while 1 in 4 (26.4%) contained radon levels between 100-199 Bq/m^3. Semi-detached and row houses in urban areas contained an average radon level of 66.6 Bq/m^3 and 55.7 Bq/m^3, respectively. Approximately 1 in 8 (12.6%) urban semi-detached and 1 in 11 (9.1%) urban row houses contained radon levels equal to or above 200 Bq/m^3. In total, 20.2% of semi-detached and 15.9% of row houses in urban areas had radon levels between 100-199 Bq/m^3.

Rural communities: 38% of Canadian detached, semi-detached, and attached residences are found in rural communities. Of these, 15% are in small towns of 1,000-29,999 people, and 23% live in villages, hamlets or isolated properties of 1-999 people.

The average rural household radon levels were found to be 99.9 Bq/m^3, with 1 in 4 (23.8%) of these buildings containing radon levels at or above 200 Bq/m^3, while 1 in 4 (25.7%) were between 100 and 199 Bq/m^3. Within rural communities, radon levels across different building types were:

- **1 in 4** Rural Single-detached properties are at or above 200 Bq/m^3
- **1 in 8** Rural Semi-detached properties are at or above 200 Bq/m^3
- **1 in 8** Rural Row-style properties are at or above 200 Bq/m^3

Rural residential radon levels between detached and semi-detached buildings were 96.5 Bq/m^3 and 75.8 Bq/m^3, respectively. However, 1 in 4 (23.0%) detached houses were at or exceeded 200 Bq/m^3, compared to almost 1 in 8 (12.2%) semi-detached houses. The average radon of a rural community row house was 61.6 Bq/m^{3,} with 1 in 8 (12.5%) at or exceeding 200 Bq/m^3. In total, 25.2% (detached), 25.5% (semi-detached), and 21.0% (row) of rural residential buildings contained 100-199 Bq/m^3 radon.

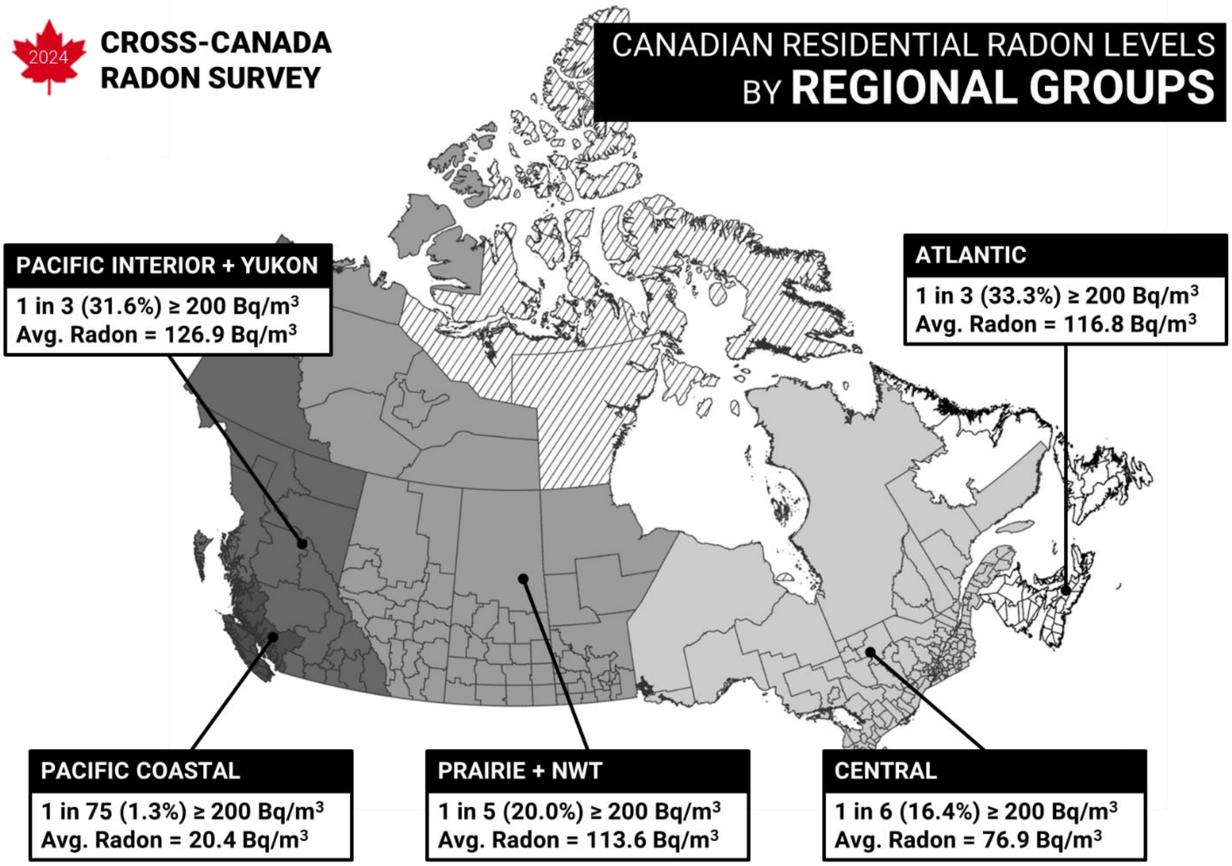
BOX #8. A Call to Action!
Whether your household is in a urban or rural community, your indoor air could contain high radon, and everyone is encouraged to test their indoor radon level. That said, survey data emphasizes a greater potential for high radon concentrations for people living in rural communities.

From these findings, people living in Canadian rural communities experience higher average radon levels relative to those in urban communities, and a greater proportion of the rural Canadian population lives in houses with radon levels at or exceeding 200 Bq/m^3. Canadian scientists have recently suggested [33–35] that, in addition to differences in single-detached houses being more common in rural areas, another factor that contributes towards the higher rural radon trend is that rural community houses are more likely to be near one or more drilled groundwater wells. In this scenario, borehole gaps surrounding well casings may increase how easily underground radon can migrate up towards the soils underneath properties. Thankfully, the recommended solution to high radon in a rural property (following a standard radon mitigation process for the house) remains effective and no direct action regarding wells is suggested at this time.

V. RADON LEVELS ACROSS CANADIAN REGIONS, AT-A-GLANCE

The total area of Canada is 9,985 km^2, with a major factor influencing indoor air radon levels of residential buildings being the geological source of radon in the ground, meaning the amount of radium, thorium and uranium in the rock and soil of a given geographic area.

In the following sections, we provide average radon for residential properties grouped across five regions: Atlantic Canada, Central Canada, The Prairie and Northwest territories, Pacific Interior and Yukon and finally, Pacific Coastal Canada **shown in the graphic below**.



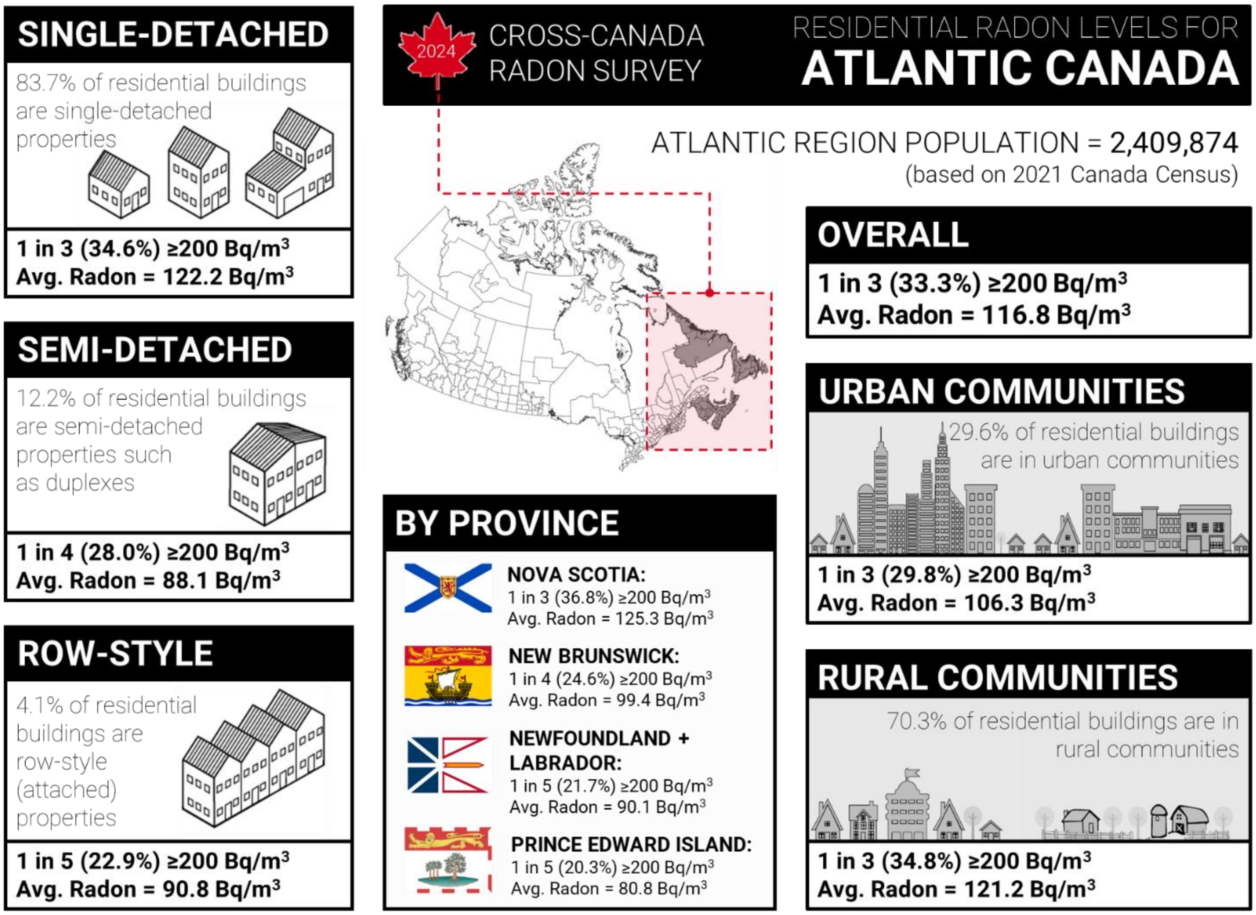
The **KEY FINDINGS** for a Canadian regional overview of residential radon levels are:

- **1 in 3** Atlantic properties are at or above 200 Bq/m^3
- **1 in 6** Central properties are at or above 200 Bq/m^3
- **1 in 5** Prairie and NT properties are at or above 200 Bq/m^3
- **1 in 3** Pacific Interior and YT properties are at or above 200 Bq/m^3
- **1 in 75** Pacific Coastal Canadian properties are at or above 200 Bq/m^3

IMPORTANT: As a reminder, these groupings were based on the following considerations: (i) commonly-grouped geographic areas (e.g. the Prairies, Atlantic region), (ii) areas with relatively comparable radon levels (e.g. Ontario and Quebec), (iii) a need to combine data for provinces or territories with relatively smaller populations in order to weight outcomes, and/or (iv) a need to divide some regions where radon levels were highly divergent within a province (e.g. British Columbia). *At this time, we were not able to obtain sufficient radon results for the territory of Nunavut to report outcomes, and so regrettably this important area will need to be studied further and reported on at a later date.*

VI. RADON LEVELS IN ATLANTIC CANADA

The Atlantic Canadian Region encompasses the provinces of Nova Scotia (NS, pop. 969,383), New Brunswick (NB, pop. 775,610), Newfoundland and Labrador (NL, pop. 510,550), and Prince Edward Island (PEI, pop. 154,331), and contains 8% of all Canadian residential building types reported on in this study.



1 in 3 (33.3%) of Atlantic Region households contain radon levels at or above 200 Bq/m^3, with an average radon level of 116.8 Bq/m^3, the second-highest average level of household radon among all five Canadian regions. In total, 22.3% of Atlantic Canadian residential properties contained radon in the 100-199 Bq/m^3 range.

FOR PROVINCES in this regional group, we find that radon levels in residential buildings are broadly comparable and generally considered high, with geometric mean radon levels ranging between 80.8 Bq/m^3 in PEI (note: unweighted value), to 90.1 Bq/m^3 in NL (note: unweighted value), to 99.4 Bq/m^3 in NB (weighted value), and 125.3 Bq/m^3 in NS (weighted value). The likelihood of a building containing at or over 200 Bq/m^3 ranges between 1 in 5 for NL and PEI (unweighted values), to 1 in 4 (24.6%) for NB (weighted value) and more than 1 in 3 (36.8%) for NS (weighted value). ***Please note, we aim to report fully weighted radon outcomes for <u>all</u> Canadian provinces in a future update to this report.***

Radon across Atlantic Canadian Urban-to-Rural Communities: In Atlantic Canada, 29.6% of residential buildings are in an urban community, while 70.3% are in a rural community.

- **1 in 3** Urban Atlantic properties are at or above 200 Bq/m^3
- **1 in 3** Rural Atlantic properties are at or above 200 Bq/m^3

Atlantic Canadian urban community residential buildings had an average radon level of 106.3 Bq/m³, with almost 1 in 3 (29.8%) of these properties being at or over 200 Bq/m³, and approximately 1 in 4 (22.9%) being within 100-199 Bq/m³.

Relative to these already high urban radon levels, Rural Atlantic Canada communities exhibit a higher average radon level of 121.2 Bq/m³, with 1 in 3 (34.8%) properties containing radon levels of 200 Bq/m³ or more, and 1 in 4 (22.1%) being within the 100-199 Bq/m³ range.

Radon across Atlantic Canadian residential building types: In Atlantic Canada, 83.7% of residential buildings are single-detached properties, 12.2% are semi-detached properties, and 4.1% are row (attached) style properties.

- **1 in 3** Atlantic Single-detached properties are at or above 200 Bq/m^3
- **1 in 4** Atlantic Semi-detached properties are at or above 200 Bq/m^3
- **1 in 5** Atlantic Row-style properties are at or above 200 Bq/m^3

Atlantic Canadian single-detached properties have an average radon level of 122.2 Bq/m³, with 1 in 3 (34.6%) at or exceeding 200 Bq/m³. Approximately 1 in 4 (23.1%) of Atlantic Canadian single-detached properties fall within the 100-199 Bq/m³ range.

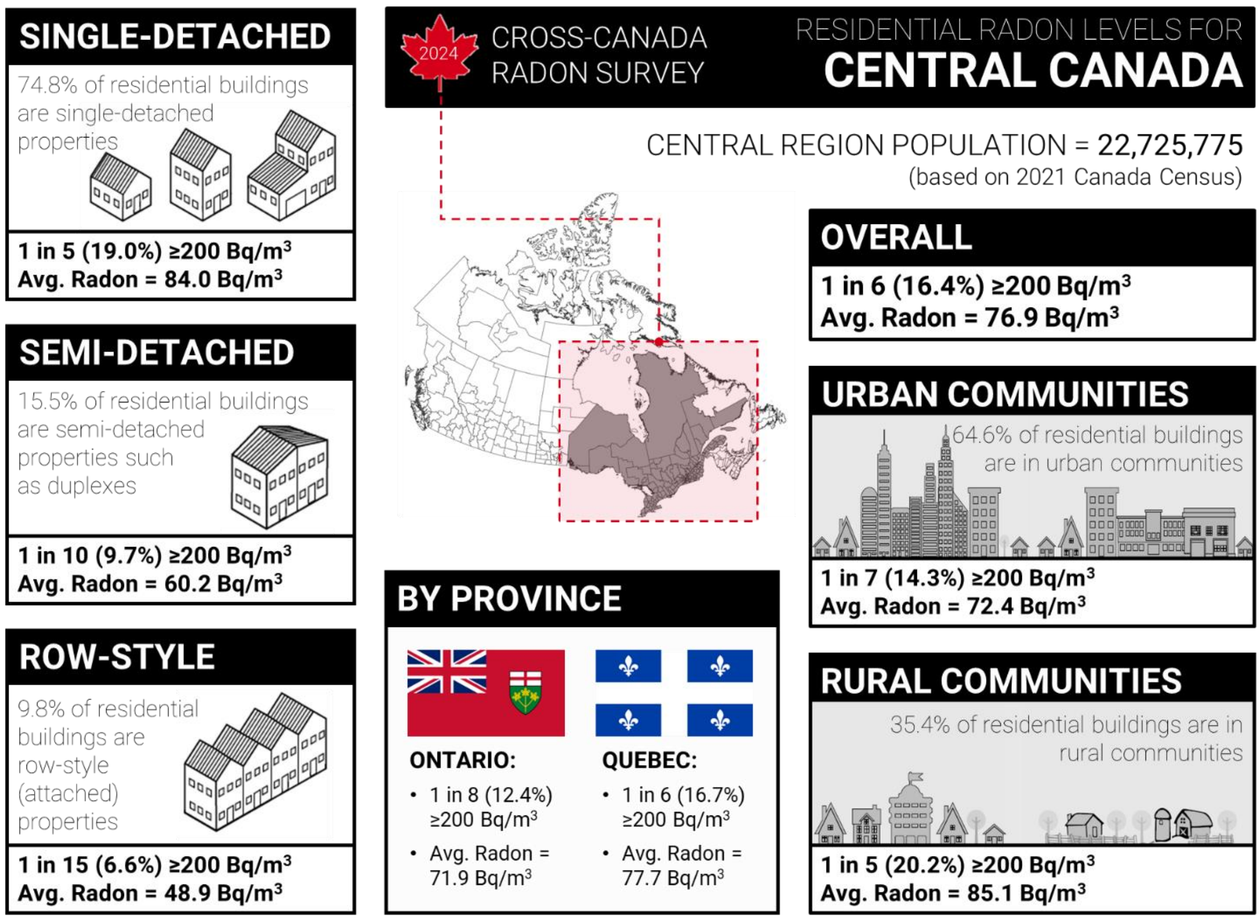
Atlantic Canadian semi-detached properties have an average radon level of 88.1 Bq/m³, with approximately 1 in 4 (28.0%) of these properties being at or over 200 Bq/m³. Approximately 1 in 6 (16.7%) of Atlantic Canadian semi-detached properties are between 100-199 Bq/m³.

Atlantic Canadian row (attached) properties have an average radon level of 90.8 Bq/m³, with almost 1 in 5 (22.9%) being at or over 200 Bq/m³. Approximately 1 in 5 (22.0%) have radon levels within 100-199 Bq/m³.

IN SUMMARY, the residential radon statistics of Nova Scotia, New Brunswick, Newfoundland, and Prince Edward Island in Atlantic Canada highlight significant variations based on community setting and housing type. Atlantic rural area properties follow a national trend of having higher indoor radon when compared to more urban communities. Similarly, Atlantic region single-detached properties contain higher radon than semi-detached. Unusually, Atlantic Region row houses have higher average radon than semi-detached houses, although overall, few of them exceed 200 Bq/m³ compared to other types. ***Atlantic Canadian residential radon levels are amongst the highest observed for any geographic area in Canada and should be considered a priority area for radon testing and mitigation.***

VII. RADON LEVELS IN CENTRAL CANADA

The Central Canadian Region encompasses the provinces of Ontario (ON, pop. 14,223,942) and Quebec (QC, pop. 8,501,833), and contains the greatest portion (59%) of all Canadian residential building types reported on in this study.



Collectively, 1 in 6 (16.4%) of Central Region households contain radon levels at or above 200 Bq/m³, with an average radon level of 76.9 Bq/m³. In total, 22.9% of Central Canadian residential properties had radon levels in the 100-199 Bq/m³ range.

FOR PROVINCES in this regional group, we find that radon levels in residential buildings are very similar between Ontario and Quebec, with weighted geometric mean radon levels ranging between 71.9 Bq/m³ in ON, to 77.7 Bq/m³ in QC. The likelihood of a building containing at or over 200 Bq/m³ ranges between 1 in 8 (12.4%) for ON and 1 in 6 (16.7%) for QC.

Radon across Central Canadian Urban-to-Rural Communities: In Central Canada, 64.6% of residential buildings are in an urban community, while 35.4% are in a rural community.

- **1 in 7** Urban Central properties are at or above 200 Bq/m³
- **1 in 5** Rural Central properties are at or above 200 Bq/m³

Central Canadian urban community residential buildings had an average radon level of 72.4 Bq/m³, with 1 in 7 (14.3%) of these properties being at or over 200 Bq/m³, and approximately 1 in 5 (22.6%) being within 100-199 Bq/m³.

Rural communities of Central Canada exhibit a higher average radon level of 85.1 Bq/m³, with almost 1 in 5 (20.2%) properties containing radon levels of 200 Bq/m³ or more, and 1 in 4 (23.6%) being within the 100-199 Bq/m³ range.

Radon across Central Canadian residential building types: In Central Canada, 74.8% of residential buildings are single-detached properties, 15.5% are semi-detached properties, and 9.8% are row (attached) style properties.

- **1 in 5** Central Single-detached properties are at or above 200 Bq/m³
- **1 in 10** Central Semi-detached properties are at or above 200 Bq/m³
- **1 in 15** Central Row-style properties are at or above 200 Bq/m³

Central Canadian single-detached properties have an average radon level of 84.0 Bq/m³, with nearly 1 in 5 (19.0%) at or exceeding 200 Bq/m³. Approximately 1 in 4 (24.6%) of Central Canadian single-detached properties fall within the 100-199 Bq/m³ range.

