A Comparative Analysis of Radon Measurements of Various Durations in Dwellings (Weekly vs Three Monthly Radon Measurements)

DEFRA Reference

EPG 1/4/72

RW 8/1/64

SECTION A

Project Objectives along with

Experimental and Analytical Requirements

Objectives:

1. Comparative estimates of radon in air in dwellings using three simple types of radon detectors as well as continuous monitoring

2. For the three detectors compare limits on annual average radon estimated from measurements of:

- One week
- One month
- Three months

Objectives:

3. Draw conclusions on spread and reproducibility of results for:

- Rapid results (e.g. home purchase)
- Non urgent situations

Experimental Work

1. Recruiting a panel of occupiers with moderate radon levels
2. Drawing up a detailed test programme
3. Installation of three types of detectors; charcoal, track etch and electrets
4. Measure ambient parameters
5. Installation of continuous monitoring
6. Oversee exposures of one week, one and three months
7. Arrange for exposed detectors and real time to be processed
8. Receive and collate resulting data.

Analytical Work

1. Comparison of results from 3 types of detectors and continuous monitoring
2. Comparison of estimated annual average radon from one week and one and three month exposures
3. Identify spread and repeatability of results
4. Analysis of ambient parameters to improve understanding of radon variation
5. Recommend preferred measurements for:

- Situations where rapid result required
- Situations where there is no urgency

SECTION B

Detector Methodology

Project detectors: numbers used and suppliers

Track-etch	CR39	St Gobain Crystals	900
Track-etch	CR39	Gammadata	500 short (10day) & long term
Charcoal	Coconut shell	Radon One (UK)Ltd	600
Electrets	Short term with L Chamber	*Rad Elec Inc*	>60 (> 600 readings)

Detector Placement

Protocol adopted was that of US, EPA - similar to NRPB.

1. Detectors were placed in lowest level room that was used as main living room
2. Detectors were placed in main bedroom
3. Detectors were placed, as near as possible, 1 metre from ground and at least 5 to 10 centimetres from objects
4. Detectors were not placed near to doors or windows, at least 30 centimetres from outside wall and away from sources of heat, forced ventilation and direct sunlight

Detectors in dwellings

Within each 3 month (90 day period) each dwelling had:

1. One set of 90 day track etch detectors in main living and bedroom

2. Three sets of 28 day (672 hours) (1 month equivalent) track etch detectors in main living and bedroom

3. Between 2 and 5 sets of 7 day (168 hours) track etch, charcoal and electret detectors in main living and bedroom

4. Due to placement and collection by trained staff, return rate >99%

Quality Control

A rigorous quality control protocol was developed and adopted to ensure rigour of data. This included:

1. Careful screening of householders to ensure that final 37 were considered `suitable`

2. Detectors stored in `radon proof` conditions

3. On collection of detectors a protocol was followed to ensure that householders compliant over time period of exposure

4. All detectors double bagged and transported in radon proof containers

5. Detectors immediately returned to suppliers for analysis

Overall:

- 3 dwellings removed from project as being `non compliant`
- >95% of exposures utilised for analysis

