Radiological Protection Institute of Ireland
An Institiúid Éireannach um Chosaint Raideolaíoch

Feidhmeannacht na Seirbhíse Sláinte
Health Service Executive

Radon Gas in Ireland
Joint Position Statement by the Radiological Protection Institute of Ireland and the Health Service Executive

Foreword

This position statement is written by the Health Service Executive (HSE) and the Radiological Protection Institute of Ireland (RPII) with a view to informing and influencing policy in this area. It provides a summary of the health risks associated with radon exposure in Ireland and the steps that can be taken to reduce those risks. It outlines suggested on-going work to reduce both the population dose from radon and the individual dose to those most at risk and considers future work needed to improve national policy to achieve these objectives.

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1. Introduction

Radon is a naturally occurring radioactive gas formed in the ground by the radioactive decay of uranium which is present in varying quantities in all rocks and soils. Radon has no colour, taste or smell. It is measured with radon detectors. Outdoors it is not a problem but, being a gas, radon can seep into buildings from the ground and can sometimes accumulate to very high concentrations.

On the basis of epidemiological studies, long term exposure to radon has been shown to increase the risk of lung cancer [International Agency for Research on Cancer, 1988]. In the air, radon decays quickly to produce radioactive particles that, when inhaled, are deposited in the airways and on lung tissue. This results in a radiation dose that can lead to lung cancer.

Radon is the principal source of radiation exposure in Ireland, representing over 56% of the dose received by the Irish population [Colgan *et al.*, 2008]. In terms of reducing our exposure to radiation, radon is the area where the greatest impact is possible. The average indoor radon concentration in Ireland is 89 becquerels per cubic metre (Bq/m^3)[1] [Fennell *et al.*, 2002]. This is the eighth highest average concentration in the world [WHO, 2009]. Some of the highest radon concentrations found anywhere in Europe have been found in homes and workplaces in Ireland.

2. Guidelines

The Reference Level for long term exposure to radon in homes is 200 Bq/m^3 measured in accordance with the RPII's measurement protocol [RPII, 2008a]. The Reference Level is not a rigid boundary between safety and danger but a guideline as to when one should consider taking action to reduce the radon concentration. Living in radon concentrations above the Reference Level should be avoided.

The risks posed by long term exposure to radon at the Reference Level are similar to other everyday risks such as death from road traffic accidents, 291 in 2006, or accidents in the home, 304 in 2006. There were 83 deaths from cancer of the cervix in 2006 [Central Statistics Office Ireland, 2006]. The Reference Level for workplaces specified in national legislation is 400 Bq/m^3 [Stationery Office, 2000]. If radon concentrations above this value are found then remedial action to reduce the concentrations is likely to be needed [RPII, 2008b]. The higher Reference Level in workplaces takes account of the lower occupancy rates in workplaces when compared to homes. This Reference Level is in line with those in other European countries and at the lower end of that recommended by international bodies [European Radon Research and Industry Collaboration Concerted Action, 2005].

3. Public Health Implications

Radon gas is a naturally occurring cause of lung cancer. Since 2000, there have been three major publications setting out the results of pooled residential case controlled studies of

[1] Radioactivity is measured in units called becquerels (Bq). One becquerel corresponds to one radioactive disintegration per second.

radon exposure in Europe, North America and China [Darby *et al.*, 2004; Krewski *et al.*, 2005 and Lubin et al., 2004]. Each of these joint analyses demonstrated an increased risk of lung cancer with increasing exposure in the home. Furthermore, these studies demonstrate an increased risk at radon concentrations in the home below 200 Bq/m^3.

Based on current epidemiological evidence it is estimated that between 150 and 200 lung cancer deaths in Ireland every year can be linked to radon. Of those cases of lung cancer that are linked to radon, approximately 90% will be observed in active and ex-smokers [RPII and NCRI, 2005]. The level of individual risk from radon depends on how high a radon level a person is exposed to and for how long, and whether or not a person smokes. Radon is not linked to other cancers or to respiratory disorders.

For each individual case of lung cancer there is no way of proving what caused it, whether it was the smoking habits of the patient or exposure to another factor such as passive smoking or radon. Most lung cancer cases are due to smoking.