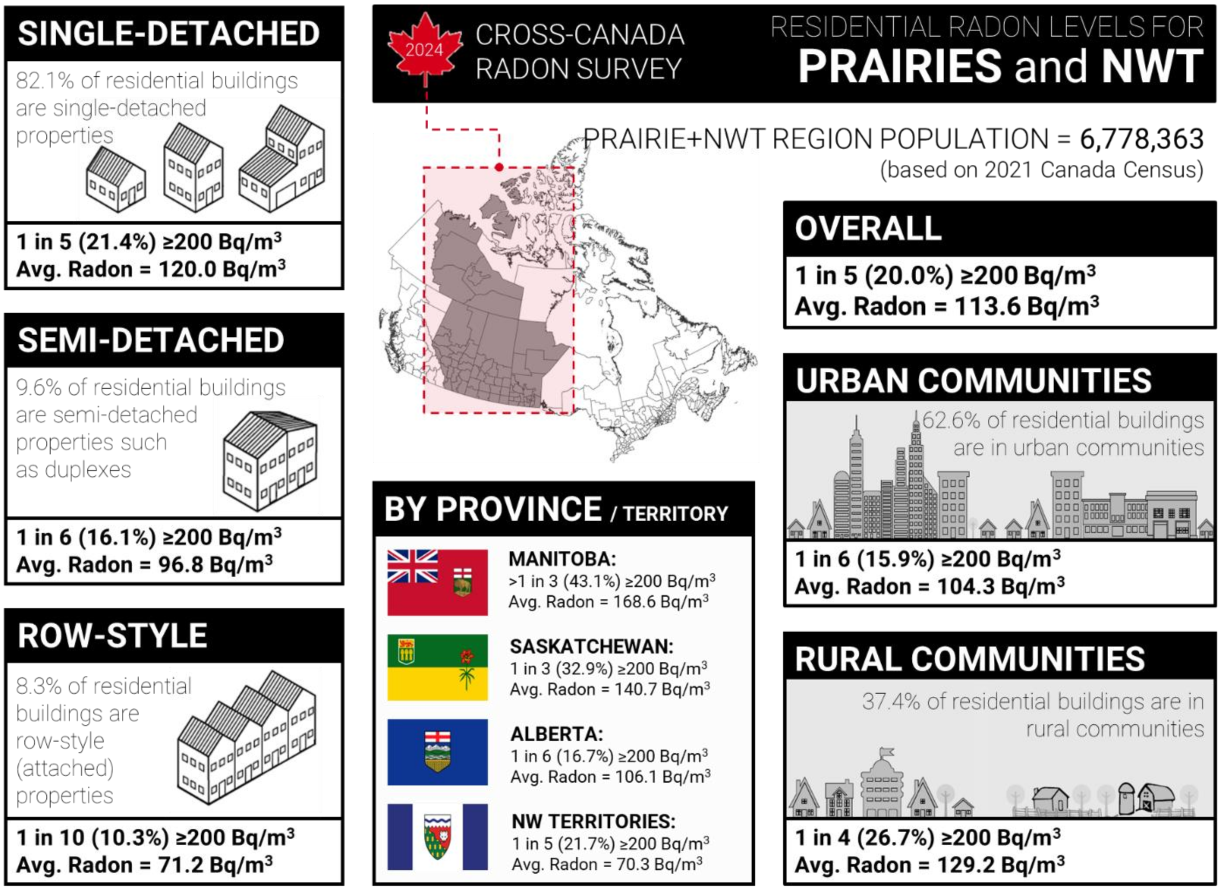
Central Canadian semi-detached properties have an average radon level of 60.2 Bq/m³, with 1 in 10 (9.7%) of these properties being at or over 200 Bq/m³. Approximately 1 in 5 (19.7%) of Central Canadian semi-detached properties are between 100-199 Bq/m³.

Central Canadian row (attached) properties have an average radon level of 48.9 Bq/m³, with 1 in 15 (6.6%) being at or over 200 Bq/m³. Approximately 1 in 7 (15.0%) have radon levels within 100-199 Bq/m³.

IN SUMMARY, the residential radon statistics of Ontario and Quebec in Central Canada highlight significant variations based on community setting and housing type. Central Canadian rural area properties follow the national trend of having a higher indoor radon when compared to more urban communities. Similarly, Central Canadian single-detached properties contain higher radon than semi-detached, which are higher than row (attached) residential houses. ***The Central Canadian region has lower residential radon concentrations relative to the Atlantic, Prairie, or Pacific Interior regions of Canada. However, with 1 in 6 properties still at or above 200 Bq/m³, radon testing is still strongly advised.***

VIII. RADON LEVELS IN THE CANADIAN PRAIRIES and NW TERRITORIES

The Prairie Canada and the Northwest Territory Region encompasses the provinces of Alberta (AB, pop. 4,262,635), Manitoba (MB, pop. 1,342,153), Saskatchewan (SK, pop. 1,132,505), and the Northwest Territories (NT or NWT, pop. 41,070), and contains 20% of all Canadian residential building types reported in this study.



Collectively, 1 in 5 (20.0%) of Prairie and NWT Region households contain radon levels at or above 200 Bq/m^3, with an average radon level of 113.6 Bq/m³. In total, 37.2% of Prairie and NWT Canadian residential properties contained radon in the 100-199 Bq/m³ range.

FOR PROVINCES and the TERRITORY in this regional group, we find that radon levels in residential buildings are all considered high but are somewhat divergent from one another, with geometric mean radon levels ranging from 70.3 Bq/m^3 in NWT (unweighted value), to 106.1 Bq/m^3 in AB (weighted value), to 140.7 Bq/m^3 in SK (unweighted value), and 168.6 Bq/m^3 in MB (unweighted value). The likelihood of a building containing at or over 200 Bq/m³ ranges between just over 1 in 6 (16.7%) for AB (weighted value), to 1 in 5 for NWT (unweighted value), to approximately 1 in 3 for SK and MB (unweighted values). ***Please note, we aim to report fully weighted radon outcomes for <u>all</u> Canadian provinces in a future update to this report.***

Radon across Prairie and NWT Canadian Urban-to-Rural Communities: In Prairie and NWT Canada, 62.6% of residential buildings are in an urban community, while 37.4% are in a rural community.

- **1 in 6** Urban Prairie and NWT properties are at or above 200 Bq/m^3
- **1 in 4** Rural Prairie and NWT properties are at or above 200 Bq/m^3

Prairie and NWT Canadian urban community residential buildings had an average radon level of 104.3 Bq/m^3, with 1 in 6 (15.9%) of these properties being at or over 200 Bq/m^3, and approximately 1 in 3 (37.5%) being within 100-199 Bq/m^3.

Relative to these already high urban radon levels, rural Prairie and NWT Canada communities exhibit a higher average radon level of 129.2 Bq/m^3, with 1 in 4 (26.7%) properties containing radon levels of 200 Bq/m^3 or more, and 1 in 3 (36.6%) being within the 100-199 Bq/m^3 range.

Radon across Prairie and NWT Canadian residential building types: In Prairie and NWT Canada, 82.1% of residential buildings are single-detached properties, 9.6% are semi-detached properties, and 8.3% are row (attached) style properties.

- **1 in 5** Prairie and NWT Single-detached properties are at or above 200 Bq/m^3
- **1 in 6** Prairie and NWT Semi-detached properties are at or above 200 Bq/m^3
- **1 in 10** Prairie and NWT Row-style properties are at or above 200 Bq/m^3

Prairie and NWT Canadian single-detached properties have an average radon level of 120.0 Bq/m^3, with 1 in 5 (21.4%) at or exceeding 200 Bq/m^3. Just over 1 in 3 (38.8%) of Prairie and NWT Canadian single-detached properties fall within the 100-199 Bq/m^3 range.

Prairie and NWT Canadian semi-detached properties have an average radon level of 96.8 Bq/m^3, with 1 in 6 (16.1%) of these properties being at or over 200 Bq/m^3. Approximately 1 in 3 (34.2%) of Prairie and NWT Canadian semi-detached properties are between 100-199 Bq/m^3.

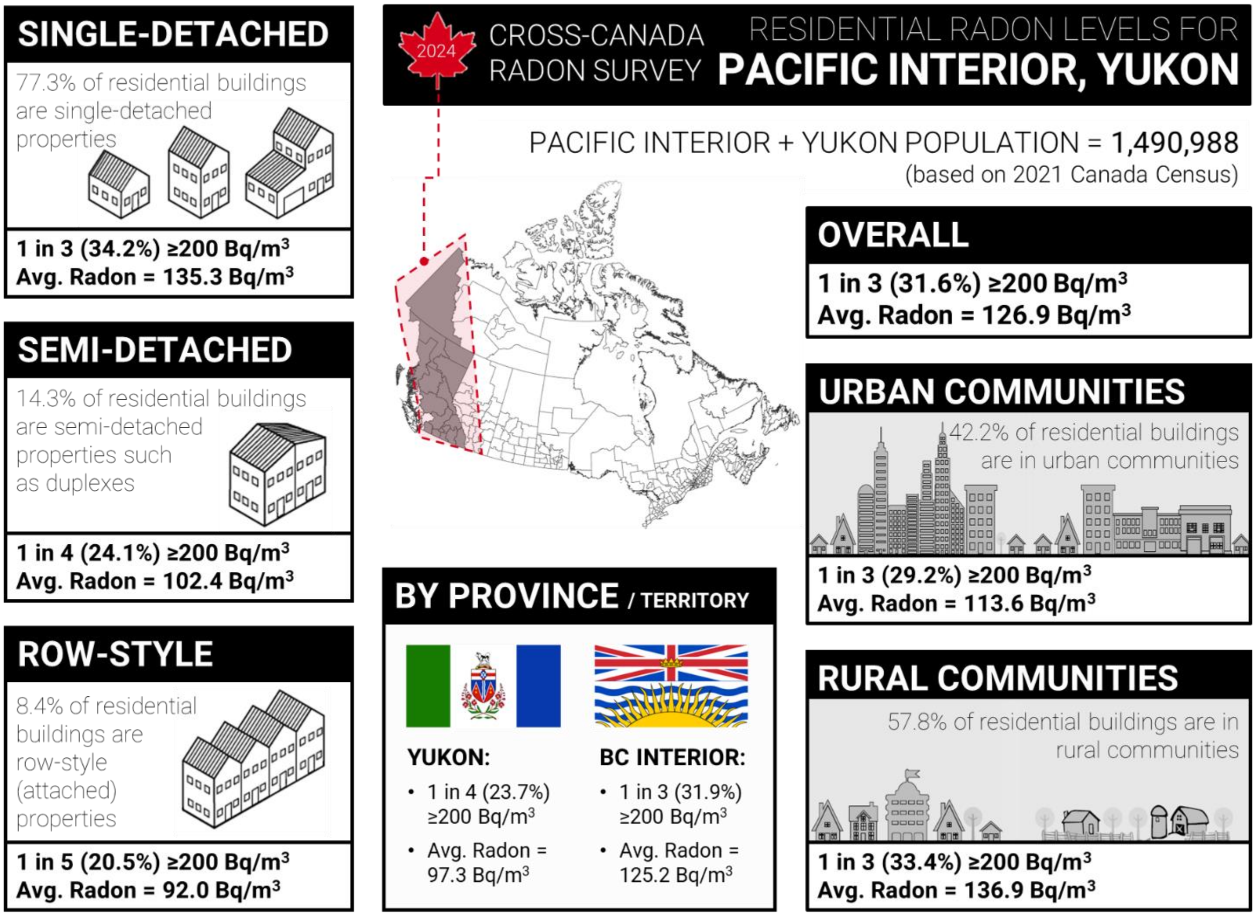
Prairie and NWT Canadian row (attached) properties have an average radon level of 71.2 Bq/m^3, with 1 in 10 (10.3%) being at or over 200 Bq/m^3. Approximately 1 in 4 (24.8%) have radon levels within 100-199 Bq/m^3.

IN SUMMARY, the residential radon statistics of Alberta, Saskatchewan, Manitoba, and the Northwest Territories highlight significant variations based on community setting and housing type. The region follows national trends of having a higher rural area radon when compared to more urban communities. Similarly, Prairie and NWT region single-detached properties contain higher radon than semi-detached, which are higher than row (attached) residential houses. ***Prairie and NWT Canadian residential radon levels are amongst the highest observed for any geographic area. Radon testing and effective mitigation systems should be considered a high priority.***

NOTE: Please also see Section XIII.1 of this report, for an analysis of radon outcomes from the Northwest Territories in the context of Northern Canada, separately from the Prairie Region.

IX. RADON LEVELS IN THE CANADIAN PACIFIC INTERIOR and YUKON

The Pacific Interior and Yukon Region encompasses Northern and Interior British Columbia, eastern Fraser Valley from Chilliwack onwards (estimated pop. 1,450,756), and Yukon Territory (YT, pop. 40,232), and contains 4% of all Canadian residential building types reported on in this study.



Collectively, 1 in 3 (31.6%) of Pacific Interior and Yukon Region households contain radon levels at or above 200 Bq/m³, with an average radon level of 126.9 Bq/m³, the highest level observed for all regions of Canada we examined. In total, 28.3% of Pacific Interior and Yukon Canadian residential properties contained radon in the 100-199 Bq/m³ range.

For the PROVINCIAL sub-region and the TERRITORY in this regional group, we find that radon levels in residential buildings are all considered high and comparable to one another, with geometric mean radon level being 97.3 Bq/m³ in YT (weighted value), to 125.2 Bq/m³ in the BC Interior (weighted value). The likelihood of a building containing at or over 200 Bq/m³ ranges between just over 1 in 4 (23.7%) for YT (weighted value) and 1 in 3 for the BC Interior (weighted value). Please also see Section XIII.1 of this report for an analysis of radon outcomes from the Yukon Territory in the context of Northern Canada separately from the BC Interior Region.

Radon across* Pacific Interior and Yukon *Canadian Urban-to-Rural Communities: In the Pacific Interior and Yukon, 42.2% of residential buildings are in an urban community, while 57.8% are in a rural community.

- **1 in 3** Urban Pacific Interior + YT properties are at or above 200 Bq/m^3
- **1 in 3** Rural Pacific Interior + YT properties are at or above 200 Bq/m^3

Pacific Interior and Yukon urban community residential buildings had an average radon level of 113.6 Bq/m^3, with nearly 1 in 3 (29.2%) of these properties equal to or over 200 Bq/m^3, and approximately 1 in 4 (26.4%) being within 100-199 Bq/m^3.

Relative to these already high urban radon levels, rural Pacific Interior and Yukon communities exhibit a higher average radon level of 136.9 Bq/m^3, with 1 in 3 (33.4%) properties containing radon levels of 200 Bq/m^3 or more, and almost 1 in 3 (29.7%) being within the 100-199 Bq/m^3 range.

Radon across Pacific Interior and Yukon residential building types: In Pacific Interior and Yukon, 77.3% of residential buildings are single-detached properties, 14.3% are semi-detached properties, and 8.4% are row (attached) style properties.

- **1 in 3** Pacific Interior + YT Single-detached properties are at or above 200 Bq/m^3
- **1 in 4** Pacific Interior + YT Semi-detached properties are at or above 200 Bq/m^3
- **1 in 5** Pacific Interior + YT Row-style properties are at or above 200 Bq/m^3

Pacific Interior and Yukon single-detached properties have an average radon level of 135.3 Bq/m^3, with 1 in 3 (34.2%) at or exceeding 200 Bq/m^3. Approximately 1 in 4 (28.3%) of Pacific Interior and Yukon single-detached properties fall within the 100-199 Bq/m^3 range.

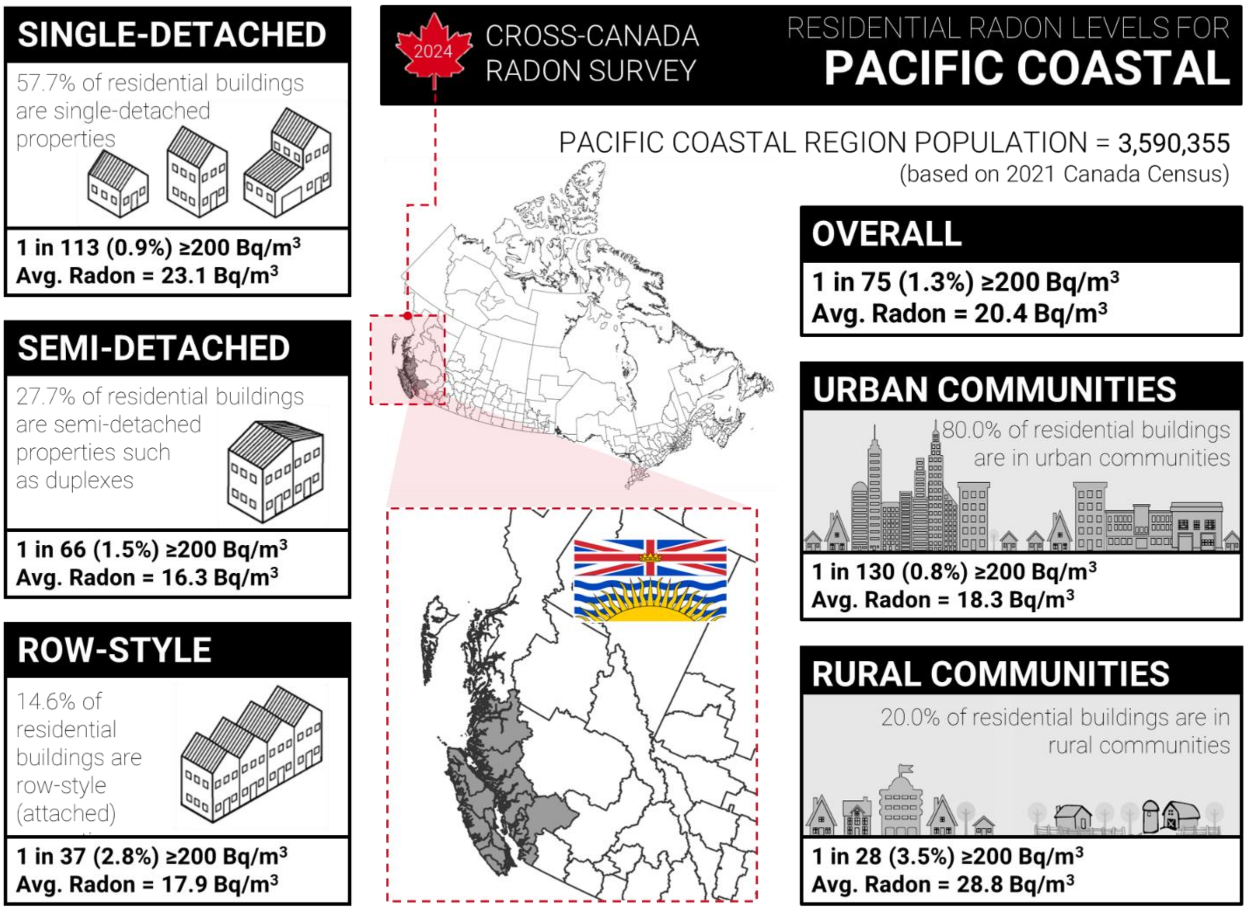
Pacific Interior and Yukon semi-detached properties have an average radon level of 102.4 Bq/m^3, with 1 in 4 (24.1%) of these properties being at or over 200 Bq/m^3. Nearly 1 in 3 (29.6%) of Pacific Interior and Yukon semi-detached properties are between 100-199 Bq/m^3.

Pacific Interior and Yukon row (attached) properties have an average radon level of 92.0 Bq/m^3, with 1 in 5 (20.5%) being at or over 200 Bq/m^3. Approximately 1 in 4 (26.2%) have radon levels within 100-199 Bq/m^3.

IN SUMMARY, the residential radon statistics of northern and interior British Columbia, Chilliwack and more eastern communities in the Fraser Valley, as well as Yukon Territory, highlight significant variations based on community setting and housing type. The region reflects national trends with higher radon levels in rural areas when compared to more urban communities. Similarly, single-detached properties in this region contain higher radon levels than semi-detached, which are higher than row (attached) residential houses. ***Pacific Interior and Yukon residential radon levels are the highest observed nationally. Therefore, radon testing and effective mitigation systems should be considered a high priority.***

X. RADON LEVELS IN PACIFIC COASTAL CANADA

The Pacific Coastal Canadian Region (estimated pop. 3,590,355) encompasses Vancouver Island, the Sea-to-Sky Corridor, the Sunshine Coast, the northern BC coast, Lower Mainland and western Fraser Valley up to but not including Chilliwack, and contains 9% of all Canadian residential building types reported on in this study.



Collectively, 1 in 75 (1.3%) of Pacific Coastal Canadian households contain radon levels at or above 200 Bq/m^3, with an average radon level of 20.4 Bq/m^3, the lowest level observed for all regions of Canada we examined. In total, 3.7% of Pacific Coastal Canadian residential properties contained radon in the 100-199 Bq/m^3 range.

Radon across Pacific Coastal Canadian Urban-to-Rural Communities: In Prairie and NWT Canada, 80.0% of residential buildings are in an urban community, while 20.0% are in a rural community.

- **1 in 130** Urban Pacific Coastal properties are at or above 200 Bq/m^3
- **1 in 28** Rural Pacific Coastal properties are at or above 200 Bq/m^3

Pacific Coastal Canadian urban community residential buildings had an average radon level of 18.3 Bq/m^3, with 1 in 130 (0.8%) of these properties being at or over 200 Bq/m^3, and approximately 1 in 48 (2.1%) being within 100-199 Bq/m^3.