SECTION C

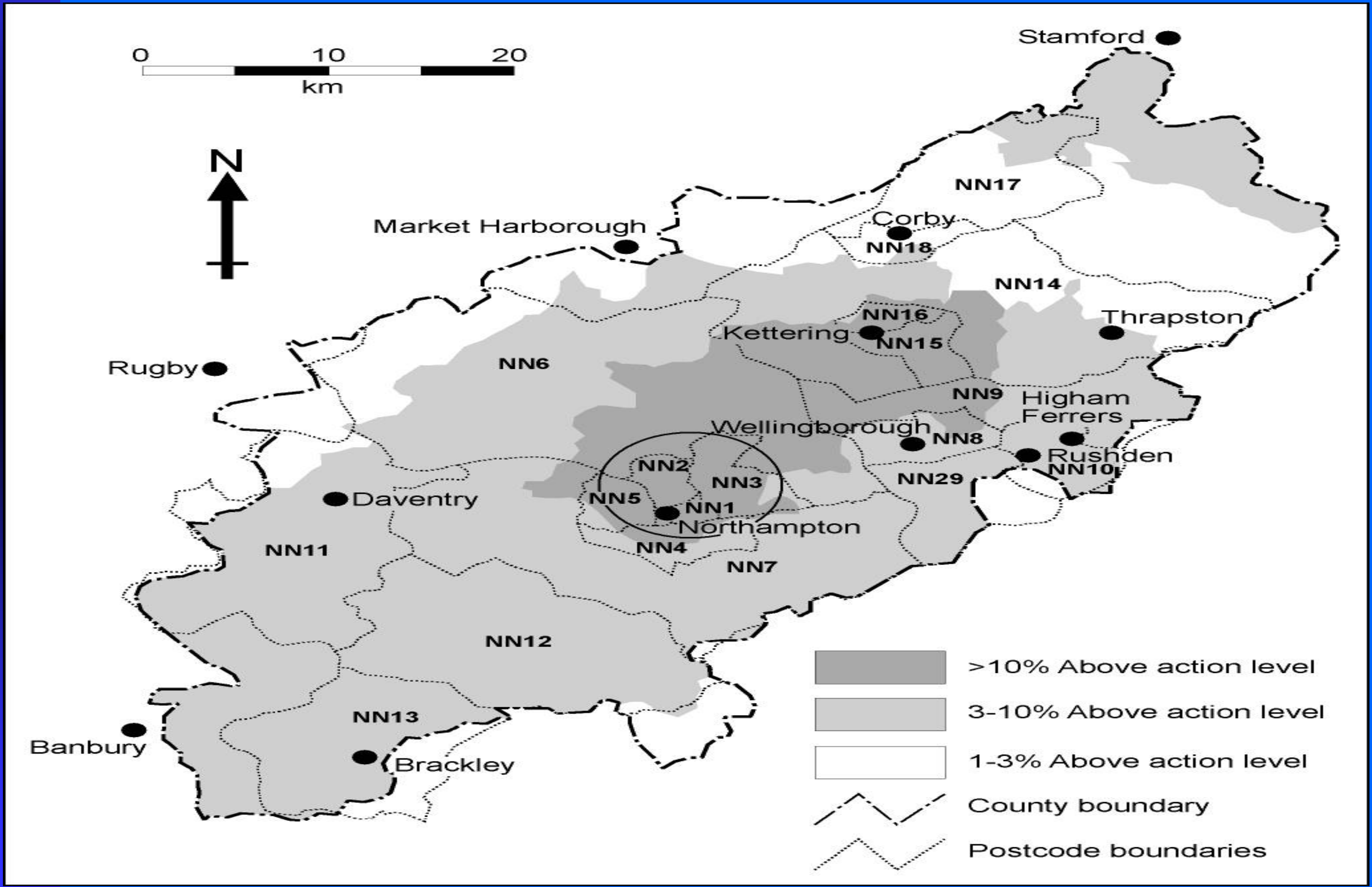
Characteristics of Project Dwellings

Dwelling selection

The final 37 dwellings were selected using a Decision Support System developed by the Project Team

1. An already existing database of dwellings was utilised to select some 60 possible candidates
2. Each dwelling visited by Project Team member
3. Previous NRPB recorded levels checked
4. Type and location (high radon geology) of dwelling checked
5. Householder suitability for likely compliance checked
6. List of possible 60 dwellings produced
7. Director and Deputy select 37 dwellings for project
8. Householders assured of confidentiality

Geographical Zone of Dwelling Location: Centred on Climatological Station in north Northampton



Dwellings completing project: Geology and homes above Action Level

1. Some 94% are on Northampton Sand

2. Some 94% are in areas with >30% of homes estimated to be above Action Level

3. Some 41% are in `compact area` (within 400 metre radius) in NN6

Duration of measurements in dwellings completing project

12 months	20
9 months	4
6 months	6
3 months	4
Total	34

Completing dwellings by type

Detached	17
Semi-detached	9
Link	4
Bungalow	4
Total	34

Completing dwellings by age of construction

Pre-1950	17
1950-1970	5
1971-1980	7
1981-1990	5
Total	34

SECTION D

Analysis of project data: some major outcomes

Some major outcomes

- Regression analysis of results suggested that charcoal has a slope of 1.22
- Others (e.g. track-etch) give a slope of 1
- Suggests that charcoal manufacturers may be using a slightly too high equilibrium factor
- This is following EPA recommendations to avoid any false negatives and could easily be adjusted
- Unopened detectors – track-etch and inappropriate results