Recent data from the UK estimates that more than four fifths (83%) of lung cancer cases there are due to smoking. Less than one percent (0.5%) of lung cancer cases are due to radon only [Gray *et al.*, 2009]. The effects of smoking and radon combine to cause about another three percent (2.8%) of lung cancer cases. The remaining cases of lung cancer, about fourteen percent (13.6%), are due to other causes such as passive smoking. It follows that reducing radon exposure can impact on the lung cancer cases due to radon (0.5%) and those cases due to the combined effect of smoking and radon (2.8%), or 3.3% of the total number of lung cancer cases. These figures apply to the UK where the mean indoor radon concentration of radon is 20 Bq/m^3.

The absolute risk of developing lung cancer depends on one's exposure to tobacco smoke. The risks of contracting lung cancer before age 75 at radon concentrations of 0, 100, 200 and 400 Bq/m^3 for lifelong non-smokers are estimated as 0.41%, 0.47%, 0.55% and 0.67%, respectively. For active smokers, the corresponding rounded values are approximately 25 times higher at 10%, 12%, 13% and 16%. Ex-smokers are at significant risk from radon for a number of years after they have stopped smoking. Each 100 Bq/m^3 increase in mean radon concentration increases the risk of lung cancer by 16% [Darby *et al.*, 2004].

The above can be summarised as follows:

- Non-Smoker, little radon exposure – LEAST RISK
- Non-Smoker, some radon exposure – SOME RISK
- Smoker, little radon exposure – INCREASED RISK
- Smoker with radon exposure – GREATEST RISK

In Ireland, the mean indoor radon concentration is 89 Bq/m^3; this is high in international terms according to the World Health Organisation (WHO) 2009 Handbook on Indoor Radon where the worldwide mean for indoor radon concentration is listed as 39 Bq/m^3. The mean indoor radon concentration in the UK, for example, is significantly lower at 20 Bq/m^3. As the increased mean radon concentration is associated with an increase in risk of lung cancer, it follows that the potential benefit of reducing exposure to radon in Ireland is greater.

Based upon current epidemiological evidence, it is estimated that in Ireland, for the population as a whole, a lifetime exposure to radon in the home at the Reference Level of 200 Bq/m^3 carries a risk of about 1 in 50 (2%) of contracting fatal lung cancer. The risk is much lower for non-smokers and far greater, than this average value, for smokers.

Reducing the radon concentration and quitting smoking will immediately reduce the risk from lung cancer.

Reducing the level of risk from radon involves

- appropriate building construction practices to prevent the accumulation of radon in new homes
- building remediation when indicated by radon testing and
- the provision of smoking cessation services.

4. Scope of the Problem in Ireland

The National Radon Survey (NRS) of radon concentrations in Irish homes was conducted by the RPII during the 1990s [Fennell *et al.*, 2002]. Measurements were made in 11,319 randomly selected homes over a 12 month period. The results of the survey enabled High Radon Areas to be identified. These areas are shown on the map of Radon in Irish Dwellings, see Appendix 1. A High Radon Area (HRA) is one where 10% or more of homes are predicted to have radon concentrations above the Reference Level.

Approximately one-third of the country, mainly in the west and the south-east, is designated as a HRA[2]. While homes with high radon concentrations are more likely to be found in High Radon Areas, high radon concentrations can be found in any part of the country. The RPII and HSE recommend that all householders, especially those in High Radon Areas should test for radon.

The National Radon Survey predicts that over 91,000 homes in the country (or about 7% of the national building stock) have high radon concentrations [Fennell *et al.*, 2002]. This prediction is based on the housing statistics in 2000. Given the large increase in the number of housing units in recent years, it is likely that even more homes now have radon concentrations above the Reference Level. This means that over 255,000 people may be living in homes with high radon concentrations, assuming an average of 2.81 people per household [Central Statistics Office Ireland, 2007].

[2] The radon map of Ireland can be viewed in more detail on the RPII's website – www.rpii.ie

5. Radon Measurements Carried Out in Ireland[3]

5.1 Radon in Homes

While the measurement of radon in the workplace is governed by legislation there is no equivalent legislation for homes.