Relative to urban radon levels, rural Pacific Coastal Canadian communities exhibit a higher average radon level of 28.8 Bq/m³, with 1 in 28 (3.5%) properties containing radon levels of 200 Bq/m³ or more, and 1 in 10 (10.2%) being within the 100-199 Bq/m³ range.

Radon across Pacific Coastal Canadian residential building types: In Pacific Coastal Canada, 57.7% of residential buildings are single-detached properties, 27.7% are semi-detached properties, and 14.6% are row (attached) style properties

- **1 in 113** Pacific Coastal Single-detached properties are at or above 200 Bq/m^3
- **1 in 66** Pacific Coastal Semi-detached properties are at or above 200 Bq/m^3
- **1 in 36** Pacific Coastal Row-style properties are at or above 200 Bq/m^3

Pacific Coastal Canadian single-detached properties have an average radon level of 23.1 Bq/m³, with 1 in 113 (0.9%) at or exceeding 200 Bq/m³. Approximately 1 in 20 (5.1%) of Pacific Coastal Canadian single-detached properties fall within the 100-199 Bq/m³ range.

Pacific Coastal Canadian semi-detached properties have an average radon level of 16.3 Bq/m³, with 1 in 66 (1.5%) of these properties being at or over 200 Bq/m³. Approximately 1 in 50 (2.0%) of Pacific Coastal Canadian semi-detached properties are between 100-199 Bq/m³.

Pacific Coastal Canadian row (attached) properties have an average radon level of 17.9 Bq/m³, with 1 in 37 (2.8%) being at or over 200 Bq/m³. Approximately 1 in 62 (1.6%) have radon levels within 100-199 Bq/m³.

IN SUMMARY, the residential radon statistics of Pacific Coastal Canada, including the Lower Mainland, and Vancouver Island, show generally low residential radon levels compared to the rest of British Columbia and Canada in general. Similar to the rest of Canada, there are significant variations based on community setting and housing type, and the region follows national trends of having higher rural indoor radon concentrations versus more urban communities. ***While radon levels in Pacific Coastal Canada are lower on average versus other regions, this area is by no means free of risk, and residents should still be aware of potential exposure and test for radon, especially those in rural communities.***

XI. RADON LEVELS IN CANADA'S SIX LARGEST (pop. >1M) CITIES

In this section, we compile data on average household radon levels across the six Canadian metropolitan areas with populations of at least 1 million. Collectively, these six urban areas are home to 17.52 million residents of Canada, or nearly half of the entire population.

The information below is ranked in order of largest to smallest population and encompasses the broader census metropolitan areas (that is, the city itself and surrounding commuter towns) as defined within the 2021 Canada Census.

Table of Metropolitan Areas with Census Weighted Radon Outcomes

Census Metro Area Name	City Population in Census 2021	Approximate number of properties with available radon data	1 in X houses (%) are in this radon exposure category			UNWEIGHTED Geometric Mean Radon Level (Bq/m^3) (based on raw values)	Maximum Observed Radon Level to Date (Bq/m^3)	WEIGHTED Geometric Mean Radon Level (Bq/m^3) (balanced by building type)
Toronto Metro Area	6,202,225	750-799	(4 in 5) 1 in 8 1 in 22	83.3% 12.2% 4.5%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	44.3	1,013	**43.0**
Montréal Metro Area	4,291,732	2,500+	1 in 2 1 in 4 1 in 6	54.7% 28.0% 17.4%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	88.7	14,652	**82.4**
Vancouver Metro Area	2,642,825	1,000-1,499	(9 in 10) 1 in 35 1 in 113	96.3% 2.8% 0.9%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	18.3	624	**17.1**
Ottawa-Gatineau Metro Area	1,488,307	2,000-2,499	1 in 2 1 in 4 1 in 6	58.4% 24.6% 17.0%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	83.9	3,165	**85.9**
Calgary Metro Area	1,481,806	2,500+	1 in 2 1 in 3 1 in 6	47.6% 36.9% 15.5%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	100.7	3,872	**102.5**
Edmonton Metro Area	1,418,118	2,500+	1 in 2 1 in 3 1 in 6	44.6% 39.2% 16.2%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	108.6	1,493	**106.4**

Toronto, Ontario, with a population of approximately 6.2 million, is the largest Canadian metropolitan area. The average radon level for a Toronto area residential building is 43.0 Bq/m^3. 1 in 22 (4.5%) of houses exceeded 200 Bq/m^3, while 12.2% are between 100 and 199 Bq/m^3.

- **1 in 22** properties in the Toronto Metro Area are at or above 200 Bq/m^3

Montréal, Quebec, with a population of approximately 4.3 million, is the second-largest Canadian metropolitan area. The average radon level for a Montréal area residential building is 82.4 Bq/m^3. 1 in 6 (17.4%) of houses was at or exceeded 200 Bq/m^3, while 28.0% were between 100 and 199 Bq/m^3.

- **1 in 6** properties in the Montréal Metro Area are at or above 200 Bq/m^3

Vancouver, British Columbia, with a population of approximately 2.6 million, is the third-largest Canadian metropolitan area. The average radon level for a Vancouver area residential building is 17.1 Bq/m^3. 1 in 113 (0.9%) of houses were at or exceeded 200 Bq/m^3, while 2.8% are between 100 and 199 Bq/m^3.

- **1 in 113** properties in the Vancouver Metro Area are at or above 200 Bq/m^3

Ottawa–Gatineau, Ontario, with a population of approximately 1.5 million, is the fourth-largest Canadian metropolitan area and the national capital. The average radon level for an Ottawa–Gatineau area residential building is 85.9 Bq/m³. Just over 1 in 6 (17.0%) of houses were at or exceeded 200 Bq/m³, while 24.6% are between 100 and 199 Bq/m³.

- **More than 1 in 6** properties in the Ottawa–Gatineau Metro Area are at or above 200 Bq/m^3

Calgary, Alberta, with a population of approximately 1.5 million, is the fifth-largest Canadian metropolitan area. The average radon level for a Calgary area residential building is 102.5 Bq/m³. 1 in 6 (15.5%) of houses were at or exceeded 200 Bq/m³, while 36.9% are between 100 and 199 Bq/m³.

- **1 in 6** properties in the Calgary Metro Area are at or above 200 Bq/m^3

Edmonton, Alberta, with a population of approximately 1.4 million, is the sixth-largest Canadian metropolitan area. The average radon level for an Edmonton area residential building is 106.4 Bq/m³. 1 in 6 (16.2%) of houses were at or exceeded 200 Bq/m³, while 39.2% are between 100 and 199 Bq/m³.

- **More than 1 in 6** properties in the Edmonton Metro Area are at or above 200 Bq/m^3

IN SUMMARY, the greatest average residential radon levels of the six largest Canadian metropolitan areas are observed in the Prairie cities of Edmonton and Calgary, with substantial levels also occurring in Montréal and Ottawa. Houses in the Toronto metro area, while displaying lower overall radon levels compared to Edmonton, Calgary, Montréal and Ottawa, still carry notable risks. Fitting with the overall regional trends for the Pacific Coastal area of Canada, radon levels in the Vancouver metro area are much lower relative to the other large cities. However, they are still at risk, and residents are therefore encouraged to test for radon.

BOX #9. Don't let your brain fool you! Many people experience optimism-bias when confronted by something concerning such as radon-induced lung cancer, and our brains naturally downplay risks in our minds. While this is very normal, optimism bias can sometimes mean that we ignore real problems. So, just because a given city has lower than average radon levels, that does not mean it is free from radon risk.

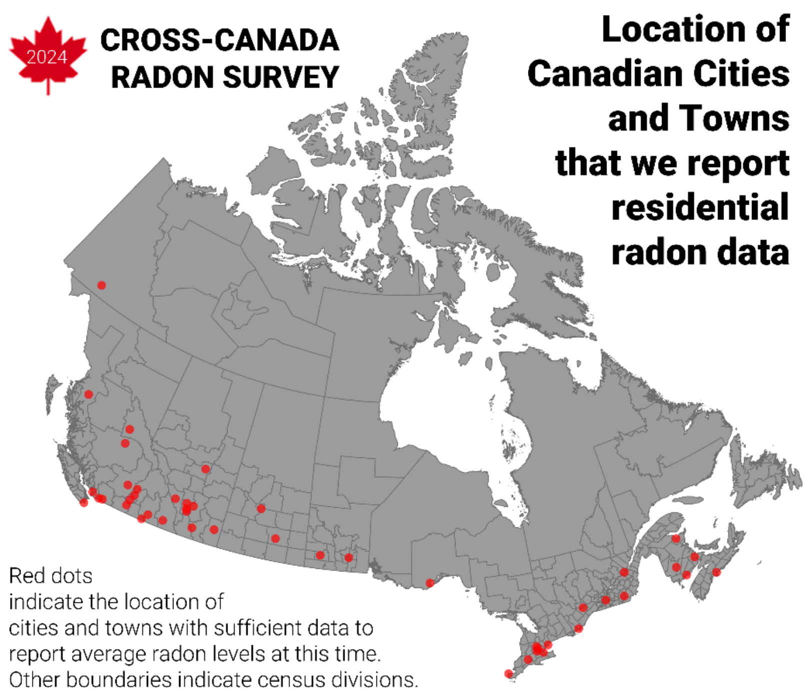
For example, when compared to Calgary or Montreal, the cities of Toronto and Vancouver have lower average levels of household radon, at 43.0 Bq/m³ and 17.1 Bq/m³ respectively. However, it is important to recognize that there are people living in those cities whose houses contain as high as 1,013 Bq/m³ in Toronto and 624 Bq/m³ in Vancouver – extremely elevated radon levels that are associated with substantially increased risk of lung cancer.

So, while the data in this report helps us all understand the scope of radon exposure for large populations, these numbers cannot tell you if you are at risk in your own home, the only way to know that is to conduct a long-term (90-day or more) test for radon where you live.

XII. RADON LEVELS IN OTHER MAJOR CANADIAN MUNICIPALITIES

In this section, we examine radon in 41 Canadian municipalities whose populations range from just under 15,000 to 999,999 people according to the most recent (2021) census conducted by Statistics Canada, *for which we had enough data to draw conclusions*. The location of these municipalities is shown in the map below.

The 2024 report includes radon information for 7 in 10 of all cities in Canada whose population exceeds 100,000 people, and half (54.8%) of all municipalities with populations greater than 50,000 people. ***We emphasize that we aim to report on as many additional cities and towns (census metropolitan areas) as possible, in near-future updates of this survey.***



Please note that the radon results we obtained for some of these towns and cities did not have sufficiently detailed information about building design type or the exact postal address to allow us to assign a precise house- and/or community-type coding. Therefore, in the table below, we will present two sets of data for average household radon:

BOX #10. Why is the weighted value for average radon levels different from the raw data? The ability to weight average radon levels can, in some cases, significantly increase or decrease the overall average household radon level for a region or city.

For example, applying weights to balance data appropriately to reflect the actual community and building design type distribution for Prince George, BC produces an 18% increase in average levels of radon relative to a simple average of the raw readings, while for Kelowna, BC weighting produces a 15.4% decrease in levels of radon.

Weighted averages account for differences in population size, geographic distribution, or sample representation, making them a more reliable indication of radon exposure for a given group of houses than the 'raw', unweighted averages.

As a result, unweighted averages can sometimes be misleading when the raw data does not accurately reflect the characteristics of the population being studied, and the reader should have this caution in mind as they interpret information.

- For cities and towns where we had sufficient data to apply weighting, we report the **weighted average radon** level that is considered representative of the distribution of house and community types in that area based on the current census outcomes. For comparison, we also show the average (geometric mean) radon level that is obtained from the unweighted data.

- For all cities and towns where we are not (yet) able to apply weighting to calculate a balanced average (geometric mean) radon level, we report the **unweighted average radon** level obtained from the 'raw' data in order to provide a far larger number of Canadians with a more localized idea of residential radon exposure within their municipality.

IMPORTANT: Readers are advised to consider that all unweighted values may increase or decrease somewhat once appropriately weighted to reflect the actual distribution of housing in their community. We also note that the real differences between weighted and unweighted average radon levels emphasize the need to capture additional housing and community type metrics associated to enable radon levels for all Canadian cities to be re-weighted into the most representative value possible. As indicated earlier, we have sufficient data for 70% of all Canadian cities, which are defined formally by Statistics Canada as census metropolitan areas with populations exceeding 100,000 people. To increase the scope of the next update to this report, the remaining 30% of cities where additional radon testing is required in the near future are, in order of population size: St. Catharines-Niagara (ON), Oshawa (ON), Barrie (ON), St. John's (NL), Greater Sudbury (ON), Saguenay (QC), Trois-Rivières (QC), Brantford (ON), Peterborough (ON), Nanaimo (BC), Belleville - Quinte West (ON), Chatham-Kent (ON), and Drummondville (QC).

IN SUMMARY, high radon levels are observed across a large number of Canadian municipalities. A number of cities and towns that have particularly elevated average residential radon levels, where at least one-quarter to one-half of residences have indoor radon levels at or above 200 Bq/m^3. These eighteen municipalities include (in west-to-east order):

- Whitehorse (YT)
- Nelson (BC)
- Kelowna (BC)
- Prince George (BC)
- Vernon (BC)
- Penticton (BC)
- Trail (BC)
- High River (AB)
- Okotoks (AB)
- Strathmore (AB)
- Regina (SK)
- Brandon (MB)
- Winnipeg (MB)
- Thunder Bay (ON)
- Kingston (ON)
- Sherbrooke (QC)
- Bathurst (NB)
- Halifax (NS)

These outcomes highlight the need for households to strongly consider doing a radon test; it is the only way to know. ***Most importantly, we remind the reader that high indoor radon is a solvable problem (via professionally-installed mitigation), that can significantly reduce your risk of lung cancer. Some amount of radon is found in every house in Canada. Having high radon and obtaining a mitigation does not negatively impact your property value - indeed, reducing radon makes for a healthier home, and is of value.***

Table 1: Canadian Cities (pop. <1M) with Weighted and Unweighted Radon Averages

Census Metro Area Name	City Population in Census 2021	Approximate number of properties with available radon data	1 in X houses (%) are in this radon exposure category			UNWEIGHTED Geometric Mean Radon Level (Bq/m^3) (based on raw values)	Maximum Observed Radon Level to Date (Bq/m^3)	WEIGHTED Geometric Mean Radon Level (Bq/m^3) (balanced by building type)
Quebec, QC	839,211	1,000-1,499	1 in 2 1 in 5 1 in 5	61.2% 20.7% 18.1%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	73.1	1,443	**72.2**
Winnipeg, MB	834,678	400-499	1 in 3 1 in 3 1 in 3	30.8% 31.9% 37.4%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	139.7	1,362	Insufficient information associated with results to apply weighting at this time.
Hamilton, ON	785,184	1000-1499	(2 in 3) 1 in 5 1 in 8	67.5% 20.5% 12.0%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	71.1	2,473	Insufficient information associated with results to apply weighting at this time.
Kitchener-Cambridge, ON	575,847	200-299	1 in 2 1 in 4 1 in 10	62.6% 27.2% 10.2%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	73.1	1,009	Insufficient information associated with results to apply weighting at this time.
London, ON	543,551	300-399	(3 in 4) 1 in 4 1 in 29	75.2% 21.3% 3.5%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	61.5	664	Insufficient information associated with results to apply weighting at this time.
Halifax, NS	465,703	2,500+	1 in 3 1 in 4 1 in 3	38.0% 23.2% 38.7%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	135.7	5,632	**134.8**
Windsor, ON	422,630	100-199	1 in 2 1 in 3 1 in 7	52.4% 33.1% 14.5%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	99.3	548	Insufficient information associated with results to apply weighting at this time.
Victoria, BC	397,237	750-999	(9 in 10) 1 in 25 1 in 200	95.6% 4.0% 0.5%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	22.4	355	**26.0**
Saskatoon, SK	317,480	600-699	1 in 3 1 in 2 1 in 6	37.9% 44.3% 17.8%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	107.2	820	Insufficient information associated with results to apply weighting at this time.
Regina, SK	249,217	750-999	1 in 5 1 in 3 1 in 2	22.8% 30.7% 46.6%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	182.7	11,333	Insufficient information associated with results to apply weighting at this time.
Sherbrooke, QC	227,398	100-199	1 in 2 1 in 5 1 in 4	56.5% 18.6% 24.9%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	91.8	1,066	Insufficient information associated with results to apply weighting at this time.
Kelowna, BC	222,162	2,500+	1 in 2 1 in 3 1 in 3	40.4% 31.1% 28.5%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	120.8	5,073	**102.2**
Abbotsford - Mission, BC	195,726	200-299	(4 in 5) 1 in 9 1 in 29	85.7% 10.9% 3.4%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	40.0	451	Insufficient information associated with results to apply weighting at this time.
Kingston, ON	172,546	100-199	1 in 2 1 in 4 1 in 4	50.5% 25.8% 23.7%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	76.6	847	Insufficient information associated with results to apply weighting at this time.
Guelph, ON	165,588	600-699	1 in 2 1 in 4 1 in 7	60.2% 26.3% 13.5%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	72.4	801	**83.2**
Moncton, NB	157,717	400-499	(3 in 4) 1 in 5 1 in 12	70.7% 21.2% 8.1%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	62.8	1,256	**60.1**
Saint John, NB	130,613	300-399	1 in 12 1 in 4 1 in 5	58.6% 23.1% 18.4%	< 100 Bq/m3 100-199 Bq/m3 ≥ 200 Bq/m3	86.2	1,221	Insufficient information associated with results to apply weighting at this time.
Lethbridge, AB	123,847	300-399	1 in 2 1 in 2 1 in 6	40.4% 42.8% 16.8%	< 100 Bq/m3 100-199 Bq/m3 ≥ 200 Bq/m3	110.7	1,959	Insufficient information associated with results to apply weighting at this time.
Thunder Bay, ON	123,258	750-999	1 in 3 1 in 3 1 in 3	34.9% 30.8% 34.3%	< 100 Bq/m3 100-199 Bq/m3 ≥ 200 Bq/m3	130.1	32,321	Insufficient information associated with results to apply weighting at this time.
Kamloops, BC	114,142	300-399	(3 in 4) 1 in 8 1 in 11	77.4% 13.1% 9.5%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	61.3	1,021	**58.5**

Table 2: Canadian Cities (pop. <1M) with Weighted and Unweighted Radon Averages

Census Metro Area Name	City Population in Census 2021	Approximate number of properties with available radon data	1 in X houses (%) are in this radon exposure category			UNWEIGHTED Geometric Mean Radon Level (Bq/m^3) (based on raw values)	Maximum Observed Radon Level to Date (Bq/m^3)	WEIGHTED Geometric Mean Radon Level (Bq/m^3) (balanced by building type)
Chilliwack, BC	113,767	400-499	(3 in 4) 1 in 5 1 in 12	71.0% 20.6% 8.4%	< 100 Bq/m3 100-199 Bq/m3 ≥ 200 Bq/m3	61.9	3,250	Insufficient information associated with results to apply weighting at this time.
Fredericton, NB	108,610	500-599	1 in 2 1 in 4 1 in 5	53.3% 28.1% 18.5%	< 100 Bq/m3 100-199 Bq/m3 ≥ 200 Bq/m3	91.9	1,254	Insufficient information associated with results to apply weighting at this time.
Red Deer, AB	100,844	200-299	1 in 2 1 in 3 1 in 7	52.7% 32.2% 15.1%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	95.3	673	**97.1**
Prince George, BC	89,490	2,500+	1 in 2 1 in 4 1 in 3	44.6% 23.9% 31.5%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	112.3	5,446	**132.5**
Medicine Hat, AB	76,376	100-199	1 in 2 1 in 3 1 in 9	57.3% 31.6% 11.1%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	92.0	508	Insufficient information associated with results to apply weighting at this time.
Vernon, BC	67,086	750-799	1 in 3 1 in 3 1 in 3	37.9% 31.4% 30.7%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	128.6	4,356	**149.5**
Brandon, MB	54,268	50-99	1 in 3 1 in 3 1 in 3	31.3% 32.5% 36.1%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	147.0	559	Insufficient information associated with results to apply weighting at this time.
Penticton, BC	47,380	300-399	1 in 2 1 in 4 1 in 4	47.7% 26.4% 25.9%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	106.1	3,262	Insufficient information associated with results to apply weighting at this time.
Whitehorse, YK	31,913	750-999	1 in 2 1 in 4 1 in 4	45.9% 26.3% 27.8%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	111.5	3,364	**101.1**
Bathurst, NB	31,387	100-199	1 in 3 1 in 4 1 in 2	30.7% 23.5% 45.8%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	167.3	1,296	Insufficient information associated with results to apply weighting at this time.
Centre Wellington, ON	31,093	100-199	(3 in 4) 1 in 5 1 in 13	70.3% 21.7% 8.0%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	64.1	514	Insufficient information associated with results to apply weighting at this time.
Okotoks, AB	30,405	300-399	1 in 3 1 in 3 1 in 3	31.2% 38.3% 30.4%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	128.3	4,852	Insufficient information associated with results to apply weighting at this time.
Cranbrook, BC	27,040	200-299	(3 in 4) 1 in 6 1 in 11	74.8% 16.1% 9.1%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	58.4	1,005	Insufficient information associated with results to apply weighting at this time.
Quesnel, BC	23,113	100-199	(3 in 4) 1 in 6 1 in 17	76.8% 17.4% 5.8%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	59.3	825	Insufficient information associated with results to apply weighting at this time.
Salmon Arm, BC	19,705	200-299	1 in 2 1 in 3 1 in 7	49.0% 36.0% 15.0%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	98.5	622	Insufficient information associated with results to apply weighting at this time.
Terrace, BC	19,606	100-199	(3 in 4) 1 in 6 1 in 13	76.0% 16.2% 7.8%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	49.4	1,052	Insufficient information associated with results to apply weighting at this time.
Nelson, BC	19,119	750-999	1 in 3 1 in 4 1 in 3	37.7% 28.6% 33.7%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	136.5	1,487	Insufficient information associated with results to apply weighting at this time.
Canmore, AB	15,990	100-199	1 in 2 1 in 3 1 in 7	57.2% 28.9% 13.9%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	85.4	571	**85.7**
Strathmore, AB	14,339	50-99	1 in 3 1 in 3 1 in 4	34.8% 37.0% 28.3%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	124.0	1,175	Insufficient information associated with results to apply weighting at this time.
High River, AB	14,324	100-199	1 in 3 1 in 2 1 in 4	29.6% 45.2% 25.3%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	137.5	2,785	**134.8**
Trail, BC	14,268	300-399	1 in 3 1 in 3 1 in 3	31.8% 33.5% 34.7%	< 100 Bq/m^3 100-199 Bq/m^3 ≥ 200 Bq/m^3	149.8	2,009	Insufficient information associated with results to apply weighting at this time.

