Radon risk mapping

Jon Miles, Health Protection Agency

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Why do we want to map indoor radon?

To avoid unnecessary radiation exposures:

- We need to identify buildings with high radon concentrations, so that the concentrations can be reduced
- We need to ensure that new buildings in high radon areas do not have high concentrations, by setting building regulations to reflect radon risk

Both of these aims require detailed maps of where high radon concentrations are found

Possible sources of data for radon mapping

- Geological maps (geology determines radon potential)
- Radon in soil gas (indoor radon comes from the ground)
- Airborne surveys of gamma rays from radon decay products (gives detailed map of radon in ground surface)
- Permeability of ground (movement of soil gas into buildings depends on permeability)
- Results of measurements of radon in houses (what we want to map is radon in houses)

Reasons for using indoor radon

- Indoor radon measurements are cheap: they are carried out by post, and householders return the detectors
- Results are collected for other purposes, such as to identify high radon houses
- Aggregated data may be used to derive a more accurate estimate of radon potential
- Large numbers of results are available - 24,000 Northern Ireland homes measured

Use of radon house data

In fact, we have no alternative to using results of indoor measurements, because we want a map of indoor radon.

Other data is supplementary data. If we use it, we have to calibrate it using house radon data.

Whether or not we use other data, we must deal with house radon data. We must therefore understand and interpret the data.

Drawbacks of using radon house data

- Indoor radon concentrations are extremely variable, even for houses on identical geology
- We do not have as much data as we would like in rural areas
- We need to know the locations of houses accurately

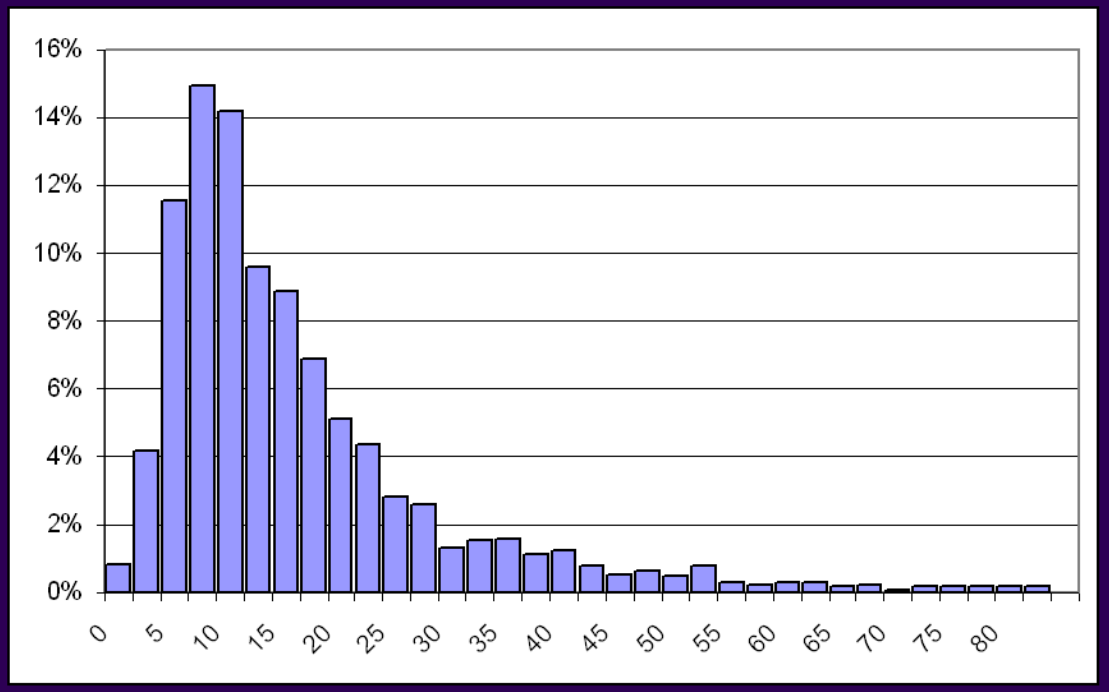
Why are indoor radon concentrations so variable?