Of the 37,500 homes measured by the RPII up to December 2009, 4900 were found to be above the Reference Level[4]. This is just over 5% of the 91,000 homes predicted to have high radon concentrations.

5.2 Radon in Schools

A comprehensive survey of radon concentrations in schools was undertaken between 1998 and 2004 [Synnott *et al.*, 2004, Synnott *et al.*, 2006 and Synnott *et al.*, 2007]. During the six years of the survey over 38,500 individual radon measurements were made in 3826 schools representing over 95% of all schools in the country. Of those schools measured, 329 (9%) were found to have one or more rooms with radon concentrations above 400 Bq/m^3. The average radon concentration in schools was 93 Bq/m^3, similar to that reported in the National Radon Survey of homes. Schools with high radon concentrations were found with greater frequency in High Radon Areas.

5.3 Radon in Workplaces

The RPII has carried out a study to assess exposure to radon in Irish workplaces [Colgan *et al.*, 2008]. Five individual sets of measurement data from other Radon Measurement Services have been included. In addition to data from schools, over 15,000 measurements in 2250 above-ground workplaces were evaluated. The average radon concentration in these workplaces was 81 Bq/m^3.

Workers in mines and show caves are occupationally exposed to radon. Four such working environments are routinely monitored in Ireland. The number of exposed workers is less than 50 and to date, doses received have been less than the statutory limit of 20 mSv per year.

About 95% of the total occupational dose to radiation is due to exposure to radon in above-ground workplaces. The reason that radon makes such a large contribution to the total occupational radiation dose is that it is present in all workplaces and therefore all workers are exposed to it to some extent. The implementation of the Public Health Tobacco Acts 2002 and 2004 introducing a ban on smoking in the workplace will reduce the occupational risk from radon.

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[3] The RPII and other private companies offer a radon measurement service to the public. Further details are available on www.rpii.ie

[4] The RPII publishes statistics of radon measurements it has made in each county on its website www.rpii.ie This information is updated every 6 months.

6. National Protocol for Dealing with Extremely High Radon Levels in Homes and Workplaces

In 2007, the RPII introduced a protocol advising a graded approach to respond to reported average radon concentrations in homes and workplaces above the Reference Level [RPII, 2007]. This protocol is summarised as follows:

Homes (Bq/m^3)	Workplaces (Bq/m^3)	Proposed Actions
200	400	Write to customer recommending remedial action is taken
800	2600	As above and phone customer
2000	6500	As above and issue public statement
›4000	›13,000	As above and take local public awareness action. Engage with other statutory agencies and local authority

A radon measurement in a home above 800 Bq/m^3 can be described as "very high". To date, 450 homes and 12 workplaces have been identified with very high radon levels in Ireland. The maximum radon concentration identified to date is 49,000 Bq/m^3 found in a home in Castleisland, Co Kerry in 2003.

The highest value found in an above-ground workplace was 25,000 Bq/m^3 in Mallow, Co Cork in 2007.

7. Legislative Framework

7.1 Exposure to Radon in the Workplace

S.I. No. 125 of 2000, which is regulated by the RPII, sets a radon concentration of 400 becquerels per cubic metre (Bq/m^3), measured over any consecutive three-month period, as the Reference Level for radon in Irish workplaces [Stationery Office, 2000]. When this Reference Level is exceeded, the employer must take measures to protect the health of workers [RPII, 2008b].

These regulations empower the RPII to direct employers to measure radon and to prosecute those who fail to comply with the regulations. In 2006, the RPII prosecuted six employers in Tralee and Ennis for failing to comply with a direction to measure radon in their workplaces. In all cases defendants were fined and ordered to pay costs. Three defendants were convicted.

The Safety, Health and Welfare at Work Act 2005, which is regulated by the Health and Safety Authority (HSA) requires employers to identify all hazards in their workplace, including radon, to assess the risk to health and safety from these hazards and to put in place measures to eliminate or reduce the risk. [Stationery Office, 2005] According to the HSA, all occupied indoor workplaces in High Radon Areas located at ground floor or basement level must be measured for radon. In respect of workplaces located in other areas, radon must be referred to in the company's safety statement.