XIII. SPECIAL CASE-REPORTS

The following section highlights some special cases of interest where we obtained sufficient data for a more focused analysis. These case reports include a more in-depth analysis of:

1. Residential Radon Levels in Multifamily Buildings – Preliminary Outcomes.
2. Radon levels in Northern Canada as a collective whole, acknowledging that this region of Canada is home to peoples with unique communities and experiences.
3. Comparative radon levels across building types between three major cities, including Halifax NS, Montréal QC, and Calgary AB.
4. Trends in changing radon levels as a function of the year that the residential building was constructed.
5. Examining differences in residential radon levels as a function of building floor.

XIII.1. Residential Radon Levels in Multifamily Buildings – Preliminary Outcomes

The data in this report encompasses data from single-detached, semi-detached, and row-style residential properties in which 69.6% of the Canadian population live.

The remaining 30.4% of Canadians live in residential buildings that include multifamily dwellings such as low and high-rise apartments, trailer / mobile houses, cottages, and cabins, each of which has its own unique building design considerations in terms of radon exposure.

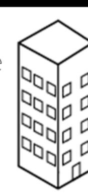
At this time, we have access to only 1,089 radon test outcomes from multifamily dwellings across Canada. These data are from multifamily properties where 63.4% are located in Central Canada, 18% in the BC interior and Yukon, 9.7% in Prairie and NWT, 5.9% in Pacific Coastal Canada, and 3.1% in Atlantic Canada, and so are generally comparable to the current Canadian population distribution. However, at least three-quarters of these buildings are multifamily apartment blocks of fewer than 5 storeys (likely similar to the building in the photograph above), so we emphasize that these preliminary data under-represent high-rise apartment blocks of 5 or more floors.

With these considerations in mind, and in the interests of inclusivity, we report the preliminary finding that approximately 1 in 10 (9.3%) of [the mostly low-rise] multifamily buildings surveyed contain radon that is at or exceeds 200 Bq/m^3, and 1 in 7 (14.3%) record radon levels between 100 and 199 Bq/m^3.

- **1 in 10** multifamily residential properties are at or above 200 Bq/m^3

MULTI-FAMILY

30.4% of residential buildings in Canada are multi-family buildings.



Note: the data below is based mostly on buildings with four or fewer floors.

1 in 10 (9.3%) ≥200 Bq/m^3

We emphasize that better understanding radon exposure in the diverse types of multifamily dwellings that exist in Canada is important work to carry out in the future, especially as these early findings suggest these buildings can have high radon exposure for the people who live in them.

XIII.2. Special Region Overview – Residential Radon of the Canadian North

The North is an area of special interest in Canada due to its unique communities, peoples, climate, and built environment that spans the Arctic and near-Arctic regions. It is home to 0.3% of the Canadian population (pop. 0.12 million).

For the many residential buildings in Northern communities that have always existed on ground not subject to permafrost, radon risks may be comparable to other areas of Canada – that is to say, potentially very high. In other communities of the Canadian North, permafrost (ground that remains frozen for at least two sequential years) is thought to act as a barrier to the movement of underground gases, including radon. In areas with still-undisturbed permafrost, radon gas movement toward the surface may be slowed, meaning that indoor air radon levels may be substantially lower. Further, the need for buildings resting on permafrost to be built on piles or stilts (common in this region) often separates regional residences from the ground in such a way that they are unlikely to experience increased indoor radon at all. However, as climate change disrupts Canada's permafrost, previously hindered radon gas can start to gain better entry to the surface, while also compromising the structural integrity of buildings otherwise designed to exist on frozen ground. Scientists are currently speculating that many Northern communities maybe – some for the first time – experiencing increased radon exposure.

Here, we provide regional radon outcomes for parts of Northern Canada, specifically the Northwest Territories (NT or NWT, pop. 41,070) and Yukon Territory (YT, pop. 40,232). As indicated earlier, at this time, we do not have access to indoor air radon information from the province of Nunavut, and we reiterate that there is a near-term need to investigate residential radon levels in this province in partnership with local communities.

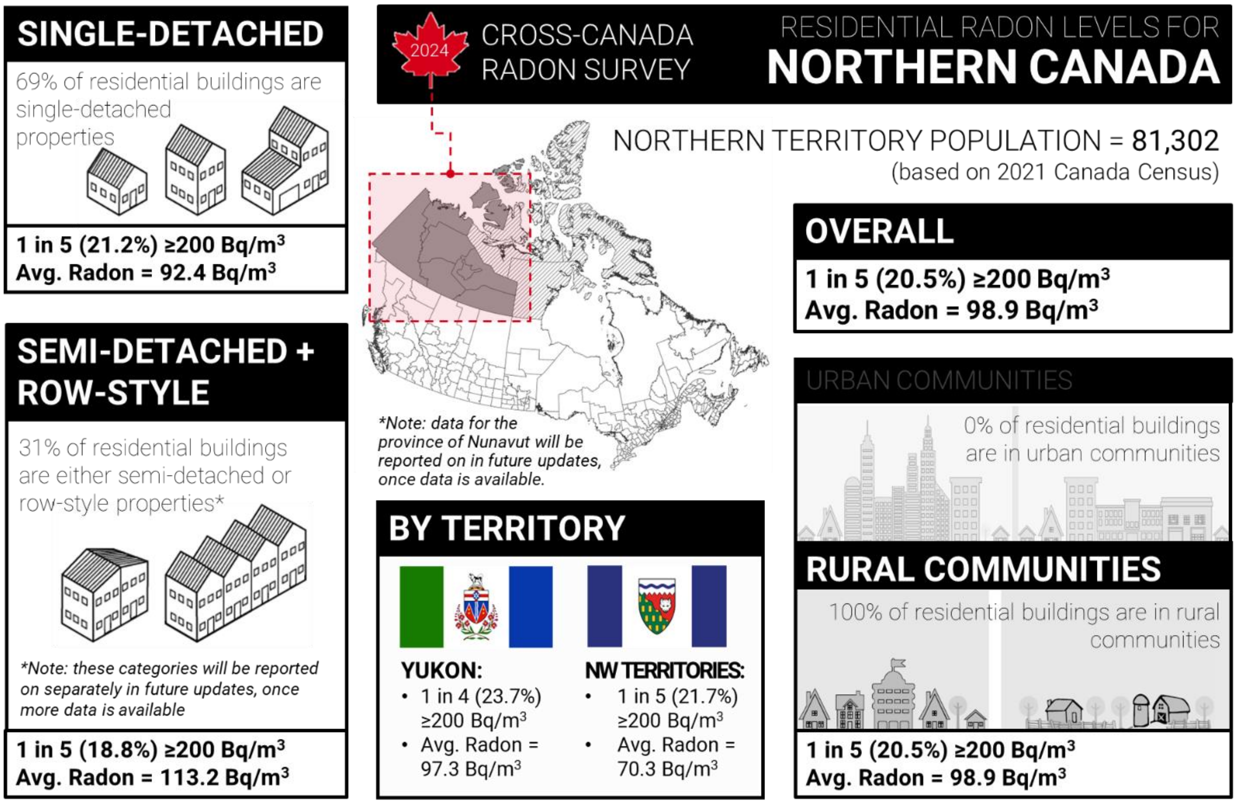
Collectively, 1 in 5 (20.5%) of Northern Region properties contain radon levels at or above 200 Bq/m^3, with an average radon level of 98.9 Bq/m^3. Just under 1 in 3 (27.7%) properties fall between 100-199 Bq/m^3. *For the purposes of this report, all towns and communities in Northern Canada are classified as rural communities, meaning all are <30,000 people in population size*.

Radon across Northern Canadian residential building types: In Northern Canada, 69% of residential buildings are single-detached properties, with the remaining 31% including semi-detached properties, and row (attached) style properties.

- **1 in 5** Northern Single-detached properties are at or above 200 Bq/m^3
- **1 in 5** Northern Semi-detached and Row-style properties are at or above 200 Bq/m^3

Northern Canadian single-detached properties have an average radon level of 92.4 Bq/m^3, with 1 in 5 (21.2%) at or exceeding 200 Bq/m^3. Approximately 1 in 4 (22.7%) of Northern Canadian single-detached properties fall within the 100-199 Bq/m^3 range.

Northern Canadian semi-detached and row-style properties have, collectively, an average radon level of 113.2 Bq/m^3, with 1 in 5 (18.8%) at or exceeding 200 Bq/m^3. More than 1 in 3 (38.8%) of Northern Canadian single-detached properties fall within the 100-199 Bq/m^3 range.



IN SUMMARY, the residential radon statistics of the two Canadian Territories in the North highlight consistently higher radon levels across all building types and across the region. While single-detached properties in this region contain higher radon levels than semi-detached and row (attached) residential houses, these differences are modest. ***Northern Territory, residential radon levels, are considered high, therefore, radon testing and effective mitigation systems should be considered a high priority for the people of this region.***

XIII.3. A Comparative Analysis – A Closer Look at Residential Radon by Building Type in the Halifax, Montreal, and Calgary metropolitan areas

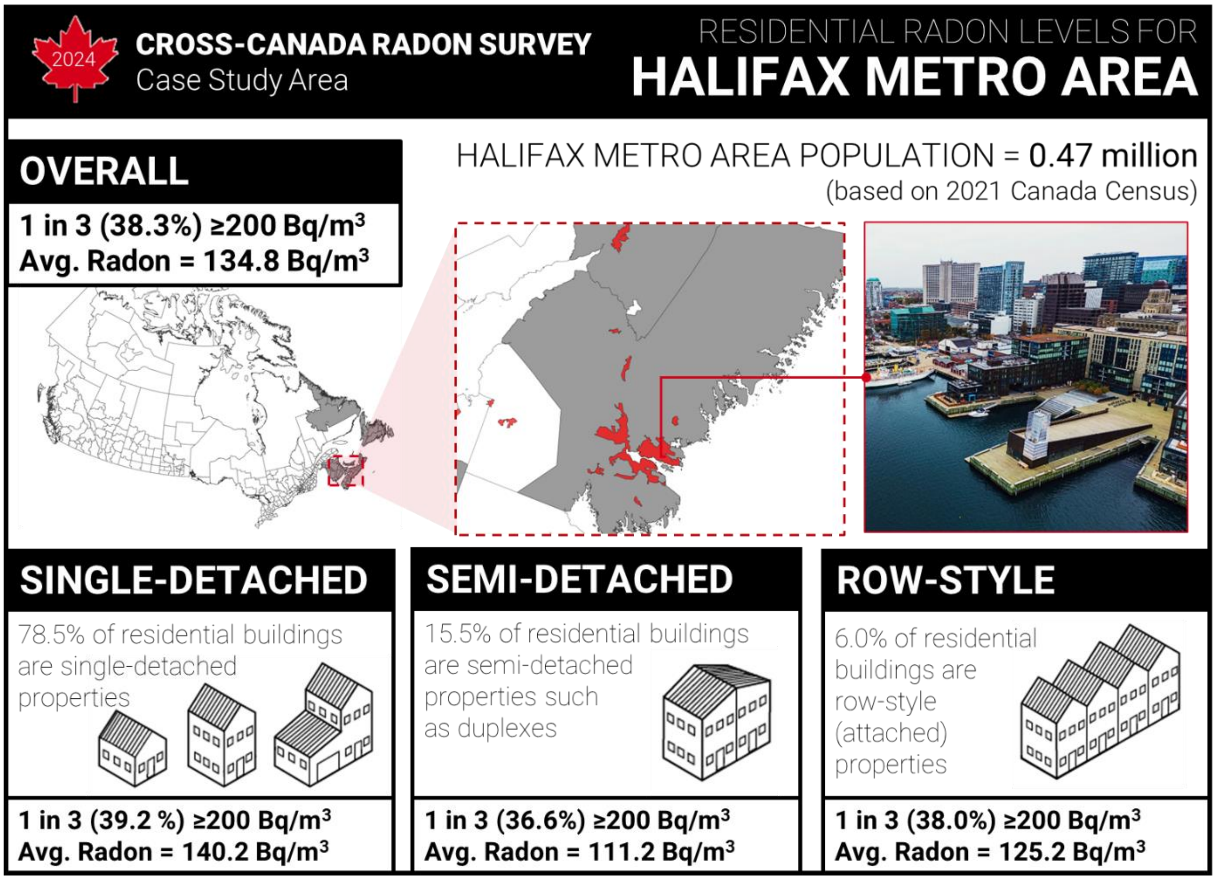
In this section, we compare and contrast the greater metropolitan areas of three large Canadian cities for which we have sufficient data for a more in-depth examination of radon as a function of community and build type. We chose the census metro areas of Halifax on the East Coast, Montréal in Central Canada, and Calgary in the West near the Rocky Mountains.

In future years, updates to this report will feature as many other Canadian metro areas as possible.

The Greater Halifax Metropolitan Area

The city of Halifax is located on the Atlantic coast in the eastern part of Canada, and is the capital of the province of Nova Scotia. Halifax, whose name in the language of the Indigenous Mi'Kmaq people is *Kjipuktuk* and means 'Great Harbour', is a major economic centre within Eastern Canada, having been founded in 1749. The local geography features rugged terrain with coastal cliffs, and encompasses a large area with >200 neighbourhoods with a strong maritime and naval tradition.

Halifax reported a population of 0.47 million people in the 2021 Canada Census, and is the largest city on Canada's Atlantic coast. 78.5% of Halifax residential properties are single-detached houses, 15.5% are semi-detached properties, and 6% are row (attached) properties.



Halifax Metro Area's average residential building radon level is among the highest of the three metropolitan areas we have analyzed in greater detail, at a weighted average of 134.8 Bq/m³. As reported above, just over 1 in 3 (38.3%) Halifax area houses contain at or above 200 Bq/m³ radon, and approximately 1 in 4 (24.5%) are between 100 to 199 Bq/m³.

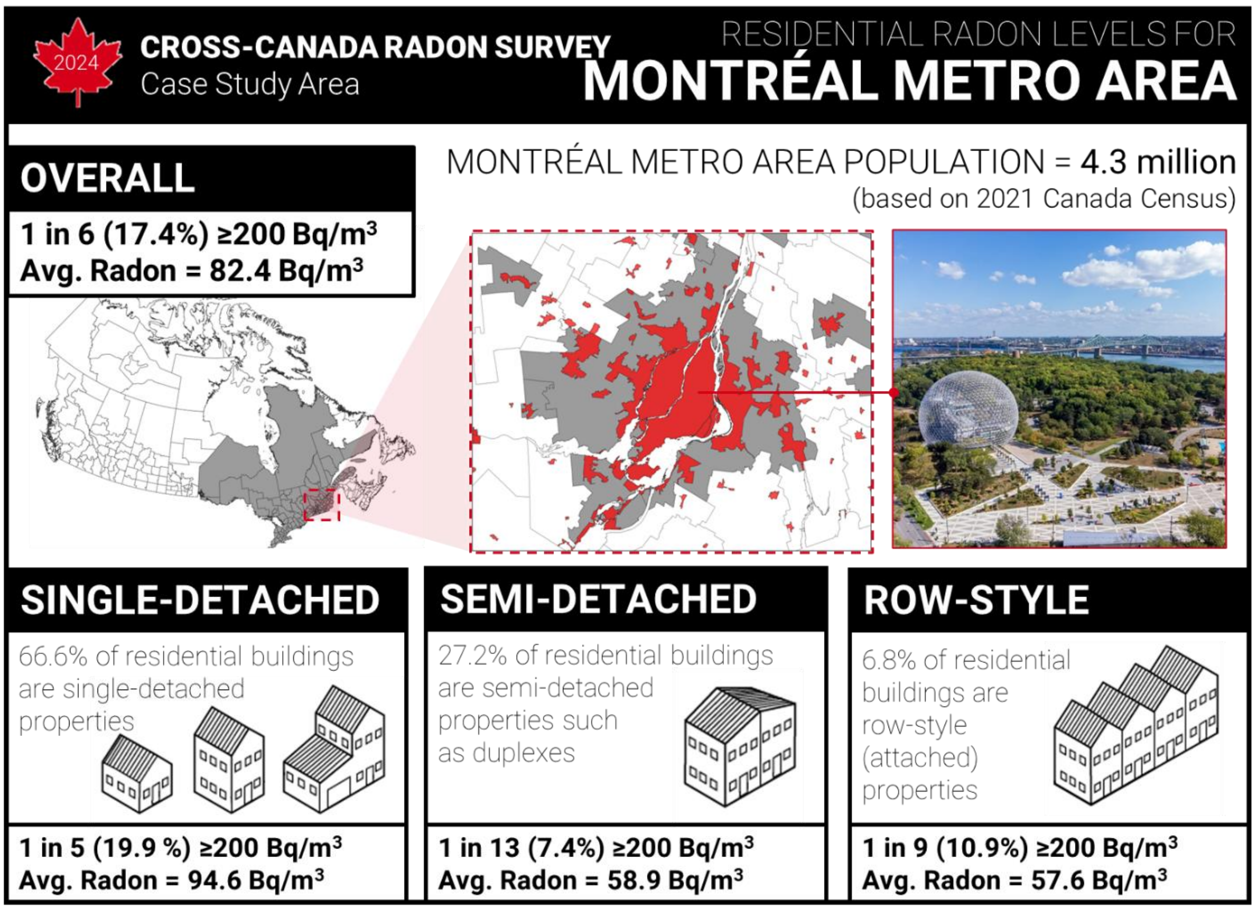
- **Single-detached houses** contain an average radon level of 140.2 Bq/m³. Just over 1 in 3 (39.2%) properties are at or exceed 200 Bq/m³ radon, and 1 in 4 (24.8%) are between 100 and 199 Bq/m³.
- **Semi-detached houses** contain an average radon level of 111.2 Bq/m³, of which 1 in 3 (36.6%) are at or exceed 200 Bq/m³ radon, and 1 in 6 (16.8%) are between 100 and 199 Bq/m³.
- **Row (attached) houses** contain an average radon level of 125.2 Bq/m³, of which, more than 1 in 3 (38.0%) properties are at or exceed 200 Bq/m³ radon, and approximately 1 in 5 (18.5%) are between 100 and 199 Bq/m³.

It is possible that Halifax's high radon levels may partly be attributed to the Meguma Terrane's geological formations, a geological region in eastern Canada, primarily overlapping with Nova Scotia, that is known for its very old and unique rock formations that can generate high levels of thorium and uranium[37].

The Greater Montréal Metropolitan Area

The city of Montréal is located in the province of Quebec, positioned in southeastern Canada. The city is centred on the island of Montréal, which has a unique geography and a greater metropolitan area consisting of 19 large boroughs that span several periphery islands and mainland Quebec. The heart of the city surrounds the triple-peaked, namesake mountain called ‘Mount Royal’. Founded in 1642 as ‘Ville-Marie’ by early French settlers, Montréal is considered an important cultural and commercial centre, with the second largest GDP of all Canadian cities. The land of Montréal shows evidence of occupation by Saint Lawrence Iroquoians, as early as 4000 years ago and in the Ojibwe language, the land is called *Mooniyaang* or *Moon’yaang* which translates as "the first stopping place".

Montréal reported a population of 4.3 million in the 2021 Canada Census, making it the largest city in Canada's French-speaking regions. 66.0% of Montréal residential properties are single-detached houses, 27.2% are semi-detached properties, and 6.8% are row (attached) properties.



Montréal Metro Area’s average residential building radon level is a weighted average of 82.4 Bq/m³. Approximately 1 in 6 (17.4%) of the Greater Montréal Metropolitan Area houses contain at or above 200 Bq/m³ radon, and just over 1 in 4 (28.0%) are between 100 to 199 Bq/m³.