SECTION E

Detector management: aspects of suitability of detector systems for utilisation by end users

Mean return time (working days) of results from analysis

Electret	0.5
Charcoal (Radon One (UK) Ltd)	3
Track-etch (Gammadata)	10-12
Track-etch (St Gobain)	> 21

SECTION F

Geology and radon: seasonal correction factors

Geology and seasonal correction

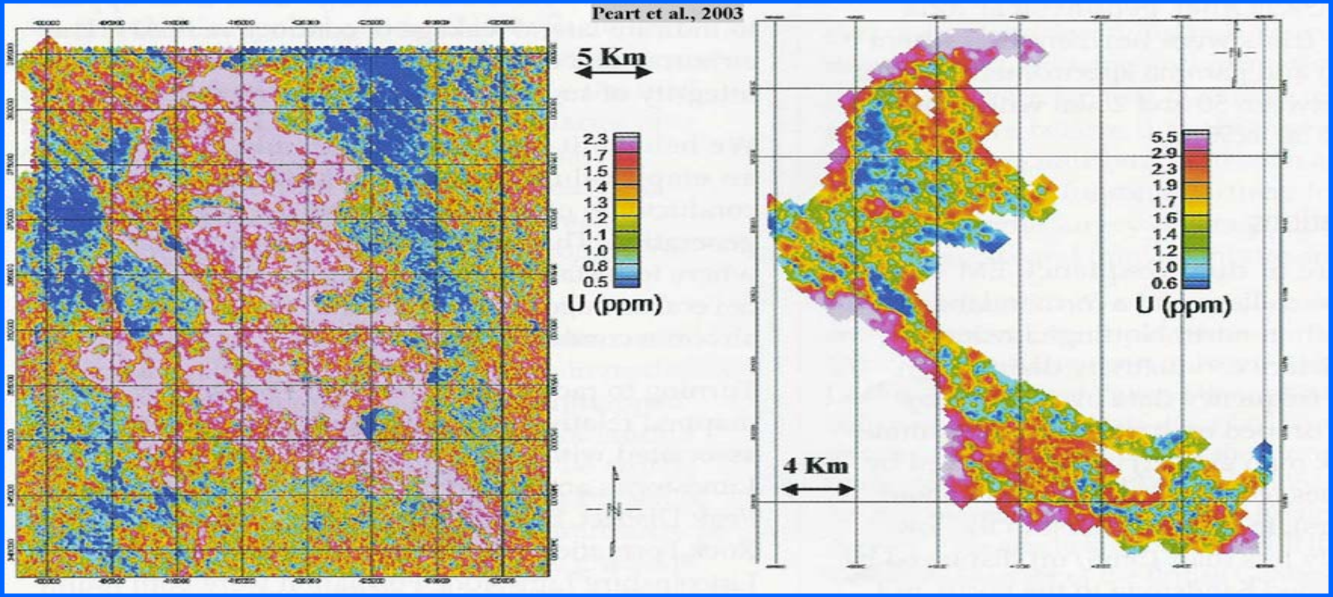
- Gunby et al. (1993), 2000 homes in the UK
- 22 categories of 'rock types'
- 'Granite 1' – SW England
- Relationship between underlying geology and indoor radon is complicated
- Radon 'potential' maps – BR211/BGS maps

Geology and seasonal correction

- Seasonal correction factors – might not be appropriate in areas where the radon levels are high.
- Grainger et al. (2000) – different seasonal correction factors needed for the Isle of Man due to different geology?
- Confirmed previous patterns observed in the UK re summer radon levels.