7.2 Radon Prevention in New Buildings

The Department of the Environment, Heritage & Local Government (DEHLG) has published guidance on radon prevention measures for new homes [DEHLG, 2008]. This guidance sets out measures to be installed in new homes that may be used to demonstrate compliance with the Building Regulations 1997. All homes built since July 1st 1998 must be fitted with a standby radon sump which can be activated at a later stage, to reduce any high radon concentrations subsequently found. For homes located in High Radon Areas, the installation of a radon barrier as well as a standby radon sump is required.

8. Policy, Awareness Efforts and Interventions

In 2000, the Attorney General advised the State of the need to inform the public of the advisability of testing premises for radon remediation of buildings having high concentrations [Office of Attorney General, 2000]. Similarly, in 2004 the State Claims Agency identified radon in State workplaces as a potential source of litigation. It recommended that all State employers should test their workplaces for radon and carry out remedial work if necessary.

Under the aegis of the RPII Memorandum of Understanding (MoU) with the Health and Safety Authority (HSA), the RPII works closely with the HSA to support the inclusion of radon in their inspections of workplaces [RPII and HSA, 2006].

Such policies seek to reduce the threat to those most at risk from radon however the objectives of a national radon policy is not only to minimise the individual's risk but also to reduce the collective (population) dose from radon. It is through reducing the collective dose from radon which will over time have a greater impact in reducing the number of lung cancers due to radon.

8.1 Ongoing Work to Reduce the Dose to those Individuals Most at Risk from Radon by Reducing Radon Levels in Existing Homes.

This work includes:

- Work with Local Authorities to encourage and support them to undertake radon measurement and remediation in social housing.
- Public awareness efforts, carried out since 2004 in many High Radon Areas. These have included public meetings, local radio and print advertising and press releases.
- Making public statements particularly when very high radon concentrations are identified and focused press releases highlighting the extent of the radon problem in selected counties.
- Hosting the annual National Radon Forum which attracts a significant amount of media interest. The Forum brings people together who have a role to play in helping to reduce the risk from radon in Ireland[5].

[5] Full details of the RPII's public awareness efforts including all press releases and information on the National Radon Forum is on the RPII website www.rpii.ie

8.1.1 Interventions – Fixing Radon Problems in Existing Homes

Homes identified as having high radon concentrations can be remediated using relatively straightforward and inexpensive building methods. Work can be carried out without undue disruption to the house and should not require the house to be vacated while the work is carried out. A detailed description of the radon remediation techniques is covered elsewhere and outside the scope of this document [RPII, 2005 and DEHLG, 2002]. It is most important that a post remediation radon measurement be carried out after completion of the remedial work. This measurement should be made in accordance with the RPII measurement protocol as this is the only way of confirming that the radon concentrations are below the Reference Level. A training course in radon remediation is run by FÁS[6].

The Scheme of Housing Aid for Older People was extended in 2007 to include radon remediation[7]. This scheme is available to assist older people, generally over 60 years, to have necessary repair or improvements carried out to their homes. Where works are being grant-aided under this scheme, Local Authorities may provide additional support for radon remediation works.

8.2 Ongoing Work to Reduce the Collective Dose – Preventing Radon Problems in New Homes and Reducing Levels in Existing Homes

Radon is the largest single component of the collective radiation dose in Ireland [Colgan *et al.*, 2008]. Work towards reducing this dose requires that the national average radon concentration be reduced. Efforts to reduce the national average radon concentration include:

- Work to include radon in the conveyancing process. The RPII considers that radon measurement and, where necessary, remediation at the time of sale and/or purchase of buildings is an appropriate mechanism to increase the number of radon measurements and reduce the collective dose. This is in line with the current thinking of the WHO [2009]. A study to look at the feasibility of including radon measurement and remediation in the conveyancing process warrants serious consideration [RPII, 2006].

- Regulations which specify the radon preventive measures required in new homes in Ireland are set out in section 7 above. It is recognised that proper implementation of building regulations requiring the correct installation of radon preventive measures in new buildings will over time reduce the average level of radon and decrease the number of new houses above the Reference Level [RPII, 2006].