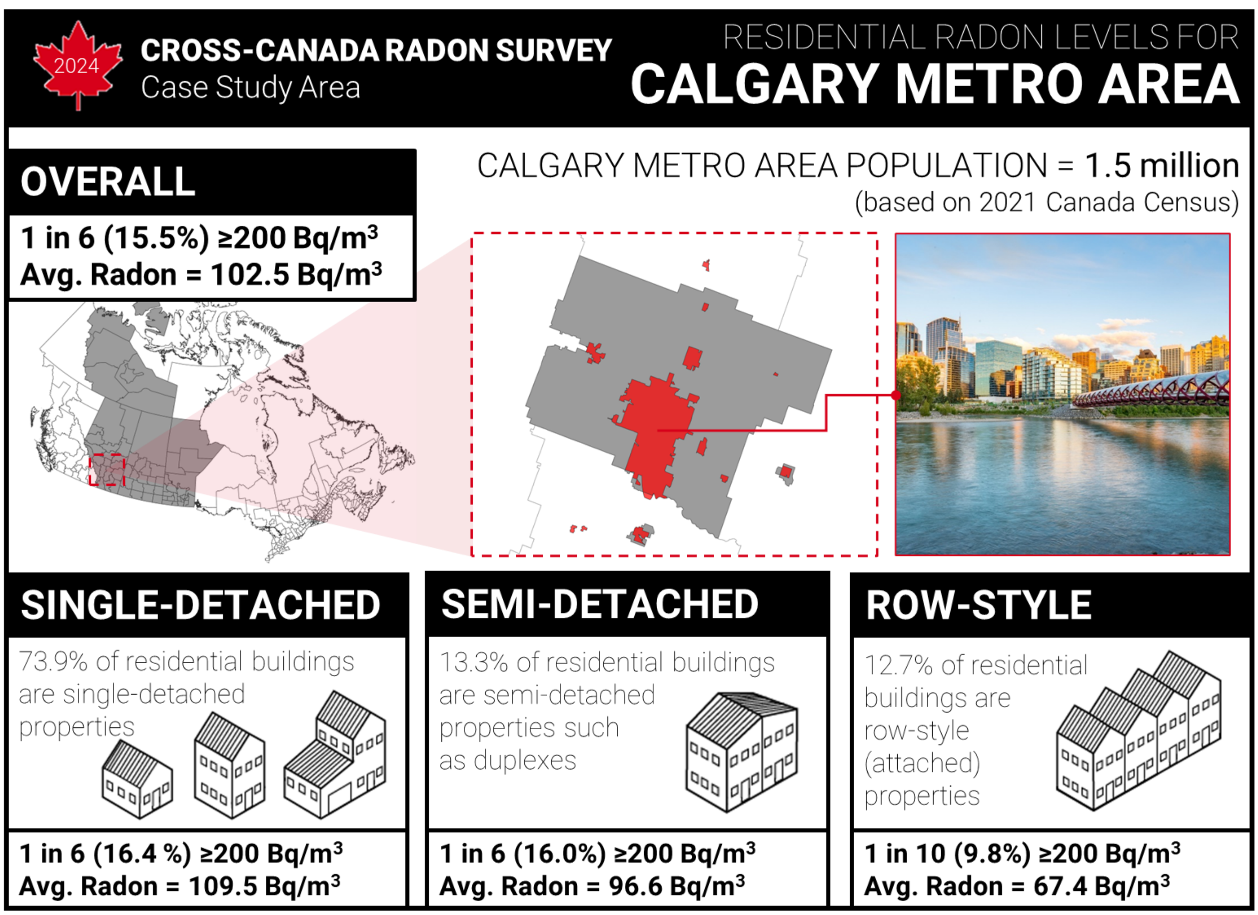
- **Single-detached houses** contain an average radon level of 94.6 Bq/m³, of which 1 in 5 (19.9%) are at or exceed 200 Bq/m³ radon. Almost 1 in 3 (30.6%) are between 100 and 199 Bq/m³.

- **Semi-detached houses** have an average radon level of 58.9 Bq/m³, of which 1 in 13 (7.4%) are at or exceed 200 Bq/m³ radon, and almost 1 in 5 (19.1%) are between 100 and 199 Bq/m³.
- **Row (attached) houses** contain an average radon level of 57.6 Bq/m³, of which 1 in 9 (10.9%) are at or exceed 200 Bq/m³ radon, and almost 1 in 5 (19.6%) are between 100 and 199 Bq/m³.

The Greater Calgary Metropolitan Area

The city of Calgary is situated in the western part of Canada in the province of Alberta, at the transition between foothills that lead up to the Rocky Mountains, and the Canadian Prairies. Calgary was founded in 1875, and its name is derived from the Gaelic word *Calgairidh*, meaning "cold garden". In the language of the Indigenous Blackfoot peoples (Siksiká), the area in which Calgary exists is referred to as *Mohkínstsis*. In contrast, the Indigenous Stoney Nakoda people refer to it as *Wîchîspa Oyade* – both translating as "Elbow" in reference to the sharp bend of local rivers. Calgary is a major economic and transportation hub in the west of Canada.

Calgary reported a population of approximately 1.5 million in the 2021 Canada Census, making it the largest city in the Canadian Prairies. 73.9% of Calgary residential properties are single-detached houses, 13.3% are semi-detached properties, and 12.7% are row (attached) properties.



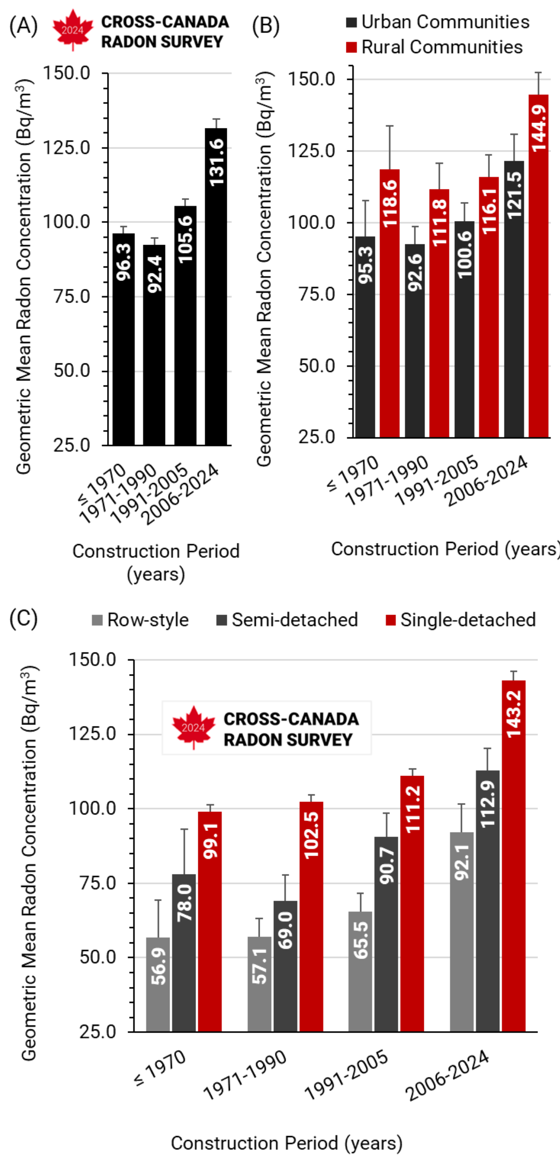
Calgary Metro Area's average residential building radon level is a weighted average of 102.5 Bq/m³. Approximately 1 in 6 (15.5%) of the Greater Calgary Metropolitan Area houses contain at or above 200 Bq/m³ radon, and more than 1 in 3 (36.9%) are between 100 to 199 Bq/m³.

- **Single-detached houses** contain an average radon level of 109.5 Bq/m³, of which 1 in 6 (16.4%) are at or exceed 200 Bq/m³ radon. Over 1 in 3 (40.0%) are between 100 and 199 Bq/m³.
- **Semi-detached houses** have an average radon level of 96.6 Bq/m³, of which 1 in 6 (16.0%) are at or exceed 200 Bq/m³ radon, and 1 in 3 (33.6%) are between 100 and 199 Bq/m³.
- **Row (attached) houses** contain an average radon level of 67.4 Bq/m³, of which 1 in 10 (9.8%) are at or exceed 200 Bq/m³ radon, and almost 1 in 4 (22.3%) are between 100 and 199 Bq/m³.

XIII.4. Case-Study: Albertan residential radon levels by construction year

Several factors have already been demonstrated to impact household radon. With the amount of data received from Alberta, it was possible to study how the year of construction may impact the levels of household radon.

The graphs to the RIGHT show increasing Alberta household radon levels as a function of the year that a residential property was constructed, with an overall increase in 39.2 Bq/m³ geometric mean radon level over the roughly 50-year period between 1971 to 2024. Albertan residential properties are currently being constructed with record-high radon levels documented within a short number of years post-completion, averaging 131.6 Bq/m³.



Albertan Residential Radon as a function of Construction Year.

In these graphs, we plot average residential radon levels in the province of Alberta as a function of the time period in which the properties were built. We consider four periods, each of which contains an equal number of radon readings (data in quartiles).

Panel A shows how average radon levels change over time across all Alberta houses, weighted to account for the distribution of building and community types.

Panel B shows how average radon levels change over time across the three different building design types, single-detached houses, semi-detached houses, and row-style (attached) houses.

Panel C shows how average radon levels change over time in either more urban or more rural communities, as defined by population size.

In all cases, average radon levels have steadily increased since the 1970s. *In future updates to the Cross Canada Radon Survey, we aim to collect sufficient [year of construction] data for houses with radon test data to apply an appropriate weighting factor to account for this variable.*

BOX #11. Why do researchers think newer Canadian residential properties have higher radon concentrations compared to older ones?
The overall trend that newer houses in Canada have higher radon has been suggested to be due to ever-evolving changes in construction practices, consumer preferences, and policies that are a part of the Canadian Building Code[34,36]. It is important to emphasize that no single change is thought to be responsible for increasing radon.

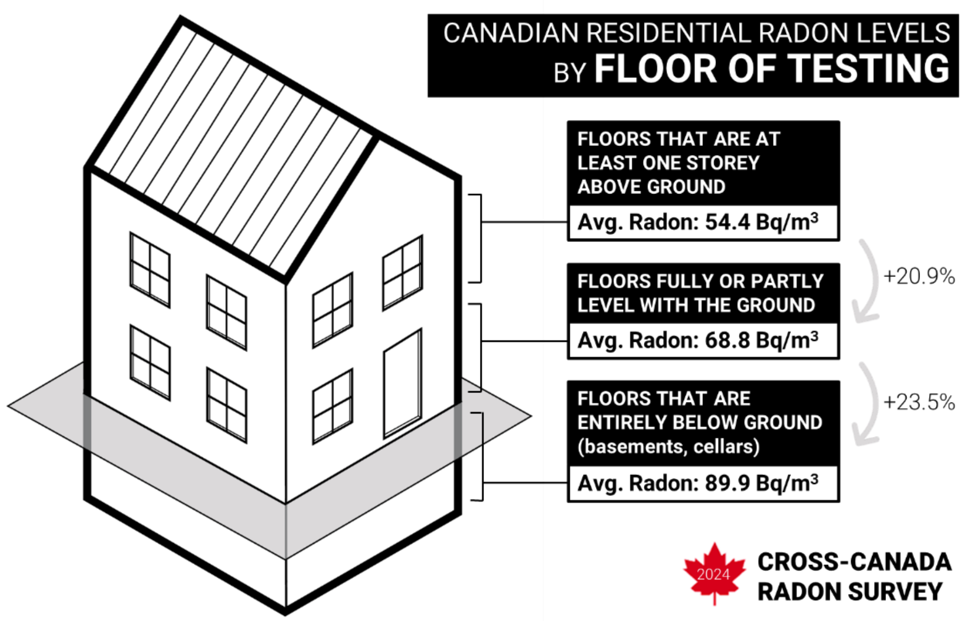
As one example, the mid-to-late 20th century trend towards building houses with larger floor plans (meeting consumer demand) is believed to have led to greater overall concrete foundation (slab) shrinkage as the concrete dries (cures) at a fixed ratio relative to its overall surface area, and creating larger gaps around the area where the concrete foundation meets basement walls [38,39]. Building scientists have speculated that larger gaps around the edges of the house foundation, if not adequately sealed, enables more radon to enter [40].

These trends are consistent between single-detached houses, semi-detached, and row-style dwellings, as well as across urban to rural communities. In future updates to the Cross-Canada Radon Survey, it will be important to gather sufficient information to perform this analysis for all Canadian provinces.

XIII.5. Examining differences in residential radon level as a function of building floor

Radon gas is generated within the Earth and typically enters a building via surfaces in direct contact with the ground, such as basement-level floors, walls, and foundation penetrations such as pipes. It has, therefore, been generally understood that the highest radon levels are observed typically on the lowest floor or storey of the building being tested; this does not mean, however, that levels of a building at or above ground level are free of risk.

To understand differences in Canadian radon exposure across the typical levels of a residential building, we calculated the average (geometric mean) radon outcome obtained from the 68% of tests that were carried out on a floor of property that is entirely below ground (such as basements or cellars), or from the 30% of tests carried out on a ground floor or walkout level (either entirely or partly level with the ground), or from the 2% of tests that were carried out on an upper floor (at least one storey above ground level).



With all outcomes weighted to the distribution of regions and building types based on the 2021 Canada Census, we find that the average radon reading on floors entirely below ground is 89.9 Bq/m^3, the average radon reading on floors at ground level is

68.8 Bq/m³, and the average radon reading on floors entirely above ground is 54.4 Bq/m³. These outcomes indicate an average of 23.5% more radon in rooms in the basement or cellar of a typical Canadian residential building relative to rooms that are on floor level with the ground. Similarly, there is an average of 20.9% more radon in rooms on the floors level with the ground, relative to 'upstairs' rooms on floors that are at least one storey above ground level.

These outcomes indicate that, in Canada, there remain substantial radon risks in rooms on levels that are at or above ground level. It is also correct that the greatest levels of radon are often observed on the level of the building that is below ground (and most likely in direct contact with the building foundation). Building scientists believe that the most probable explanation for somewhat lower radon levels observed on higher floors is that there are more opportunities for radon to be diluted with air from openings such as windows and doors, as indoor air migrates through the building to these levels (following entry via the foundation).

XIV. DISCUSSION and INTERPRETATION

XIV.1 Synopsis of Major Outcomes and Recommendations

The 2024 *Cross-Canada Survey of Radon Exposure in the Residential Buildings of Urban and Rural Communities* finds that there are no areas of Canada that are 'radon free', and that approximately 1 in 5 (17.8%) of people residing in Canada are living in buildings with radon levels at or above the current radon guideline of 200 Bq/m^3. The results of this study can be used by federal, provincial, and municipal governments as well as health, occupational, and building safety professionals to help prioritize radon outreach and education efforts, and to encourage or enable radon testing and remediation where necessary.

Of the Census Divisions in which we obtained at least 25 radon readings, approximately 30% encompassed communities in which 25-50% of houses contained radon at or above 200 Bq/m^3. A majority of (7 in 10) Canadians live in single-detached, semi-detached, and row-style residential dwellings, and we report that the average radon level in these property types is 84.7 Bq/m^3, weighted by their distribution across Canadian regions and urban-to-rural communities.

We also find that radon levels vary significantly across regions, urban-to-rural communities, and by building design types. Areas where high indoor radon levels are especially prevalent include Atlantic Canada, Prairie Canada, the North, and the British Columbian interior. Of the building types we have examined, single-detached houses generally demonstrate the highest risk of being at or above 200 Bq/m^3 relative to semi-detached houses, which in turn have a higher risk relative to row-style houses. While limited data was available for multi-family housing (i.e. apartments), current information suggests these property types do carry some risk of high radon exposure. Residential buildings of any type in rural Canadian communities (meaning population centres of 1-29,999 people) generally demonstrated a greater risk of being at or above 200 Bq/m^3 relative to already high-risk urban community equivalents.

For Canadian municipalities, the risk of residential radon levels being at or above the current radon guideline of 200 Bq/m^3 is generally high, with four of Canada's cities with populations exceeding 1 million people (Montréal, Ottawa-Gatineau, Calgary, and Edmonton) demonstrating a 1 in 6 risk, and weighted average residential radon levels between approximately 80-110 Bq/m^3. Other towns and cities where at least one-quarter to half of residences contain radon at or above 200 Bq/m^3 include Whitehorse (YT), Nelson (BC), Kelowna (BC), Prince George (BC), Vernon (BC), Penticton (BC), Trail (BC), High River (AB), Okotoks (AB), Strathmore (AB), Regina

(SK), Brandon (MB), Winnipeg (MB), Thunder Bay (ON), Kingston (ON), Sherbrooke (QC), Bathurst (NB), and Halifax (NS). Many of these municipalities contain houses with average residential radon levels greater than 130 Bq/m^3. Therefore, we recommend that public health stakeholders who are active in these communities take particular care to increase the promotion of radon awareness and access to radon reduction resources.

The results of the 2024 Cross-Canada Radon Survey show that, even for those regions, cities, and towns where the overall results indicate a lower incidence of residential buildings with elevated radon levels, there are still houses with high radon levels and higher increases in occupants relative lifetime risk of lung cancer. Therefore, it is important that readers be aware that the results in this report should not be used as a tool to determine personalized radon risk potential, or to decide whether or not to test a specific household for radon. Radon levels are influenced by several factors, including building features and the behaviour of the people occupying it. Ultimately, the only way to know if a house has an elevated level of radon is to test it, regardless of region or community.

BOX #12. Did you know? There are multiple initiatives and organizations involved in raising radon awareness, enabling radon testing, facilitating radon mitigation, and carrying out radon research across Canada.

Some of the groups raising radon awareness include:

The Take Action on Radon program, sponsored by Health Canada and administered by the Canadian Association for Radon Scientists and Technologists (CARST) and partners such as CAREX Canada (see below) and the Canadian Cancer Society, aims to educate Canadians about the risks of radon and how to reduce radon exposure.

The Evict Radon National Study is a pan-Canadian, university research-focused initiative that studies the fundamental origins of Canadian radon exposure using transdisciplinary techniques. With funding support from the Canadian Institutes of Health Research (CIHR), Health Canada, and the Canadian Cancer Society, researchers enable 'citizen scientist' style public participation in radon testing and aim to help by providing Canadians with scientifically-informed knowledge and access to tools and resources needed to reduce radon exposure and, in the future, access lung cancer screening if exposed.

Carcinogen Exposure (CAREX) Canada is a multi-institutional research project focusing on the number of Canadians exposed to carcinogens in an occupational setting. CAREX researchers are based across Canada and provide policymakers with information to strategize ways to reduce workplace exposure risks through building codes and public health initiatives.

The British Columbia Centre of Disease Control (BC CDC) is a public health agency that promotes health in British Columbia and provides access to radon-related material for the public and health professionals.

The **Lung Health Foundation** and **Canadian Lung Associations** are involved in raising awareness about the dangers of radon and various aspects about lung health in general. The Lung Health Foundation and the many provincial Lung Associations are all carrying out work to educate the public about the importance of testing homes for radon, understanding the risks associated with long-term exposure, and taking necessary mitigation measures if elevated radon levels are detected.

The **Canadian–National Radon Proficiency Program** (C-NRPP) is a certification program for professional radon testing and mitigation workers developed to protect consumers by ensuring they receive services from qualified individuals who adhere to a recognized high standard of practice. The C-NRPP operates under the Radiation Safety Institute of Canada and is designed to ensure the competency and professionalism of radon measurement and mitigation service providers in Canada.

XIV.2 Comparing the 2012 and 2024 Cross-Canada Radon Surveys

The 2024 survey of residential radon in Canada is an update of Cross-Canada radon reporting, and does not invalidate the previous work carried out in 2012, which is a robust snapshot of Canadian radon exposure of that time period. That said, it is important to address differences in observations between the 2012 and 2024 Cross-Canada Radon Surveys.

The 2024 Cross-Canada Radon Survey found that 17.8% of Canadian residential properties contain an average radon level that is at or exceeds 200 Bq/m^3, a nearly 2.5-fold increase compared to the 6.9% of households that tested at or over 200 Bq/m^3 in the 2012 Cross-Canada Radon Survey. We speculate that this substantial increase in average radon levels could be attributed to the following factors:

Building Construction. The simplest explanation is that Canadian residential radon levels have actually increased over the past decade due to changing build practices, meaning newer houses contain substantially higher radon versus their older equivalents. It has been suggested that evolving Canadian building codes (and practices) have unintentionally led to higher radon levels in newer buildings due to factors such as increased air tightness coupled with limited or imbalanced fresh air exchange, changes in concrete used within foundations, and more. These ideas have been discussed in detail within the academic literature[34] and the trends supporting this phenomenon are summarized within the Albertan Case Study presented in Section XIII.4 of this report.

Distribution of Tests by Floor. As determined in Section XIII.5 of the 2024 report, we find that radon test outcomes from rooms located on floors below ground (such as basements or cellars) are 23.5% higher in radon, on average, than outcomes from tests placed in rooms on the (main) floor of the building that is level with the ground. In the 2012 Cross Canada Radon Survey, 31% of results were from radon test devices placed in rooms below ground, and 58% were from rooms on floors level with the ground – a major difference to the 2024 report, where 68% of results were from rooms below ground and 30% were from rooms level with the ground. We speculate that this difference explains part of the increase in outcomes between the two surveys. We emphasize that participants in both surveys were advised to place the test device on the lowest floor of the household where a person spends, on average, four or more hours per day. Since this modality of testing increases the likelihood that test results reflect radon levels in the air that people are being exposed to, we chose not to re-weight any outcomes in the report to harmonize with the floor on which the tests were placed. We speculate that the increase in people choosing to test on lower levels of properties may reflect the increased use of such spaces as living areas, such as 'basement suites.'