- Radon enters buildings not by diffusion, but with bulk airflow
- Even if houses are apparently identical, they vary in detail
- Ground conditions under houses vary, such as previous disturbance of the ground or cracks in the ground
- The habits of occupants vary, such as whether windows are opened upstairs or downstairs, the average indoor temperature, and occupancy patterns

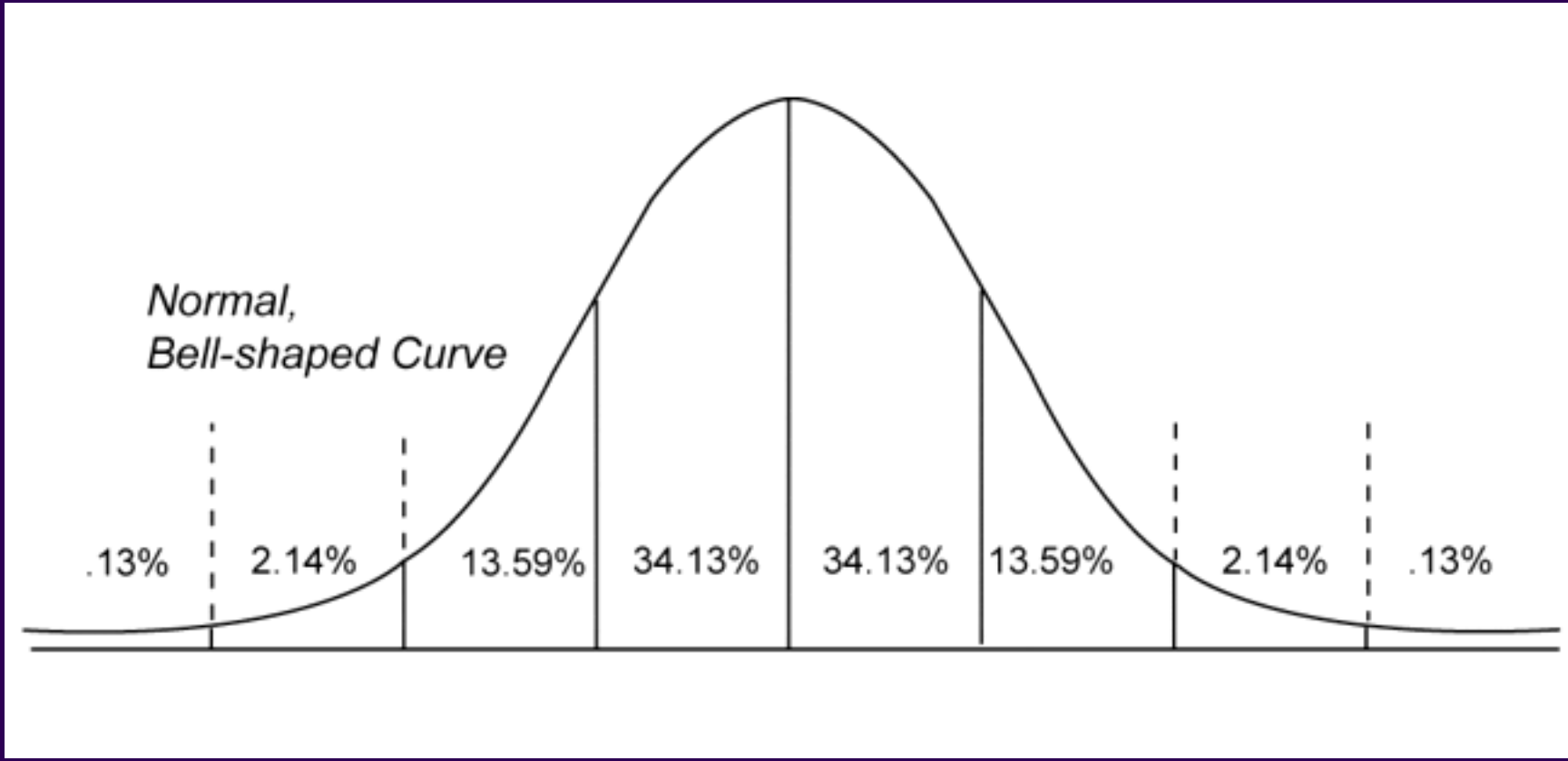
Indoor radon distribution

Indoor radon in the UK is distributed lognormally, after subtraction of outdoor radon (4 Bq m^{-3})