[6] Details of the radon remediation course are available from FÁS. www.FÁS.ie
[7] Information on this Scheme is available from the Department of the Environment Heritage and Local Government. www.environ.ie

9. Development of a National Radon Strategy for Ireland

An effective response to the radon problem in Ireland will involve a range of measures both to reduce high radon levels in existing buildings and to prevent the problem occurring in new buildings. This response will require input from a range of public authorities and other agencies. The HSE and RPII believe that radon is a significant public health problem which requires a coordinated national response. Furthermore, HSE and RPII believe it is timely now to develop a National Radon Strategy, which will form the basis for a coordinated response for the future. The reasons why it is appropriate to develop a strategy at this time include:

- In 2009, the WHO published its Handbook on Indoor Radon – a Public Health Perspective [WHO, 2009]. This handbook sets out a framework for development of national radon programmes. A number of European countries are currently reviewing their approach in light of this publication.
- New epidemiological evidence published between 2004 and 2006 established a direct link between exposure to radon in the home and an increased risk for lung cancer [Darby *et al.*, 2004; Krewski *et al.*, 2005 and Lubin *et al.*, 2004].
- There is an increasing body of experience on remediation and prevention of radon in homes in Ireland and elsewhere.
- The majority of deaths from lung cancer due to radon occur in the large percentage of the population exposed to modest radon levels.
- The revised EU Basic Safety Standards Directive, due to be published in 2011, will require EU Member States to implement a radon control strategy[8].
- In addition, other international bodies such as the WHO, International Commission for Radiological Protection (ICRP), the UK Health Protection Agency (UKHPA) and the International Atomic Energy Agency (IAEA) have recently issued or are developing new guidelines[9] [ICRP, 2009 and HPA, 2009].

In June 2009, the Health Protection Agency in the UK prompted authorities there to consider revising the UK's radon protection policy in light of the review by the Independent Advisory Group on Ionising Radiation (AGIR), Radon and Public Health [AGIR, 2009]. AGIR and other recent UK publications have recommended that greater emphasis is needed on lowering the national average indoor radon concentrations through installation of radon prevention measures in all new buildings reflecting the fact that the majority of deaths from lung cancer due to radon occur in the large percentage of the population exposed to modest radon levels [Gray *et al.*, 2009]. This new public health approach raises the question whether equal emphasis needs to be given to reducing the collective dose through properly installed passive protective measures in new buildings as well as to reducing the individual's risk by identifying homes with high radon concentrations and needs to be considered in the development of a National Radon Strategy.

[8] The Basic Safety Standards Directive (96/29/Euratom) is under revision as part of a recasting procedure aimed at merging five Euratom Directives into one. www.ec.europa.eu/energy/nuclear/consultations/doc/2009_04_20_natural_radiation_sources.pdf

[9] The IAEA International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources is currently under revision. Details can be found at http://www-ns.iaea.org/standards/review-of-the-bss.htm

The HSE and RPII believe that the issues to be addressed in the development of a National Radon Strategy include: the population risk, cost-effectiveness of primary prevention in new buildings, definitions of High Radon Areas, the Reference Level, priorities for funding and other questions relating to effectiveness of current policy. The HSE and RPII believe these issues should be considered further by an appropriately constituted group, which brings together the key experts from the relevant public authorities, as part of the development of a National Radon Strategy. The group should ideally have access to expertise on national policy, building sciences and technology, health economics, public health, as well as radiation protection.

10. Recommendations

Overall Aim of this Position Paper

To propose evidence based measures that would lead to a reduction in the number of cases of lung cancer in Ireland due to radon exposure.

Recommendation

The immediate establishment of an appropriately constituted group including key experts from relevant public authorities tasked with driving the development of a National Strategy on radon control in Ireland.