Building Retrofit and Renovation. Another contributor to high radon levels could possibly be the increased airtightness of older building envelopes produced by energy efficiency retrofits installed without increasing the rate of mechanical ventilation. This change can increase how radon-laden soil gases are retained at high levels within indoor air. Indeed, over the past decade, federal and provincial incentive programs have increased the uptake of energy-efficient retrofits in older buildings. It is possible that part of the difference in outcomes between the 2024 and 2012 surveys can be attributed to the unintentional impact of certain energy efficiency measures. <u>It is important here to note that increased energy efficiency does not, in of itself, necessarily result in high radon.</u> Indeed, in other cold-climate nations such as Sweden, the most energy-efficient houses display the overall lowest average indoor radon levels[34]. This highlights the need to consider the way in which buildings circulate and exchange air as a whole when considering retrofits, and that energy efficiency can be improved without inadvertently increasing radon.

Overall Scale of Data Collection. The 2024 report collected five times more long-term radon results than the 2012 report (~70,000 results versus ~14,000 results), and applied multiple re-weighting factors to increase the balance between the distribution of surveyed houses versus what is known to exist in Canada based on the most recent census. To our knowledge, this is the first time national radon outcomes have been adjusted for regional, community, and building design type factors at the same time, a process only made possible by the larger sample size that covers a greater proportion of Canada in greater depth. It is possible that part of the difference in outcomes between the 2024 and 2012 surveys is due to this enhanced balance.

Recruitment Strategies. There were differences in participant recruitment strategies between the 2024 and earlier surveys. For example, during the 2012 survey, participants were recruited via phone calls to landlines via a process intended to be random and administered by a third-party company, with no digital or word-of-mouth recruitment. At the time, landline recruitment was an appropriate strategy for constructing representative surveys, a fact that is no longer true in our modern digital society. By contrast, the 2024 survey compiled data obtained via varied recruitment modalities, including digital recruitment, which likely increased the diversity of participants. Therefore, differences in recruitment strategy possibly accounts for some of the underlying differences in survey outcomes.

- ***Sampling techniques.*** As indicated earlier, the 2024 survey compiled data from a number of different sources using different sampling techniques, such as tests provided for free, subsidized radon tests provided using citizen science-based initiatives, and tests purchased at market cost through varied vendors in different sectors. Participants were selected randomly, through semi-random processes, or by convenience sampling. We acknowledge that using raw and unweighted radon data from convenience sampling alone has the potential to introduce bias to outcomes, since people may be more likely to opt for radon testing if they have a history of lung cancer, hear about testing via neighbours whose radon test outcomes are high, and/or live in a single-detached house. The impact of many of these potential biases can be mitigated if participant houses are well understood (i.e. building type and age). The regions and the communities in which radon test outcomes are from can be appropriately re-weighted in reference to independently collected census data to avoid over-representation of house types, communities and any regions with unusually high radon. Indeed, this is precisely what has been done in the 2024 survey to produce outcomes that are as ‘symmetric’ as possible with the reality of the Canadian built environment.
- ***Participant demographics.*** Understanding the people who participate in radon testing matters as there is evidence that population demographics are not randomly distributed across Canadian housing types or locations (See Box #12 for further details). While we do not have access to complete demographic data for all participants who performed a radon test as part of this survey,

> **BOX #13 The age of a house and its occupants matter.** As just one example of many different demographic trends that could influence radon test outcomes, there is growing evidence[43] that the age demographics of a population are not randomly distributed across Canadian housing types or locations, and that younger people are more likely to live in generally newer (and hence more affordable) properties that in some regions of Canada tend to have higher radon levels (and vice versa). The use of broader range of recruitment strategies in the 2024 survey may have increased participation amongst younger people in these newer and potentially higher-radon containing households.

approximately 6,000 people from the 32% of readings in this survey that were contributed by The Evict Radon National Study have been polled for age, gender, socioeconomic demographics, as well as personal and family cancer history. These polls indicated that those who consented to carry out radon testing between 2018-2024 were, overall, balanced by gender, were an average of 50 years of age (with a broad spread across ages 30-70), were not over-represented by people with a history of lung cancer, and have household incomes near the average reported in the 2021 Canada Census. Nevertheless, complete demographic characteristics for the 2024 (and indeed earlier) Cross-Canada Radon Survey participant cohorts are not fully understood, and they are a potential factor influencing survey outcomes.

In summary, we suggest that the differences observed in the 2024 report versus the 2012 report are likely due to the following:

- Increases in residential radon due to changing build practices;
- The use of weighting as a function of building design and community type to improve data symmetry with the Canadian built environment;
- The increased adoption of building retrofits without balanced mechanical ventilation by Canadians may unintentionally increase household radon;
- The increased testing on floors that are entirely below ground;
- The increased sample size of the 2024 survey, and inclusion of diverse sampling methodologies.

XIV.3 Radon – a modifiable, preventable source of radiation exposure and lung cancer

Ultimately, it is the cumulative dose of radiation (to the lungs) from radon that a person experiences that modifies their lifetime risk of lung cancer. Radon and its decay products are the most significant contributors to a person's lifetime dose of ionizing radiation exposure, accounting for nearly half of the effective dose received from all background radiation sources [44]. In addition to region, community, and building design type factors that influence radon levels in air, the major influence on the actual dose of radiation that people absorb from radon exposure is behaviour, and how much time a given person spends within an indoor air environment containing radon[41–43].

For example, people's behaviour may modify how a building draws on and retains radon-containing soil gas. Regularly maintaining a household's air balance (by cleaning fresh return air filters), ensuring correct operation of HVAC systems, having gas-sealed sump pumps, and/or how likely a person is to open (and keep open) windows all can influence a building's radon level. Beyond radon-modifying behaviours, lifestyles, personal demographics, and/or occupational choices can also impact the total radiation doses that people absorb from indoor radon exposure, and therefore their relative risk of subsequently developing cancer[41–43]. For example, two adults may occupy a single property with an identical radon level, but each experiences distinct radiation doses from it, as one person works from home five days a week (more time spent in the house equates to a greater annual dose of radiation from radon). In contrast, the other person works away at a large commercial office with little radon (low annual relative dose). In the years during and since the end of the Canadian response to the COVID-19 pandemic, the proportion of people working from home some or all of the time has increased[41]. From a radon exposure policy perspective, the outcomes of this radon survey may be considered by occupational health and safety stakeholders as such work environments become more widespread for some job types, compared to pre-pandemic periods.

The differing health and demographics of home occupants must also be considered, as an otherwise identical level of indoor air radon can exert different effects on lifetime lung cancer risk based on age and other health metrics. For example, one adult and one child may occupy the same property and have a near-identical pattern of activity, resulting in the same exposure to radon. However, the child, due to their developing respiratory system, higher breathing rates relative to their body size, smaller size and greater amount of 'life left to live,' receives a greater relative dose of radiation and is thought to incur a greater relative risk of lung cancer when compared to adults[44].

A similar phenomenon of differential risk is anticipated between an adult without any other lung health risks/exposures and someone who has experienced another exposure or health event that increases the risk of lung cancer, such as inhalation of tobacco smoke, asbestos fibres, or other combustion particulates[45–47], and/or severe lung inflammatory events such as tuberculosis, chronic obstructive pulmonary disease (COPD), and/or severe pneumonia[48]. Based on this, people who are aware of an exposure to another cause of lung cancer (such as a history of tobacco smoking) or whose medical history includes a severe lung inflammatory event are strongly recommended to test the buildings in which they live for radon.

XIV.4 Future Directions and the next update of the Cross-Canada Radon Survey

The 2024 *Cross-Canada Survey of Radon Exposure in the Residential Buildings of Urban and Rural Communities* represents an important new starting point in reporting residential radon exposures in Canada on a more regular timeline, and ***we are committed to consistent updates of Canadian radon exposure statistics as new data becomes available.***

We also anticipate presenting the primary information contained within this survey to Canadians as a more interactive data dashboard by Spring 2025.

We reiterate the near-term need to improve radon test information across the Canadian North and especially in the province of Nunavut for which we do not have any outcomes to report at this time. Additional radon test information connected with key geographic and building type data is also required for communities in those census divisions that we have, as yet, been unable to report radon exposure estimates.

We are optimistic that, in coming years, additional radon testing will occur in areas in need of greater data density and/or additional (existing) radon data will be obtained through future data-sharing partners. Achieving this will enable increasingly complete reporting of Canadian radon exposure risks through future versions of the survey, and for all provinces, cities, towns, and rural areas in a manner that is appropriately weighted by building and community type. We look forward to helping Canadians understand the scale and nuances of residential radon gas exposure through these near-future activities.

XV. METHODOLOGY

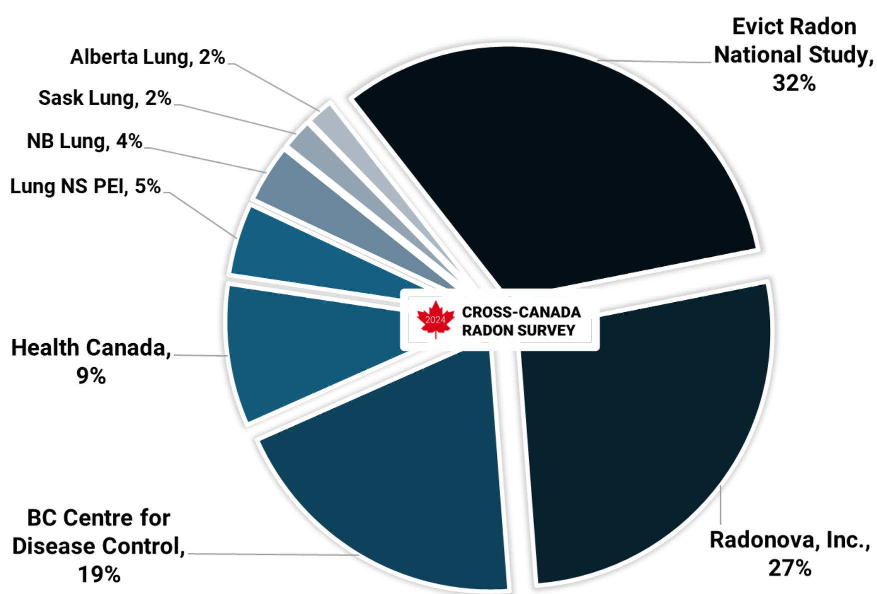
XV.1. Assembly of Radon Test Outcome Databases

The 2024 Cross-Canada Radon Survey includes long-term (> 90-day test duration) radon test outcomes obtained from the analysis of certified alpha track radon tests performed by Canadians who consented to test their primary households. Participant recruitment and support, test device quality control, and subsequent data stewardship and security were administered by multiple groups as outlined below.

All activities required for database assembly using the information provided by data-sharing partners were pre-approved by the Conjoint Health Research Ethics Board, Research Services, University of Calgary (IDs = REB17-2239, REB19-1522), adhering to research ethics best practice, and in accordance with all regional guidelines and regulations to preserve participant privacy and ensure rigorous data security.

Where applicable, data-sharing agreements between the study team and partner groups were established in advance of data being transferred, and/or data had been integrated into working radon datasets by agreement via previously published peer-reviewed academic articles.

Long-term alpha track device radon test data was entirely from residential properties located across Canada. Test outcomes were contributed by the following organizations, distributed per the pie chart below. A total of 69,478 readings were assembled for this survey.



- Evict Radon National Study Team (including researchers at the British Columbia Cancer Agency, University of Calgary, University of Saskatchewan, and Dalhousie University).
- Radonova Inc.
- BC Centre for Disease Control*
- Health Canada, Radiation Protection Bureau**
- The Lung Associations of Nova Scotia and PEI, of New Brunswick, of Saskatchewan, and of Alberta.

**It should be noted that BC CDC radon test data is, of itself, comprised of data collected from a variety of data providers. Special care was taken to remove any duplicated data points that existed between the BC CDC compilation data and that held by another organization providing data for this survey.*

***Data from the 2012 Cross-Canada Radon Survey was not re-used in the 2024 dataset, and the Health Canada dataset provided for the 2024 survey represents new readings collected after the completion of the 2012 survey.*

Funding for database assembly and report preparation was provided by a project grant from the Canadian Institutes of Health Research - Healthy Cities Research Initiative held by A. Goodarzi, J. Taron and D. Brenner (University of Calgary (AB) with C. Peters at the University of British Columbia (BC); a radon outreach program contract from Health Canada's National Radon Program to the Evict Radon National Study team; via a research grant held by A. Goodarzi at the University of Calgary (AB) from the Alberta Real Estate Foundation; and via team grant funding from the Canadian Cancer Society Breakthrough program to diverse researchers working on the "Changing the Narrative of Lung Cancer" program, based at the University of British Columbia (BC), University of Calgary (AB), Queens University (ON), and Dalhousie University (NS).

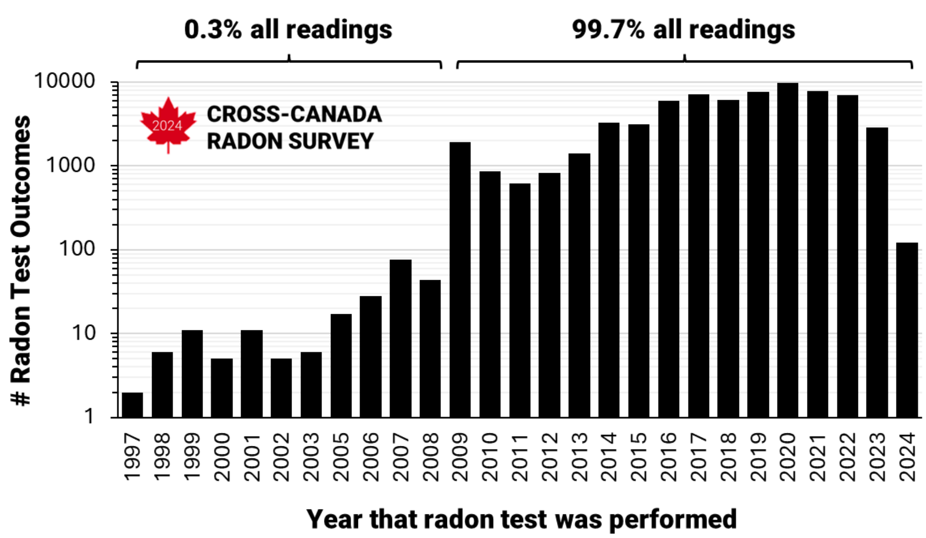
XV.2. Radon Test Devices and Testing Advice for Participants

As discussed earlier (see Section II.2), participants were instructed to follow current best practices for residential radon testing carried out by occupants, as indicated by Health Canada and the Canadian National Radon Proficiency Program (C-NRPP). To our knowledge, the majority of participants had access to online and telephone support from qualified persons to address any questions regarding the correct placement and use of radon test devices. As part of standardized advice given to all persons in Canada performing a radon test, participants were advised to place at least one test device on the lowest level (floor/storey) of the building where a person spends an average of four or more hours per day.

Alpha track radon test devices were all closed passive etched track detectors made from CR-39 plastic film inside antistatic holders enclosed in electrically conductive housing with filtered openings to permit gas diffusion, intended for long-term (>90 days) use with a typical linear range of 15 to 25,000 Bq/m^3. All devices were sourced from certified radon testing laboratories, and included the RadTrak2 and RadTrak3 from Radonova, Inc., the AT100 from Accustar Labs, and long-term alpha track radon tests from the Saskatchewan Research Council, Lex Scientific Inc., and RPC Science and Engineering. To be read, CR-39 films are etched in 5.5 N NaOH at 70°C for 15.5 min and scored using software such as TrackEtch (Radonova laboratories, Sweden, EU) or comparable programs.

XV.3. Time Period of Radon Testing

The majority (99.7%) of radon tests included in this survey were conducted between 2009 and 2024, with a very small set of legacy data (0.3%) dating between 1997-2008 (with no readings from 2004).



A complete breakdown of the number of tests included in this survey by year that the test was performed is shown in the graph to the right.

XV.4. Graphics, Photos and Data Access Statement.

All figures, charts, and infographics shown in this report have been designed and produced by our team and should not be altered by third parties in any way if shared. All photos used in this report were obtained through license to the Adobe Stock or Canva Images.

Administration and stewardship of the raw data used in this report are held independently by the five groups described in Section XV.1, with each dataset governed separately by the rules and regulations of that group. As such, any public-sector research organization that is interested in obtaining access to these datasets is required to contact each group separately and follow the specific data access process indicated by that team.

In general, access to raw data is only permitted for researchers at public organizations governed by a Canadian research ethics board. It is not available to private sector groups or individuals in order to adhere to data privacy rules and the informed consent agreements signed between research groups and people in Canada testing their properties for radon.

XV.5. Statistics Canada Data and Weighting Procedure

Statistics Canada Census 2021 data: Publicly available data on Census 2021 population, property type distribution, Census Division, Census Metropolitan Areas, and others were retrieved from: https://www12.statcan.gc.ca/census-recensement/2021/dp-pd/prof/details/download-telecharger.cfm?Lang=E

Regional Building Year of Construction Data: To understand the year of construction across regions, Housing completion data were accessed from the Canadian Mortgage and Housing Corporation Data hosted on the Government of Canada Statistics website. The data were accessed from: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3410013501.

Assigning Community type. Using Statistics Canada provided census information and Census Boundary files (available at https://www12.statcan.gc.ca/census-recensement/2021/geo/sip-pis/boundary-limites/index2021-eng.cfm?year=21) radon entries were assigned to i) a Province, ii) a census division, iii) a population centre, iv) a designated place and v) a census metropolitan area using ArcGIS Pro 3.1.0. Using population density and overall population, radon results were assigned to a Large city (population ≥ 100,000), Large Town (population = 30,000 – 99,999), Small Town (population = 1,000 – 29,999) or rural area (population ≤ 999).

Community and Building Type Weighting of Data (See Example Weighting Method): Taking Canada Overall as an example, the geometric mean radon was determined for each property type (Single-detached, Semi-detached and Row House) across urban and rural communities. To determine the community-type weighted geometric mean radon, the percentages of Statistics Canada properties in each building category were determined for urban and rural communities. Using the percentages as a weighting factor, the geometric mean radon for a building type was multiplied by the percentage of properties reported to create the weighted mean radon. The weighted geometric means were summed across the property types to get a weighted geometric mean for each community type. This process was repeated for community types to determine the overall geometric mean radon for each region of Canada. Finally, the regional geometric mean radon was weighted by region to determine Canada's overall geometric mean radon. This weighting process was repeated.

Example Weighting Method:

$$\boldsymbol{Determining\ Urban\ Community\ Weighted\ Geometric\ Mean\ Radon}:$$

$$\boldsymbol{A_{Urban} = Urban\ Single\ Detached\ Geometric\ mean \times Percentage\ of\ Single\ Detached\ properties\ in\ Urban\ Communities}$$

$$\boldsymbol{B_{Urban} = Urban\ Semi - detached\ Geometric\ mean \times Percentage\ of\ Semi - detached\ properties\ in\ Urbanc\ Communities}$$

$$\boldsymbol{C_{Urban} = Urban\ Row\ properties\ Geometric\ mean \times Percentage\ of\ Row\ properties\ in\ Urban\ Communities}$$

$$\boldsymbol{Weighted\ Urban\ Community\ Geometric\ mean\ radon = A_{Urban} + B_{Urban} + C_{Urban}}$$

$$\boldsymbol{Determining\ Rural\ Community\ Weighted\ Geometric\ Mean\ Radon}:$$

$$\boldsymbol{A_{Rural} = Rural\ Single\ Detached\ Geometric\ mean \times Percentage\ of\ Single\ Detached\ properties\ in\ Rural\ Communities}$$

$$\boldsymbol{B_{Rural} = Rural\ Semi - detached\ Geometric\ mean \times Percentage\ of\ Semi - detached\ properties\ in\ Rural\ Communities}$$

$$\boldsymbol{C_{Rural} = Rural\ Row\ properties\ Geometric\ mean \times Percentage\ of\ Row\ properties\ in\ Rural\ Communities}$$

$$\boldsymbol{Weighted\ Rural\ Community\ Geometric\ mean\ radon = A_{Rural} + B_{Rural} + C_{Rural}}$$

Software: All analysis was carried out on de-identified data, using R (Version 4.2.2), R Studio (Version 2022.12.0 Build 353) and Microsoft® Excel® for Microsoft 365 MSO (Version 2408 Build 16.0.17928.20114) 64-bit. Maps and boundary files were analyzed using ArcGIS.

XVI. TABLES OF RADON DATA BY CANADIAN CENSUS DIVISIONS

We obtained at least 25 long-term residential radon test outcomes for 58.4% (171 of the 293) individual Canadian census divisions. We obtained between 1 to 24 long-term residential radon test outcomes for another 37.2% (109 of the 293) census divisions.

Acknowledging that all areas of Canada are important to report on if possible, we clustered those census divisions with 1-24 readings together with other census divisions that directly border them, so that the pooled outcomes for a minimal geographic area can be based on a minimum of 25 long term radon readings. Doing this allows us to report useful information in a way that reduces the chance of over or under-estimating residential radon levels due to insufficient data points within a single census division and is a strategy that has been used before in this context.