Geology and seasonal correction

- Enormous variability that any one geological formation will have in uranium/radium content



Geology and seasonal correction

- Significant local variations
- Different geological conditions can give rise to trends in indoor radon levels that do not fit the seasonal pattern of variation
- Arvela et al. (1988, ’94, ‘95), Finnish eskers
- Variations in radon levels due to sloping site, sandy porous sediment and air convection
- Derbyshire and karstic limestones

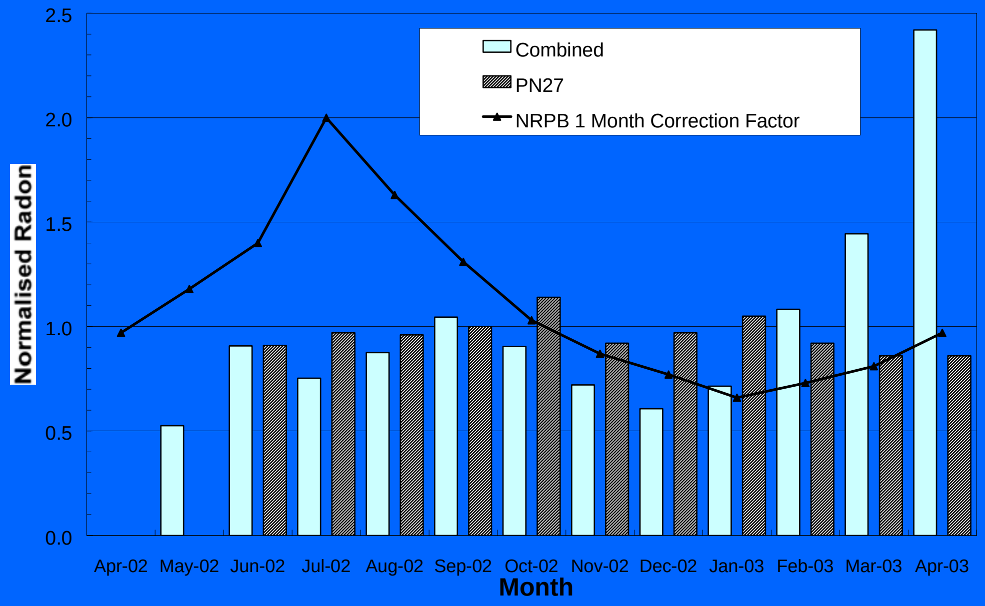
Geology and seasonal correction

- Significant local geological variability exists
- Gunby et al. (1993)
- 78% of the variation in radon levels in homes could not be explained
- In this study, test results highlight the unpredictability of radon results, with low levels in the Autumn and early winter