Applies nationally and in small areas



Distribution of logarithms of radon concentrations



Use of lognormal distribution

- Not enough radon results to estimate % > AL for each area directly
- We can calculate the geometric mean (GM) and geometric standard deviation (GSD) of any lognormal distribution
- These parameters allow us to calculate the proportion of houses above the Action Level
- It is particularly useful for mapping, as it defines the areas where the worst problems are to be found

Procedure for mapping proportion of homes above Action Level

1. Identify locations of measured homes accurately
2. Group data geographically
3. Estimate GM and GSD of each group
4. Use lognormal model to calculate percentages above Action Level
5. Colour map accordingly

How should we group the radon data?

- By administrative unit (county, district, postal area, etc)
- By grid square
- By geological unit

5-km grid square mapping

Group results by 5-km grid square

Estimate geometric mean

Smooth with adjacent squares if necessary

Use national average GSD

Average accuracy of lognormal model in 5-km grid square mapping

Predicted percentage of homes above the Action Level	Actual percentage of homes above the Action Level
0 - 1	0.7
1 - 3	2.1
3 - 5	4.8
5 - 10	7.9
10 - 30	18
30 - 100	48

1-km grid square mapping

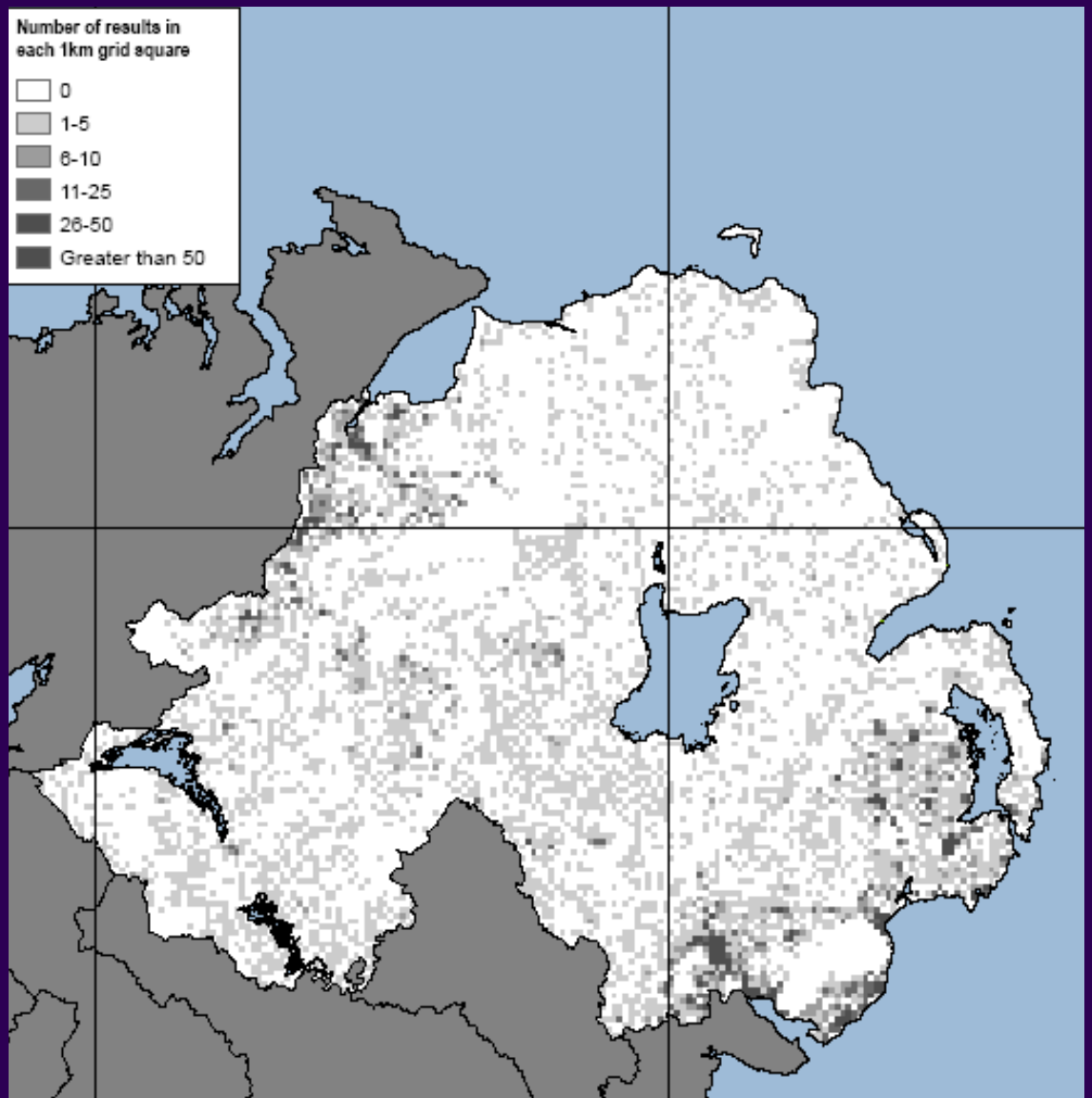
To provide a more detailed map, use 1-km grid squares