Including clustered group and single census divisions, we report on 183 geographic units encompassing 94.9% (278/293) of Canadian census divisions. The geometric mean number of radon tests per census division or per census division cluster is 109.

BOX #14. A Call to Action! If you are part of a group or organization with access to long-term (90+ day) alpha track radon test data, please consider contacting the study lead or any member of the data management team who helped prepare this report (see page 3) ***to discuss becoming a Cross Canada Radon Survey data partner***. By working together, we can all help understand the scale of Canada's radon problem better and faster!

If interested in becoming a Cross Canada Radon Survey partner, please send an email to info@crosscanadaradon.ca indicating the team member or members you wish to contact.

We emphasize that all areas of Canada will benefit from new radon testing as well as the acquisition of any existing data from potential future partners, and that **individual census divisions with fewer than 25 radon test readings (i.e. any currently reported within a cluster) are areas of priority to update in near-future versions of this report**.

Census Division ID	Census Division Name	Census Division Province	Number of Radon Readings
1011	Division No. 11	NL	0
1314	Restigouche	NB	0
3551	Manitoulin	ON	0
4619	Division No. 19	MB	0
4620	Division No. 20	MB	0
4621	Division No. 21	MB	2
4622	Division No. 22	MB	3
4623	Division No. 23	MB	0
6101	Region 1	NT	0
6102	Region 2	NT	0
6103	Region 3	NT	0
6104	Region 4	NT	0
6204	Qikiqtaaluk	NU	0
6205	Kivalliq	NU	0
6208	Kitikmeot	NU	0

We did not have access to any long-term residential radon test outcomes for 4.4% (13 of the 293) census divisions and had insufficient data (<4 readings) for two census divisions that could not be clustered as they were bordered by areas with no data (tabulated to the LEFT). This group of census divisions is over-represented by those in more northern, less populated regions of Canada.

These census divisions should be considered high-priority areas for immediate radon test data collection, as well as the acquisition of any existing data from potential future partners. They will be areas of the ***highest priority to update in near-future versions of this report***.

Census Division ID	Name of Census Division or Census Division Cluster	Census Division Province(s)	Number of Radon Readings	1 in X houses (%) are in this radon exposure category	**Geometric Mean Radon Level (Bq/m^3)**	Lower 95% Confidence Interval	Upper 95% Confidence Interval	Maximum Observed Radon Level to Date (Bq/m^3)
1001	Division No. 1	NL	52	1 in 2 48.1 < 100 Bq/m^3 1 in 2 42.3 100-200 1 in 10 9.6 ≥ 200 Bq/m^3	**92.9**	70.4	122.6	2461
1002, 1003, 1004, 1005, 1006, 1007, 1008, 1009	Division No. 9, Division No. 8, Division No. 7, Division No. 6, Division No. 5, Division No. 4, Division No. 3, Division No. 2	NL	43	1 in 2 44.2 < 100 Bq/m^3 1 in 4 25.6 100-200 1 in 3 30.2 ≥ 200 Bq/m^3	**93.2**	66.5	130.6	796
1010, 2498, 2497, 2496, 2495	Minganie--Le Golfe-du-Saint-Laurent, Sept-Rivières--Caniapiscau, Manicouagan, La Haute-Côte-Nord, Division No. 10	NL, QC	64	(3 in 4) 71.9 < 100 Bq/m^3 1 in 5 21.9 100-200 1 in 16 6.2 ≥ 200 Bq/m^3	**59.8**	48.6	73.7	684
1201, 1204	Queens, Shelburne	NS	32	1 in 2 59.4 < 100 Bq/m^3 1 in 4 28.1 100-200 1 in 8 12.5 ≥ 200 Bq/m^3	**68.3**	48.8	95.7	333
1203, 1202	Digby, Yarmouth	NS	38	(3 in 4) 78.9 < 100 Bq/m^3 1 in 5 18.4 100-200 1 in 38 2.6 ≥ 200 Bq/m^3	**46.1**	34.7	61.2	418
1205	Annapolis	NS	29	(3 in 4) 79.3 < 100 Bq/m^3 1 in 10 10.3 100-200 1 in 10 10.3 ≥ 200 Bq/m^3	**45.6**	29.0	71.9	455
1206	Lunenburg	NS	177	1 in 2 43.5 < 100 Bq/m^3 1 in 6 18.1 100-200 1 in 3 38.4 ≥ 200 Bq/m^3	**122.6**	105.1	143.0	2731
1207	Kings	NS	116	1 in 2 62.1 < 100 Bq/m^3 1 in 6 16.4 100-200 1 in 5 21.6 ≥ 200 Bq/m^3	**76.2**	63.1	92.1	1018
1208	Hants	NS	86	1 in 2 58.1 < 100 Bq/m^3 1 in 5 18.6 100-200 1 in 4 23.3 ≥ 200 Bq/m^3	**87.5**	70.0	109.3	1336
1209	Halifax	NS	2854	1 in 3 36.8 < 100 Bq/m^3 1 in 4 24.5 100-200 1 in 3 38.7 ≥ 200 Bq/m^3	**137.2**	131.8	142.9	5632
1211, 1210	Cumberland, Colchester	NS	118	1 in 2 55.1 < 100 Bq/m^3 1 in 5 22 100-200 1 in 4 22.9 ≥ 200 Bq/m^3	**89.7**	73.3	109.7	1591
1212	Pictou	NS	30	1 in 2 56.7 < 100 Bq/m^3 1 in 4 26.7 100-200 1 in 6 16.7 ≥ 200 Bq/m^3	**68.8**	46.7	101.2	555
1213, 1214	Antigonish, Guysborough	NS	32	(3 in 4) 75 < 100 Bq/m^3 1 in 5 18.8 100-200 1 in 16 6.2 ≥ 200 Bq/m^3	**46.6**	33.8	64.3	307
1217, 1216	Cape Breton, Richmond	NS	111	1 in 2 55.9 < 100 Bq/m^3 1 in 6 18 100-200 1 in 4 26.1 ≥ 200 Bq/m^3	**76.8**	61.4	96.0	1554
1218, 1215	Victoria, Inverness	NS	54	1 in 2 57.4 < 100 Bq/m^3 1 in 5 18.5 100-200 1 in 4 24.1 ≥ 200 Bq/m^3	**84.5**	59.7	119.6	2094
1301	Saint John	NB	103	1 in 2 64.1 < 100 Bq/m^3 1 in 6 17.5 100-200 1 in 5 18.4 ≥ 200 Bq/m^3	**76.5**	63.6	92.1	695
1302	Charlotte	NB	49	1 in 2 51 < 100 Bq/m^3 1 in 4 26.5 100-200 1 in 4 22.4 ≥ 200 Bq/m^3	**92.5**	72.3	118.3	509
1303	Sunbury	NB	54	1 in 2 55.6 < 100 Bq/m^3 1 in 3 29.6 100-200 1 in 7 14.8 ≥ 200 Bq/m^3	**79.2**	63.7	98.5	334
1304	Queens	NB	36	1 in 2 44.4 < 100 Bq/m^3 1 in 4 27.8 100-200 1 in 4 27.8 ≥ 200 Bq/m^3	**101.3**	69.3	148.3	1309
1305	Kings	NB	341	1 in 2 46.6 < 100 Bq/m^3 1 in 4 22.6 100-200 1 in 3 30.8 ≥ 200 Bq/m^3	**128.8**	113.5	146.1	5847
1306	Albert	NB	111	(3 in 4) 76.6 < 100 Bq/m^3 1 in 7 15.3 100-200 1 in 12 8.1 ≥ 200 Bq/m^3	**58.1**	48.4	69.8	1256
1307	Westmorland	NB	546	1 in 2 65 < 100 Bq/m^3 1 in 4 22.9 100-200 1 in 8 12.1 ≥ 200 Bq/m^3	**71.2**	66.2	76.6	1128
1310	York	NB	1049	1 in 2 40.9 < 100 Bq/m^3 1 in 4 26.7 100-200 1 in 3 32.4 ≥ 200 Bq/m^3	**123.2**	116.0	130.9	1462
1311	Carleton	NB	46	1 in 3 32.6 < 100 Bq/m^3 1 in 6 17.4 100-200 1 in 2 50 ≥ 200 Bq/m^3	**141.3**	103.6	192.8	862
1312	Victoria	NB	189	1 in 4 27 < 100 Bq/m^3 1 in 7 15.3 100-200 1 in 2 57.7 ≥ 200 Bq/m^3	**192.4**	166.7	222.0	1354
1313	Madawaska	NB	33	1 in 3 39.4 < 100 Bq/m^3 1 in 5 21.2 100-200 1 in 3 39.4 ≥ 200 Bq/m^3	**132.9**	95.1	185.8	655
1315, 1309, 1308	Gloucester, Northumberland, Kent	NB	98	1 in 3 38.8 < 100 Bq/m^3 1 in 5 21.4 100-200 1 in 3 39.8 ≥ 200 Bq/m^3	**137.1**	108.7	173.0	3055

Census Division ID	Name of Census Division or Census Division Cluster	Census Division Province(s)	Number of Radon Readings	1 in X houses (%) are in this radon exposure category	**Geometric Mean Radon Level (Bq/m^3)**	Lower 95% Confidence Interval	Upper 95% Confidence Interval	Maximum Observed Radon Level to Date (Bq/m^3)
2401, 1101, 1102, 1103	Communauté maritime des Îles-de-la-Madeleine, Prince, Queens, Kings	PE, QC	146	1 in 2 53.4 < 100 Bq/m^3 1 in 4 26 100-200 1 in 5 20.5 ≥ 200 Bq/m^3	**81.8**	69.0	97.1	914
2403, 2402	La Côte-de-Gaspé, Le Rocher-Percé	QC	44	1 in 4 22.7 < 100 Bq/m^3 1 in 4 22.7 100-200 1 in 2 54.5 ≥ 200 Bq/m^3	**199.5**	142.4	279.4	2913
2404, 2405	Bonaventure, La Haute-Gaspésie	QC	40	1 in 2 42.5 < 100 Bq/m^3 1 in 4 27.5 100-200 1 in 3 30 ≥ 200 Bq/m^3	**109.8**	77.7	155.3	865.8
2406	Avignon	QC	55	1 in 5 18.2 < 100 Bq/m^3 1 in 5 18.2 100-200 1 in 2 63.6 ≥ 200 Bq/m^3	**228.9**	170.4	307.6	1382
2409, 2407, 2408	La Mitis, La Matanie, La Matapédia	QC	33	1 in 2 45.5 < 100 Bq/m^3 1 in 4 24.2 100-200 1 in 3 30.3 ≥ 200 Bq/m^3	**105.2**	73.2	151.2	471
2410	Rimouski-Neigette	QC	65	1 in 2 46.2 < 100 Bq/m^3 1 in 3 30.8 100-200 1 in 4 23.1 ≥ 200 Bq/m^3	**103.0**	83.8	126.5	555
2411, 2412, 2413	Témiscouata, Rivière-du-Loup, Les Basques	QC	28	1 in 2 64.3 < 100 Bq/m^3 1 in 6 17.9 100-200 1 in 6 17.9 ≥ 200 Bq/m^3	**83.5**	58.8	118.6	525
2414, 2417, 2418	Montmagny, L'Islet, Kamouraska	QC	40	1 in 2 55 < 100 Bq/m^3 1 in 7 15 100-200 1 in 3 30 ≥ 200 Bq/m^3	**100.8**	76.0	133.8	507
2415, 2416, 2421	La Côte-de-Beaupré, Charlevoix, Charlevoix-Est	QC	64	(2 in 3) 67.2 < 100 Bq/m^3 1 in 6 17.2 100-200 1 in 6 15.6 ≥ 200 Bq/m^3	**58.3**	45.0	75.5	363
2419, 2426, 2427, 2428	Les Etchemins, Robert-Cliche, La Nouvelle-Beauce, Bellechasse	QC	57	1 in 2 47.4 < 100 Bq/m^3 1 in 4 24.6 100-200 1 in 4 28.1 ≥ 200 Bq/m^3	**115.6**	88.6	150.9	1110
2420	L'Île-d'Orléans	QC	27	1 in 2 48.1 < 100 Bq/m^3 1 in 14 7.4 100-200 1 in 2 44.4 ≥ 200 Bq/m^3	**140.9**	88.0	225.6	1110
2422	La Jacques-Cartier	QC	86	1 in 2 54.7 < 100 Bq/m^3 1 in 4 23.3 100-200 1 in 5 22.1 ≥ 200 Bq/m^3	**94.6**	76.5	117.1	1110
2423	Québec	QC	876	1 in 2 61.2 < 100 Bq/m^3 1 in 5 20.9 100-200 1 in 6 17.9 ≥ 200 Bq/m^3	**72.3**	67.6	77.4	1443
2425	Lévis	QC	129	(3 in 4) 72.1 < 100 Bq/m^3 1 in 5 19.4 100-200 1 in 12 8.5 ≥ 200 Bq/m^3	**52.7**	44.7	62.0	433
2430, 2441, 2444	Coaticook, Le Haut-Saint-François, Le Granit	QC	53	1 in 2 58.5 < 100 Bq/m^3 1 in 4 22.6 100-200 1 in 5 18.9 ≥ 200 Bq/m^3	**94.3**	73.5	120.9	773
2431, 2429	Les Appalaches, Beauce-Sartigan	QC	28	1 in 2 50 < 100 Bq/m^3 1 in 2 42.9 100-200 1 in 14 7.1 ≥ 200 Bq/m^3	**96.0**	76.0	121.3	655
2433, 2432	Lotbinière, L'Érable	QC	25	(2 in 3) 68 < 100 Bq/m^3 1 in 5 20 100-200 1 in 8 12 ≥ 200 Bq/m^3	**65.1**	44.8	94.7	518
2434	Portneuf	QC	57	1 in 2 63.2 < 100 Bq/m^3 1 in 4 22.8 100-200 1 in 7 14 ≥ 200 Bq/m^3	**70.2**	54.4	90.6	622
2435, 2436	Shawinigan, Mékinac	QC	27	(9 in 10) 88.9 < 100 Bq/m^3 1 in 27 3.7 100-200 1 in 14 7.4 ≥ 200 Bq/m^3	**44.3**	32.2	60.9	418
2437	Francheville	QC	110	(39 in 40) 97.3 < 100 Bq/m^3 1 in 37 2.7 100-200 0 0 ≥ 200 Bq/m^3	**37.1**	33.3	41.4	126
2439	Arthabaska	QC	43	(4 in 5) 81.4 < 100 Bq/m^3 1 in 7 14 100-200 1 in 21 4.7 ≥ 200 Bq/m^3	**49.2**	37.6	64.5	400
2443	Sherbrooke	QC	140	1 in 2 52.1 < 100 Bq/m^3 1 in 5 18.6 100-200 1 in 3 29.3 ≥ 200 Bq/m^3	**99.5**	83.3	118.7	1065.6
2445	Memphrémagog	QC	73	1 in 2 60.3 < 100 Bq/m^3 1 in 4 26 100-200 1 in 7 13.7 ≥ 200 Bq/m^3	**83.3**	69.1	100.5	496
2446	Brome-Missisquoi	QC	57	1 in 2 49.1 < 100 Bq/m^3 1 in 4 28.1 100-200 1 in 4 22.8 ≥ 200 Bq/m^3	**98.0**	77.5	123.9	777
2447	La Haute-Yamaska	QC	50	1 in 2 50 < 100 Bq/m^3 1 in 4 28 100-200 1 in 5 22 ≥ 200 Bq/m^3	**87.5**	65.4	117.2	751
2448, 2442, 2440	Acton, Le Val-Saint-François, Les Sources	QC	31	(7 in 10) 71 < 100 Bq/m^3 1 in 8 12.9 100-200 1 in 6 16.1 ≥ 200 Bq/m^3	**63.3**	44.1	90.6	455
2449	Drummond	QC	57	(9 in 10) 91.2 < 100 Bq/m^3 1 in 19 5.3 100-200 1 in 29 3.5 ≥ 200 Bq/m^3	**37.7**	31.0	45.8	278

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2451, 2452	D'Autray, Maskinongé	QC	31	(4 in 5) 1 in 8 1 in 31	83.9 12.9 3.2	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**39.6**	29.7	53.0	229.4
2453, 2450, 2438	Pierre-De Saurel, Nicolet-Yamaska, Bécancour	QC	39	(4 in 5) 1 in 6 1 in 38	79.5 17.9 2.6	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**49.1**	37.6	64.1	211
2454	Les Maskoutains	QC	50	1 in 2 1 in 5 1 in 6	62 20 18	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**74.5**	57.0	97.3	411
2455	Rouville	QC	32	1 in 2 1 in 11 1 in 4	65.6 9.4 25	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**82.7**	59.6	114.9	651
2456	Le Haut-Richelieu	QC	84	1 in 2 1 in 4 1 in 6	56 26.2 17.9	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**86.3**	67.0	111.0	1965
2457	La Vallée-du-Richelieu	QC	474	1 in 3 1 in 3 1 in 4	35.2 38.4 26.4	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**117.4**	108.4	127.3	14652
2458	Longueuil	QC	481	1 in 2 1 in 4 1 in 13	65.3 27.2 7.5	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**69.3**	64.6	74.4	543.9
2459	Marguerite-D'Youville	QC	215	1 in 3 1 in 3 1 in 3	32.1 38.1 29.8	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**127.5**	115.1	141.2	888
2460	L'Assomption	QC	74	(3 in 4) 1 in 7 1 in 8	73 14.9 12.2	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**62.7**	50.9	77.2	447.7
2461	Joliette	QC	34	(9 in 10) 1 in 11 1 in 34	88.2 8.8 2.9	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**44.6**	33.3	59.7	669.7
2462	Matawinie	QC	25	(17 in 20) 1 in 8 1 in 25	84 12 4	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**38.3**	23.2	63.3	834
2463	Montcalm	QC	28	(17 in 20) 1 in 14 1 in 14	85.7 7.1 7.1	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**41.1**	29.8	56.8	285
2464	Les Moulins	QC	75	(7 in 10) 1 in 4 1 in 15	70.7 22.7 6.7	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**60.7**	50.4	73.2	340
2465	Laval	QC	253	1 in 2 1 in 4 1 in 6	56.5 25.7 17.8	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**84.7**	75.2	95.5	1073
2466	Montréal	QC	650	1 in 2 1 in 5 1 in 6	62.3 21.1 16.6	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**76.3**	70.9	82.0	2126
2467	Roussillon	QC	116	1 in 2 1 in 3 1 in 5	40.5 39.7 19.8	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**106.0**	92.0	122.1	851
2468, 2469, 2470	Beauharnois-Salaberry, Le Haut-Saint-Laurent, Les Jardins-de-Napierville	QC	52	1 in 2 1 in 4 1 in 5	55.8 23.1 21.2	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**90.6**	71.4	115.0	707
2471	Vaudreuil-Soulanges	QC	132	1 in 2 1 in 3 1 in 5	49.2 30.3 20.5	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**92.8**	79.5	108.2	585
2472	Deux-Montagnes	QC	185	1 in 2 1 in 3 1 in 4	41.6 30.8 27.6	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**117.8**	102.2	135.9	1221
2473	Thérèse-De Blainville	QC	135	1 in 2 1 in 4 1 in 5	52.6 25.9 21.5	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**88.9**	75.1	105.2	777
2475, 2474	La Rivière-du-Nord, Mirabel	QC	92	1 in 2 1 in 4 1 in 5	58.7 22.8 18.5	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**71.6**	58.7	87.3	573.5
2476	Argenteuil	QC	31	(3 in 4) 1 in 4 #DIV/0!	74.2 25.8 0	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**55.4**	41.7	73.5	196.1
2477	Les Pays-d'en-Haut	QC	60	(9 in 10) 1 in 12 1 in 59	90 8.3 1.7	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**40.8**	32.8	50.7	340
2478	Les Laurentides	QC	43	(4 in 5) 1 in 11 1 in 9	79.1 9.3 11.6	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**47.0**	34.4	64.3	962
2480, 2479	Papineau, Antoine-Labelle	QC	92	1 in 3 1 in 3 1 in 3	37 31.5 31.5	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**123.1**	99.8	151.9	1406
2481	Gatineau	QC	313	1 in 2 1 in 4 1 in 6	55.9 28.1 16	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**84.5**	76.4	93.4	1365.3
2482	Les Collines-de-l'Outaouais	QC	175	1 in 3 1 in 5 1 in 2	35.4 20.6 44	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**144.8**	124.5	168.5	1406