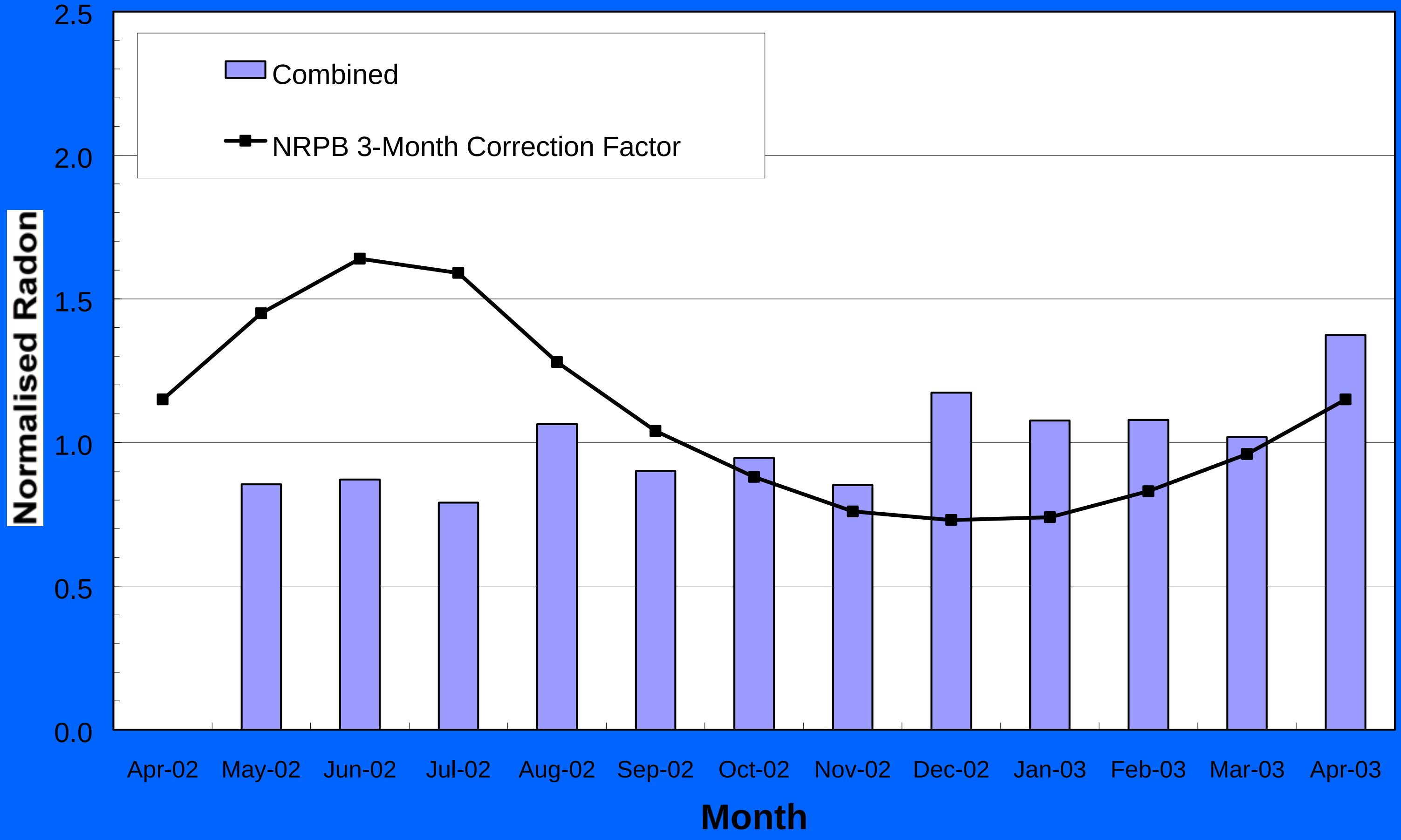
Geology and Seasonal Correction

NRPB pattern – higher winter, lower summer.

May not be the case



Geology and Seasonal Correction



Geology and seasonal correction - Conclusions

- The seasonal pattern observed in this study does not follow the typical NRPB trend despite homes being based on an apparently homogeneous underlying geology of Northants Sand Formation (NSF)
- In reality the NSF is highly variable in sedimentological terms, e.g. grain size, pore size, porosity, permeability, organic content

Geology and seasonal correction - Conclusions

- Recommend that consideration should be given to establishing different seasonal correction factors for areas where it can be demonstrated that radon variation does not fit the NRPB summer/winter pattern
- Recommend long-term exposure project in homes to establish year on year variation on areas of different geologies

SECTION G

End User Dialogue

The Radon Council

1. All properties (in a given area) should be tested at the time of conveyancing.

2. Tests, usually of 4-7 days, suitable for testing at time of conveyancing.

3. Longer term required in a smaller `limited` number of borderline cases.

NRPB: Letter to Radon Centres Ltd for 7 day exposure of Volalpha detectors

“ ..the level of 75 Bq m^{-3} to be an upper limit where the Action Level is unlikely to be exceeded. Until there is further research published, this could be used as the cut off point, above which longer testing, or mitigation, should be undertaken.”

Survey of Solicitors in Northamptonshire

% of purchasers asking about radon	>60%
% seek 7 day test	1%
% seek 3 month test	2%
Max. time for test between CON29 and exchange	28 days (20 working days)
% setting up radon bond	2%
Impact of Sellers Pack	Much greater requirement for 7 day testing

SECTION H

Some key recommendations

Recommendations

- Should look at seasonal correction by geology
- There is a demand for short-term testing because of HIPS
- Short-term testing e.g. using charcoal can be utilised using appropriate protocols effectively
- Recommendations mirror the EPA approach
- This study shows up problems re detector accuracy – blind testing a necessity

Research Update I

- Analysis of data from extended radon concentration time-series
- ‘Earth Tides’ and ‘Ocean Tidal Loading’
- Drive periodic radon liberation
- Via geophysically-driven ground-water level variations.
- Astronomical influences, including tides, play a part in controlling radon release from the soil.

Research Update II

- A number of developers in the east of England are now undertaking short-term testing prior to occupancy

- Driven by the NHBC guarantee and possible future liabilities