Taking each square in turn:

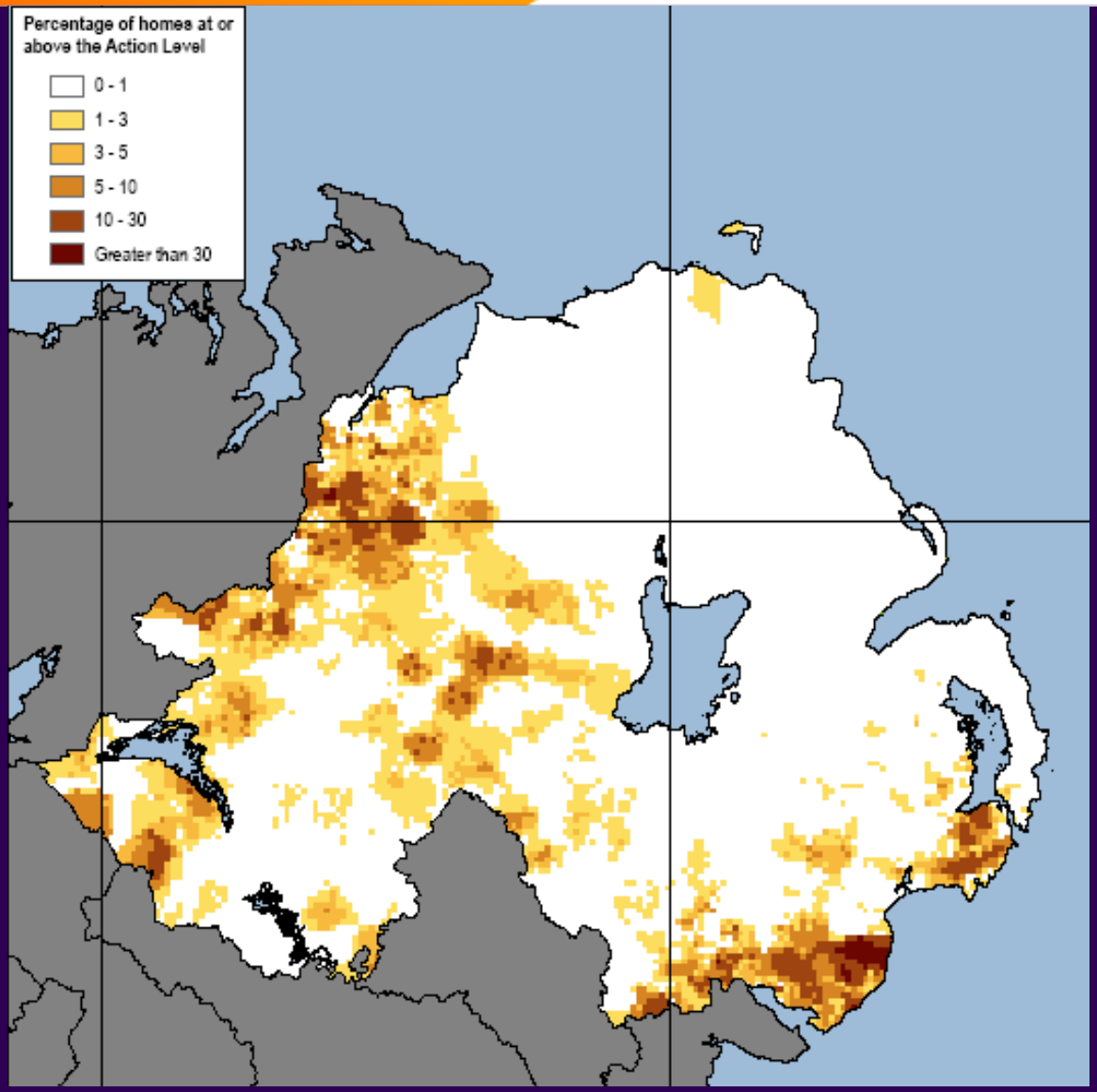
- Expand a ring centred on the square until it includes sufficient results (30)
- Take GM and GSD of these results
- Calculate % > Action Level for this square