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2486	Rouyn-Noranda	QC	31	(19 in 20) 93.5 < 100 Bq/m^3 1 in 31 3.2 100-200 1 in 31 3.2 ≥ 200 Bq/m^3	**32.1**	23.7	43.6	291
2488	Abitibi	QC	31	1 in 1 100 < 100 Bq/m^3 #DIV/0! 0 100-200 #DIV/0! 0 ≥ 200 Bq/m^3	**32.6**	26.2	40.4	96.2
2489, 2483, 2484, 2487, 2485	La Vallée-de-l'Or, Abitibi-Ouest, Témiscamingue, Pontiac, La Vallée-de-la-Gatineau	QC	60	(2 in 3) 68.3 < 100 Bq/m^3 1 in 4 23.3 100-200 1 in 12 8.3 ≥ 200 Bq/m^3	**58.8**	45.9	75.4	1348
2493, 2491, 2490	Lac-Saint-Jean-Est, Le Domaine-du-Roy, La Tuque	QC	26	(3 in 4) 73.1 < 100 Bq/m^3 1 in 5 19.2 100-200 1 in 13 7.7 ≥ 200 Bq/m^3	**57.1**	41.3	79.1	270.1
2499, 2494, 2492	Nord-du-Québec, Le Saguenay-et-son-Fjord, Maria-Chapdelaine	QC	92	(4 in 5) 80.4 < 100 Bq/m^3 1 in 7 14.1 100-200 1 in 19 5.4 ≥ 200 Bq/m^3	**49.1**	40.7	59.3	781
3501	Stormont, Dundas and Glengarry	ON	28	(2 in 3) 67.9 < 100 Bq/m^3 1 in 3 28.6 100-200 1 in 28 3.6 ≥ 200 Bq/m^3	**53.1**	37.8	74.5	216
3502	Prescott and Russell	ON	71	(3 in 4) 73.2 < 100 Bq/m^3 1 in 6 16.9 100-200 1 in 10 9.9 ≥ 200 Bq/m^3	**61.3**	48.7	77.2	840
3506	Ottawa	ON	1349	1 in 2 63.4 < 100 Bq/m^3 1 in 4 24.6 100-200 1 in 8 12 ≥ 200 Bq/m^3	**72.8**	69.3	76.5	1889
3507	Leeds and Grenville	ON	220	1 in 2 46.4 < 100 Bq/m^3 1 in 4 22.3 100-200 1 in 3 31.4 ≥ 200 Bq/m^3	**113.0**	98.6	129.6	3165
3509	Lanark	ON	114	1 in 3 31.6 < 100 Bq/m^3 1 in 4 26.3 100-200 1 in 2 42.1 ≥ 200 Bq/m^3	**137.6**	112.9	167.9	1464
3510	Frontenac	ON	214	1 in 2 52.3 < 100 Bq/m^3 1 in 4 24.3 100-200 1 in 4 23.4 ≥ 200 Bq/m^3	**74.8**	62.7	89.3	847
3511	Lennox and Addington	ON	38	1 in 3 34.2 < 100 Bq/m^3 1 in 5 21.1 100-200 1 in 2 44.7 ≥ 200 Bq/m^3	**130.7**	90.7	188.2	430
3512	Hastings	ON	56	1 in 2 57.1 < 100 Bq/m^3 1 in 5 21.4 100-200 1 in 5 21.4 ≥ 200 Bq/m^3	**67.3**	47.4	95.4	600
3513	Prince Edward	ON	85	1 in 2 41.2 < 100 Bq/m^3 1 in 3 31.8 100-200 1 in 4 27.1 ≥ 200 Bq/m^3	**102.1**	81.4	128.2	551
3514	Northumberland	ON	39	(3 in 4) 74.4 < 100 Bq/m^3 1 in 10 10.3 100-200 1 in 6 15.4 ≥ 200 Bq/m^3	**37.7**	23.1	61.6	349
3515	Peterborough	ON	60	(7 in 10) 70 < 100 Bq/m^3 1 in 9 11.7 100-200 1 in 5 18.3 ≥ 200 Bq/m^3	**73.9**	55.6	98.2	2809
3518	Durham	ON	114	(17 in 20) 87.7 < 100 Bq/m^3 1 in 16 6.1 100-200 1 in 16 6.1 ≥ 200 Bq/m^3	**41.9**	35.5	49.5	416
3519	York	ON	177	(9 in 10) 89.3 < 100 Bq/m^3 1 in 15 6.8 100-200 1 in 25 4 ≥ 200 Bq/m^3	**37.5**	33.2	42.4	369
3520	Toronto	ON	387	(17 in 20) 86.3 < 100 Bq/m^3 1 in 8 12.4 100-200 1 in 77 1.3 ≥ 200 Bq/m^3	**40.3**	36.7	44.2	358
3521	Peel	ON	113	(4 in 5) 81.4 < 100 Bq/m^3 1 in 7 14.2 100-200 1 in 23 4.4 ≥ 200 Bq/m^3	**45.5**	38.3	54.1	557
3522	Dufferin	ON	74	1 in 2 64.9 < 100 Bq/m^3 1 in 4 24.3 100-200 1 in 9 10.8 ≥ 200 Bq/m^3	**66.7**	54.2	82.1	489
3523	Wellington	ON	798	1 in 2 62.4 < 100 Bq/m^3 1 in 4 24.9 100-200 1 in 8 12.7 ≥ 200 Bq/m^3	**71.2**	66.8	75.9	940
3524	Halton	ON	230	(2 in 3) 68.7 < 100 Bq/m^3 1 in 5 21.7 100-200 1 in 10 9.6 ≥ 200 Bq/m^3	**66.3**	59.0	74.5	1013
3525	Hamilton	ON	1011	(2 in 3) 67.5 < 100 Bq/m^3 1 in 5 19.8 100-200 1 in 8 12.8 ≥ 200 Bq/m^3	**71.6**	67.7	75.7	2473
3526	Niagara	ON	95	(3 in 4) 73.7 < 100 Bq/m^3 1 in 7 14.7 100-200 1 in 9 11.6 ≥ 200 Bq/m^3	**62.9**	51.3	77.0	857
3529, 3528	Brant, Haldimand-Norfolk	ON	50	(2 in 3) 68 < 100 Bq/m^3 1 in 5 22 100-200 1 in 10 10 ≥ 200 Bq/m^3	**76.1**	60.7	95.4	476
3530	Waterloo	ON	258	1 in 2 63.2 < 100 Bq/m^3 1 in 4 26.4 100-200 1 in 10 10.5 ≥ 200 Bq/m^3	**72.3**	64.9	80.6	1009

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3531	Perth	ON	33	1 in 2 1 in 7 1 in 5	63.6 15.2 21.2	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**87.3**	63.1	120.7	746
3532	Oxford	ON	27	1 in 2 1 in 3 1 in 5	51.9 29.6 18.5	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**92.5**	63.2	135.4	1144
3534	Elgin	ON	185	(3 in 4) 1 in 5 1 in 37	77.3 20 2.7	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**58.3**	52.3	64.9	528
3536	Chatham-Kent	ON	44	1 in 2 1 in 3 1 in 5	45.5 34.1 20.5	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**109.7**	81.2	148.1	1092
3537	Essex	ON	145	1 in 2 1 in 3 1 in 7	52.4 33.1 14.5	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**99.3**	89.0	110.8	548
3538	Lambton	ON	42	1 in 2 1 in 5 1 in 5	61.9 19 19	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**86.7**	66.9	112.5	567
3539	Middlesex	ON	139	(3 in 4) 1 in 5 1 in 23	74.1 21.6 4.3	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**63.8**	56.8	71.7	664
3540	Huron	ON	27	1 in 2 1 in 3 1 in 9	55.6 33.3 11.1	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**89.9**	64.6	125.0	665
3541	Bruce	ON	43	1 in 2 1 in 3 1 in 7	53.5 32.6 14	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**62.0**	42.1	91.4	718
3542	Grey	ON	63	(2 in 3) 1 in 8 1 in 5	66.7 12.7 20.6	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**73.8**	54.3	100.3	2756
3543	Simcoe	ON	150	(4 in 5) 1 in 7 1 in 21	80 15.3 4.7	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**46.3**	39.4	54.5	733
3544, 3546, 3516	Haliburton, Muskoka, Kawartha Lakes	ON	45	(2 in 3) 1 in 5 1 in 9	66.7 22.2 11.1	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**65.7**	47.8	90.3	492
3547	Renfrew	ON	192	1 in 2 1 in 4 1 in 3	45.3 25.5 29.2	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**106.1**	92.2	122.1	946
3548, 3549	Parry Sound, Nipissing	ON	30	(2 in 3) 1 in 4 1 in 10	66.7 23.3 10	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**60.0**	40.6	88.5	471
3557, 3552, 3556, 3554, 3553	Algoma, Cochrane, Timiskaming, Greater Sudbury / Grand Sudbury, Sudbury	ON	60	1 in 2 1 in 3 1 in 8	55 31.7 13.3	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**86.1**	67.8	109.2	1799
3558	Thunder Bay	ON	896	1 in 3 1 in 3 1 in 3	34.4 30.8 34.8	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**132.6**	123.6	142.2	32321
3560, 3559	Kenora, Rainy River	ON	32	1 in 5 1 in 3 1 in 2	21.9 34.4 43.8	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**156.3**	126.2	193.6	448
4602, 4601	Division No. 2, Division No. 1	MB	95	1 in 3 1 in 3 1 in 4	33.7 37.9 28.4	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**129.3**	110.1	151.9	720
4606, 4605, 4604, 4603	Division No. 6, Division No. 5, Division No. 4, Division No. 3	MB	25	1 in 4 1 in 4 1 in 2	24 24 52	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**221.9**	141.5	348.1	1763
4607	Division No. 7	MB	86	1 in 3 1 in 3 1 in 3	32.6 32.6 34.9	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**144.7**	125.0	167.4	559
4608, 4615, 4616	Division No. 16, Division No. 15, Division No. 8	MB	59	1 in 12 1 in 6 (3 in 4)	8.5 16.9 74.6	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**325.3**	259.5	407.7	1569
4610, 4614, 4613, 4612, 4617, 4618, 4609	Division No. 18, Division No. 17, Division No. 14, Division No. 13, Division No. 12, Division No. 10, Division No. 9	MB	175	1 in 8 1 in 4 1 in 2	12.6 22.3 65.1	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**280.9**	241.0	327.4	3567
4611	Division No. 11	MB	392	1 in 3 1 in 3 1 in 3	32.4 33.2 34.4	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**133.6**	121.6	146.8	1176
4702, 4701	Division No. 2, Division No. 1	SK	35	1 in 6 1 in 2 1 in 3	17.1 48.6 34.3	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**153.3**	117.3	200.2	750
4704, 4703	Division No. 4, Division No. 3	SK	33	1 in 5 1 in 3 1 in 2	18.2 30.3 51.5	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**192.4**	146.6	252.5	885
4705	Division No. 5	SK	37	1 in 6 1 in 2 1 in 4	16.2 56.8 27	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**157.5**	118.8	208.9	881
4706	Division No. 6	SK	818	1 in 4 1 in 3 1 in 2	23 31.1 46	< 100 Bq/m^3 100-200 ≥ 200 Bq/m^3	**181.3**	169.6	193.9	11333

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4707	Division No. 7	SK	50	1 in 3 32 < 100 Bq/m^3 1 in 2 42 100-200 1 in 4 26 ≥ 200 Bq/m^3	**124.3**	99.4	155.4	1258
4708	Division No. 8	SK	70	1 in 4 22.9 < 100 Bq/m^3 1 in 3 40 100-200 1 in 3 37.1 ≥ 200 Bq/m^3	**165.5**	135.2	202.6	1704
4709	Division No. 9	SK	30	1 in 3 36.7 < 100 Bq/m^3 1 in 3 33.3 100-200 1 in 3 30 ≥ 200 Bq/m^3	**126.3**	93.4	170.8	443
4711	Division No. 11	SK	707	1 in 3 37.9 < 100 Bq/m^3 1 in 2 43.8 100-200 1 in 5 18.2 ≥ 200 Bq/m^3	**107.7**	101.6	114.1	1678
4713, 4712	Division No. 13, Division No. 12	SK	55	1 in 3 30.9 < 100 Bq/m^3 1 in 3 38.2 100-200 1 in 3 30.9 ≥ 200 Bq/m^3	**133.1**	107.1	165.6	906
4714, 4710	Division No. 14, Division No. 10	SK	47	1 in 4 27.7 < 100 Bq/m^3 1 in 3 31.9 100-200 1 in 2 40.4 ≥ 200 Bq/m^3	**153.2**	119.9	195.6	2225
4715	Division No. 15	SK	68	1 in 3 35.3 < 100 Bq/m^3 1 in 3 38.2 100-200 1 in 4 26.5 ≥ 200 Bq/m^3	**116.9**	98.2	139.1	473
4717, 4716	Division No. 17, Division No. 16	SK	53	1 in 4 28.3 < 100 Bq/m^3 1 in 2 43.4 100-200 1 in 4 28.3 ≥ 200 Bq/m^3	**130.1**	102.5	165.2	1800
4718	Division No. 18	SK	61	1 in 2 50.8 < 100 Bq/m^3 1 in 3 37.7 100-200 1 in 9 11.5 ≥ 200 Bq/m^3	**77.4**	58.9	101.7	642
4801	Division No. 1	AB	177	1 in 2 57.1 < 100 Bq/m^3 1 in 3 31.6 100-200 1 in 9 11.3 ≥ 200 Bq/m^3	**91.7**	83.4	100.7	508
4802	Division No. 2	AB	407	1 in 2 43 < 100 Bq/m^3 1 in 2 40.3 100-200 1 in 6 16.7 ≥ 200 Bq/m^3	**110.4**	103.3	118.1	1959
4803	Division No. 3	AB	128	1 in 3 34.4 < 100 Bq/m^3 1 in 3 29.7 100-200 1 in 3 35.9 ≥ 200 Bq/m^3	**143.8**	122.7	168.5	1337
4804	Division No. 4	AB	33	1 in 3 39.4 < 100 Bq/m^3 1 in 3 36.4 100-200 1 in 4 24.2 ≥ 200 Bq/m^3	**122.7**	98.4	153.2	407
4805	Division No. 5	AB	217	1 in 3 34.1 < 100 Bq/m^3 1 in 3 37.3 100-200 1 in 3 28.6 ≥ 200 Bq/m^3	**131.1**	117.6	146.2	1175
4806	Division No. 6	AB	17203	1 in 2 45.4 < 100 Bq/m^3 1 in 3 37.6 100-200 1 in 6 17.1 ≥ 200 Bq/m^3	**102.8**	101.5	104.0	7199
4807	Division No. 7	AB	47	1 in 4 25.5 < 100 Bq/m^3 1 in 2 44.7 100-200 1 in 3 29.8 ≥ 200 Bq/m^3	**140.3**	115.5	170.3	802.8
4808	Division No. 8	AB	422	1 in 2 44.1 < 100 Bq/m^3 1 in 3 30.3 100-200 1 in 4 25.6 ≥ 200 Bq/m^3	**110.7**	102.2	119.8	1333
4809	Division No. 9	AB	41	1 in 3 36.6 < 100 Bq/m^3 1 in 2 41.5 100-200 1 in 5 22 ≥ 200 Bq/m^3	**114.9**	87.8	150.4	1231
4810	Division No. 10	AB	154	1 in 2 44.8 < 100 Bq/m^3 1 in 3 36.4 100-200 1 in 5 18.8 ≥ 200 Bq/m^3	**102.1**	90.4	115.2	479
4811	Division No. 11	AB	4397	1 in 2 43.2 < 100 Bq/m^3 1 in 3 39.5 100-200 1 in 6 17.3 ≥ 200 Bq/m^3	**108.3**	106.1	110.5	1493
4812	Division No. 12	AB	85	1 in 2 42.4 < 100 Bq/m^3 1 in 3 34.1 100-200 1 in 4 23.5 ≥ 200 Bq/m^3	**113.8**	98.4	131.6	455
4813	Division No. 13	AB	92	1 in 2 40.2 < 100 Bq/m^3 1 in 3 39.1 100-200 1 in 5 20.7 ≥ 200 Bq/m^3	**109.2**	92.1	129.4	716
4814	Division No. 14	AB	54	1 in 2 50 < 100 Bq/m^3 1 in 4 27.8 100-200 1 in 5 22.2 ≥ 200 Bq/m^3	**96.5**	74.1	125.7	691
4815	Division No. 15	AB	276	1 in 2 55.1 < 100 Bq/m^3 1 in 4 25.7 100-200 1 in 5 19.2 ≥ 200 Bq/m^3	**90.1**	80.2	101.2	1492
4819, 4818	Division No. 19, Division No. 18	AB	191	1 in 2 64.4 < 100 Bq/m^3 1 in 3 28.8 100-200 1 in 15 6.8 ≥ 200 Bq/m^3	**76.4**	68.7	84.9	490
5901	East Kootenay	BC	689	1 in 2 48 < 100 Bq/m^3 1 in 4 23.1 100-200 1 in 3 28.9 ≥ 200 Bq/m^3	**104.8**	96.9	113.3	4074
5903	Central Kootenay	BC	2837	1 in 3 30.7 < 100 Bq/m^3 1 in 4 27.7 100-200 1 in 2 41.6 ≥ 200 Bq/m^3	**162.2**	156.5	168.1	10600
5905	Kootenay Boundary	BC	745	1 in 3 34.2 < 100 Bq/m^3 1 in 3 31.9 100-200 1 in 3 33.8 ≥ 200 Bq/m^3	**145.1**	135.9	154.9	2557

Census Division ID	Name of Census Division or Census Division Cluster	Census Division Province(s)	Number of Radon Readings	1 in X houses (%) are in this radon exposure category			**Geometric Mean Radon Level (Bq/m^3)**	Lower 95% Confidence Interval	Upper 95% Confidence Interval	Maximum Observed Radon Level to Date (Bq/m^3)
5907	Okanagan-Similkameen	BC	827	1 in 2 1 in 4 1 in 3	44.4 25.5 30.1	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**117.0**	108.4	126.2	3262
5909	Fraser Valley	BC	708	(3 in 4) 1 in 6 1 in 14	75.6 17.5 6.9	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**53.7**	50.3	57.2	3250
5915	Greater Vancouver	BC	1476	(19 in 20) 1 in 36 1 in 111	96.3 2.8 0.9	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**18.3**	17.3	19.3	624
5917	Capital	BC	990	(37 in 40) 1 in 19 1 in 56	92.9 5.3 1.8	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**23.7**	22.2	25.2	989
5919	Cowichan Valley	BC	94	(9 in 10) 1 in 23 1 in 19	90.4 4.3 5.3	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**38.5**	32.0	46.2	651
5921	Nanaimo	BC	386	(39 in 40) 1 in 77 1 in 100	97.7 1.3 1	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**18.4**	16.9	20.0	483
5923	Alberni-Clayoquot	BC	31	(39 in 40) 1 in 31 NA	96.8 3.2 0	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**5.6**	3.5	9.2	186
5924	Strathcona	BC	36	(3 in 4) 1 in 5 1 in 18	75 19.4 5.6	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**36.2**	21.5	60.9	540
5926	Comox Valley	BC	61	(19 in 20) 1 in 30 1 in 63	95.1 3.3 1.6	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**21.2**	16.6	27.2	206
5927	Powell River	BC	27	(37 in 40) 1 in 14 NA	92.6 7.4 0	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**22.4**	13.9	36.2	155
5929	Sunshine Coast	BC	35	(19 in 20) 1 in 34 1 in 34	94.3 2.9 2.9	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**28.6**	21.8	37.7	333
5931	Squamish-Lillooet	BC	183	(19 in 20) 1 in 30 1 in 91	95.6 3.3 1.1	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**24.2**	21.0	27.9	529
5933	Thompson-Nicola	BC	744	1 in 2 1 in 5 1 in 4	51.9 21 27.2	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**108.1**	99.9	117.1	2190
5935	Central Okanagan	BC	3615	1 in 2 1 in 3 1 in 4	40.4 31.1 28.5	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**120.9**	117.2	124.6	5073
5937	North Okanagan	BC	921	1 in 3 1 in 3 1 in 3	39.8 31.2 29	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**124.7**	118.3	131.5	4356
5939	Columbia-Shuswap	BC	1085	1 in 3 1 in 3 1 in 3	38.7 28.8 32.5	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**134.1**	126.6	142.0	4527
5941	Cariboo	BC	357	(3 in 4) 1 in 6 1 in 13	76.2 16 7.8	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**58.2**	53.0	64.0	973
5945, 5943	Central Coast, Mount Waddington	BC	49	(4 in 5) 1 in 10 1 in 12	81.6 10.2 8.2	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**38.1**	27.1	53.6	927
5947	Skeena-Queen Charlotte	BC	140	(99 in 1 in 143 NA	99.3 0.7 0	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**9.9**	8.3	11.8	103
5949	Kitimat-Stikine	BC	211	(3 in 4) 1 in 6 1 in 14	75.8 17.1 7.1	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**47.4**	41.6	54.1	1052
5951	Bulkley-Nechako	BC	148	(3 in 4) 1 in 7 1 in 10	75.7 14.2 10.1	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**51.1**	42.8	60.9	727
5953	Fraser-Fort George	BC	2936	1 in 2 1 in 4 1 in 3	46.6 23.5 29.9	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**108.3**	104.2	112.5	5446
5955	Peace River	BC	261	(3 in 4) 1 in 8 1 in 9	77 11.9 11.1	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**56.0**	50.2	62.5	1251
5957	Stikine	BC	36	1 in 2 1 in 5 1 in 5	61.1 19.4 19.4	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**77.2**	55.3	107.7	688
5959	Northern Rockies	BC	83	(4 in 5) 1 in 7 1 in 21	80.7 14.5 4.8	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**59.2**	51.4	68.0	377
6001	Yukon	YT	1399	1 in 2 1 in 4 1 in 4	50.3 25.9 23.7	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**101.0**	95.4	106.9	3364
6106, 6105, 4816, 4817	Region 6, Region 5, Division No. 17, Division No. 16	AB, NT	110	1 in 2 1 in 4 1 in 9	65.5 23.6 10.9	< 100 Bq/m³ 100-200 ≥ 200 Bq/m³	**73.6**	61.8	87.7	576

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