11. Acknowledgements

The Memorandum of Understanding between the RPII and HSE (RPII and HSE, 2007) identified radon as a public health hazard requiring specific co-operation between both agencies. In this context a radon working group was set up and tasked with developing this Joint Position Paper. The radon working group comprised

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Dr Mary O'Mahony
Dr Ina Kelly

Radiological Protection Institute of Ireland

Mr David Fenton
Ms Stephanie Long
Dr Tony Colgan (left in July 2009)
Mr David Pollard (since July 2009)

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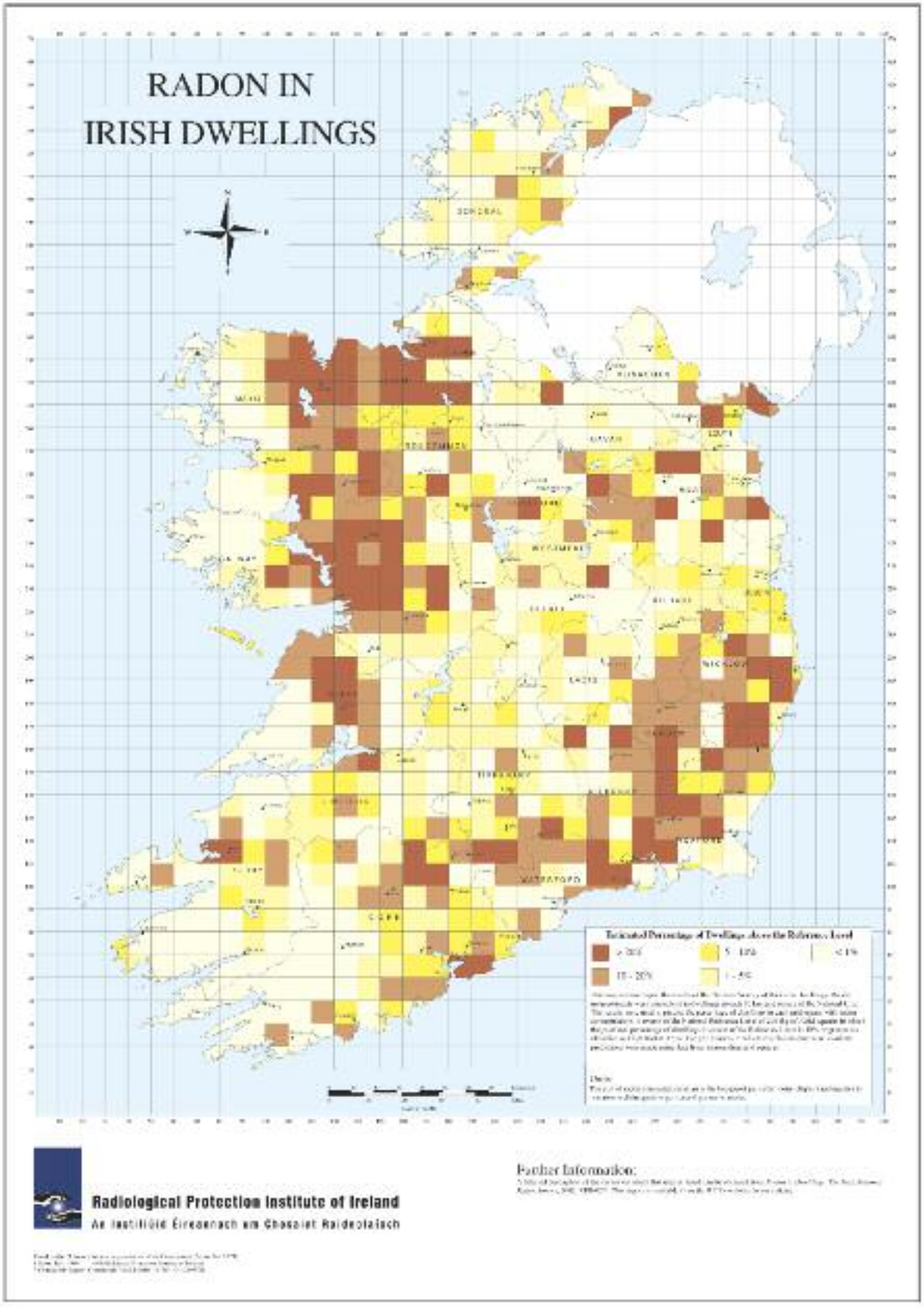
Appendix 1
Radon Map of Ireland



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Health Service Executive

The Radiological Protection Institute of Ireland (RPII) is the national organisation with regulatory, monitoring and advisory responsibilities in matters relating to ionising radiation. With a mission to protect people from the harmful effects of ionising radiation, both natural and man-made.

The Health Service Executive is the statutory body responsible for providing public health and social services to everyone living in Ireland.

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