Applied to SW England 2002, Northern Ireland 2009

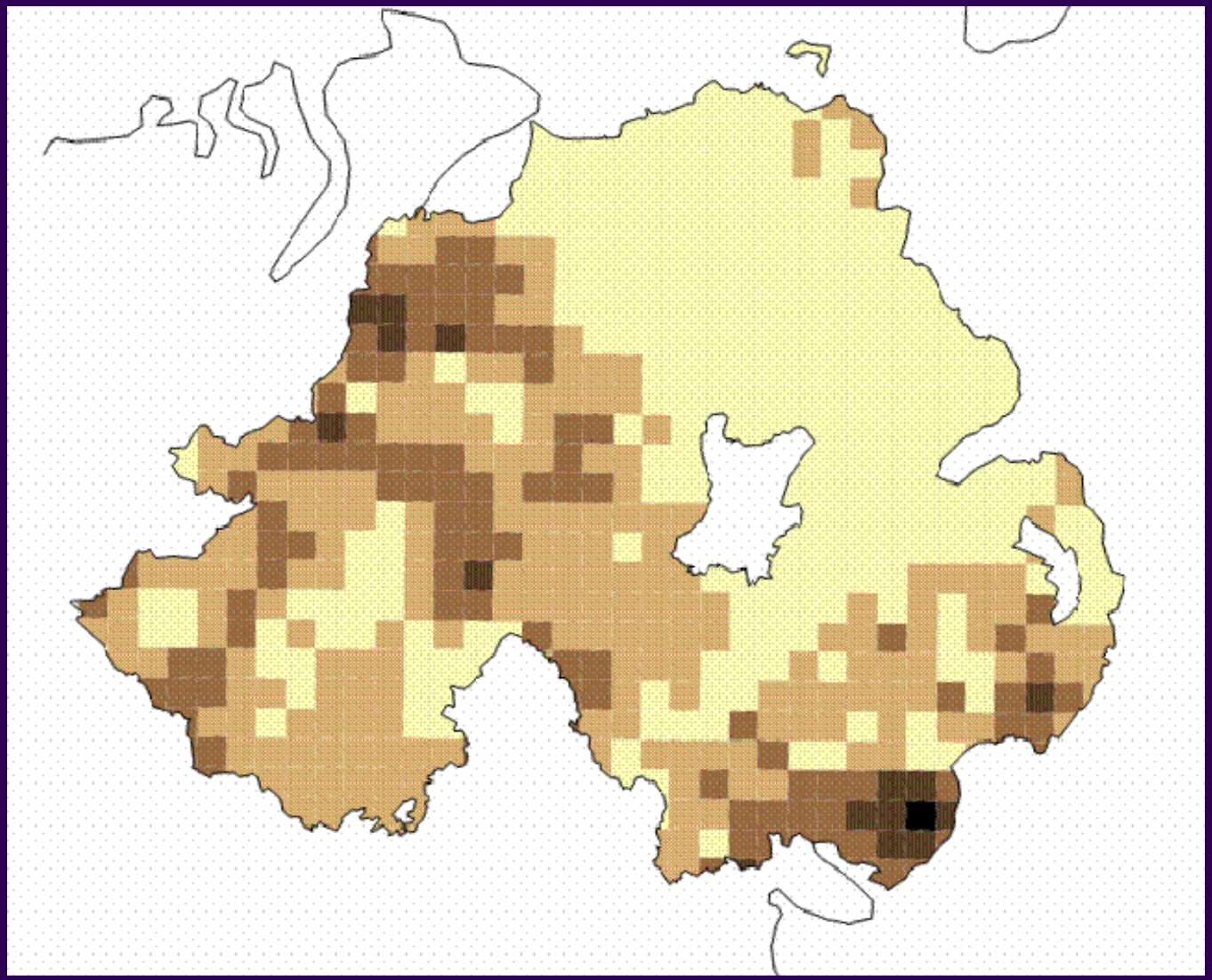
Numbers of radon measurement results

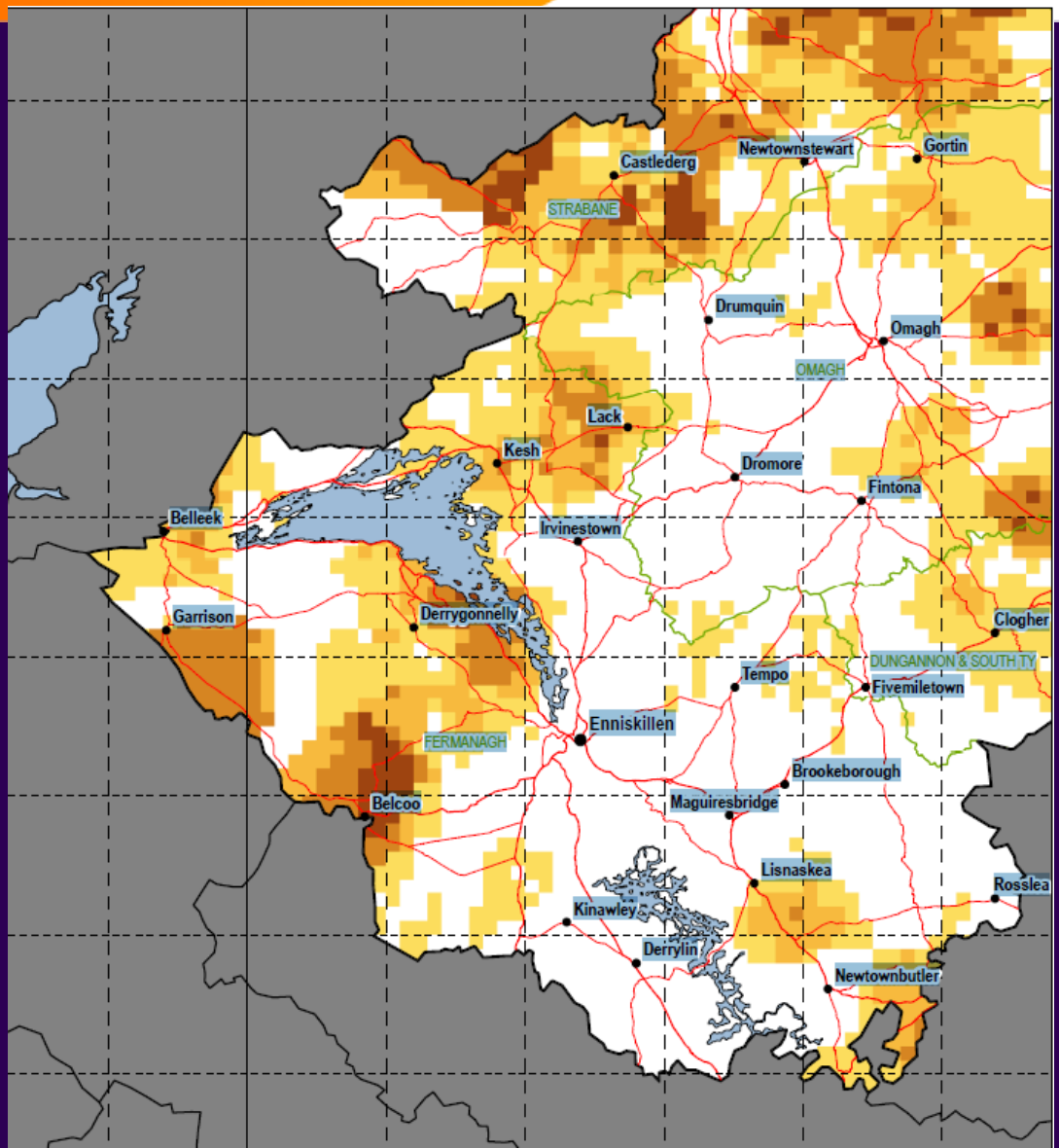


Estimated percentage of homes above Action Level



Previous 5-km grid square map

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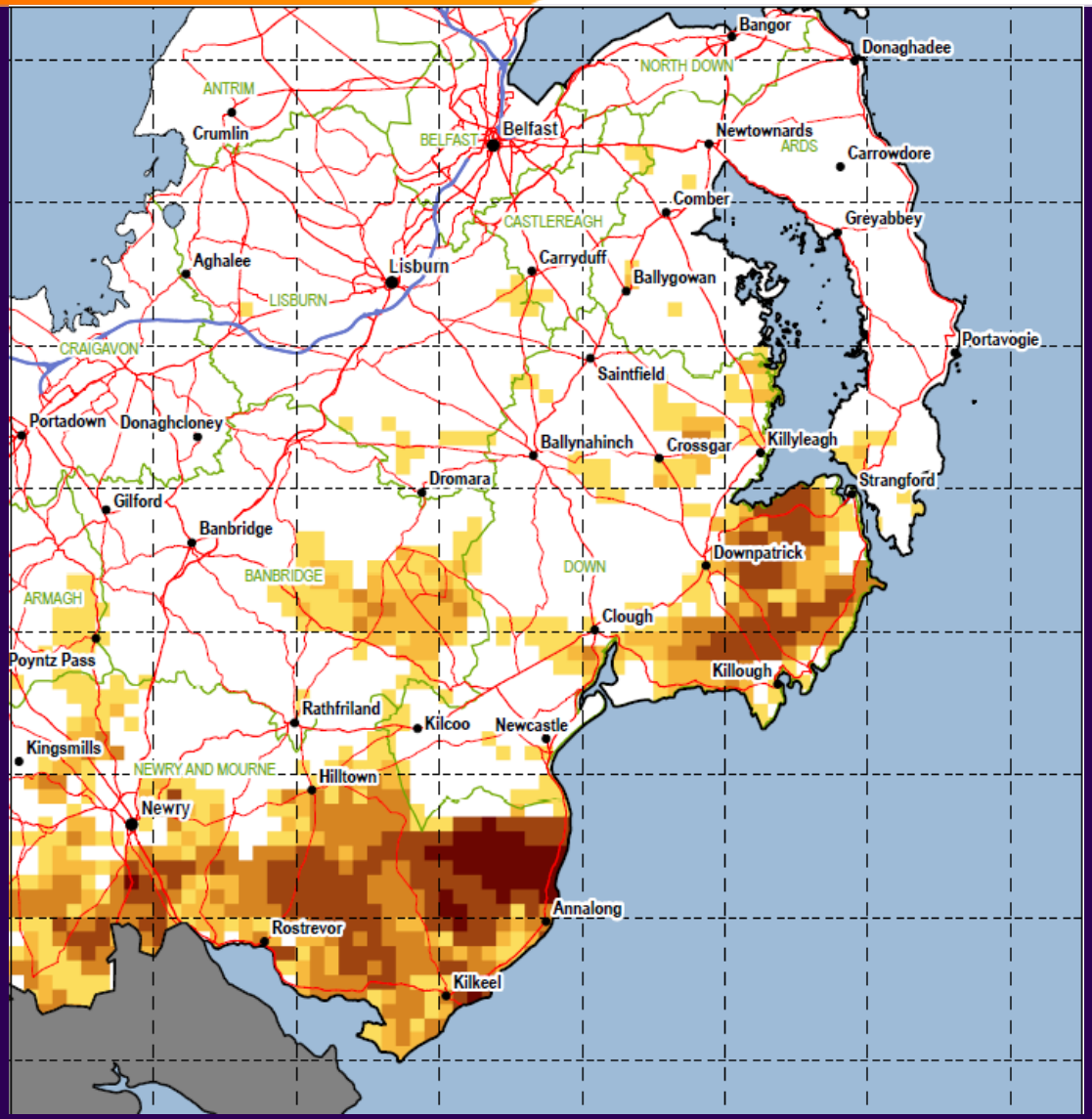
Newtownstewart
Gortin
STRABANE
Drumquin
Omagh
OMAGH
Lack
Kesh
Dromore
Fintona
Belleek
Irvinestown
Garrison
Derrygonnelly
Clogher
DUNGANNON & SOUTH TY
Tempo
Fivemiletown
Enniskillen
FERMANAGH
Brookeborough
Belcoo
Maguiresbridge
Lisnaskea
Rosslea
Kinawley
Derrylin
Newtownbutler


Bangor
Donaghadee
NORTH DOWN
ANTRIM
Crumlin
BELFAST
Belfast
Newtownards
ARDS
Carrowdore
Comber
CASTLEREAGH
Greyabbey
Aghalee
Lisburn
Carryduff
Ballygowan
LISBURN
CRAIGAVON
Portavogie
Saintfield
Portadown
Donaghcloney
Ballynahinch
Crossgar
Killyleagh
Dromara
Strangford
Gilford
Banbridge
Downpatrick
BANBRIDGE
DOWN
ARMAGH
Clough
Poyntz Pass
Killough
Rathfriland
Kilcoo
Newcastle
Kingsmills
NEWRY AND MOURNE
Hilltown
Newry
Annalong
Rostrevor
Kilkeel

Joint geological / grid square radon mapping

Data are grouped first by geology, then by 1 km grid square

Lognormal modelling of distributions of radon concentrations allows percentage above Action Level to be calculated

Map shows variation both ***between*** geological units and ***within*** geological units

The mapping method is based on more than 5 years of joint research by HPA and British Geological Survey

Applied to England and Wales 2007, to be applied to Northern Ireland and Scotland in future

Airborne survey data

- TELLUS gamma-ray data available for Northern Ireland
- HPA and BGS have used the data with house radon data and digital geological maps
- Investigated spatial variation in radon and gamma-ray data within each geological unit
- Investigated relationship between radon and gamma-ray data within each geological unit
- “…it is difficult to conclude exactly how much value the Tellus data adds to the radon mapping process.”

Present and future maps

The values of radon potential given are the best estimates that we can make on the basis of current information and mapping methods, but no map is perfect.

Maps only show probability - measurements are required to find out whether particular properties have high radon levels.