Explanation of the Map

[numbered references listed on the back]
[all reported averages are geometric means]

Radon is a radioactive gas found naturally in the environment as a decay product of uranium. Radon may contribute to an increased risk of lung cancer, especially in smokers [1;2]. The U.S. Environmental Protection Agency (EPA) has an action guideline of 4 picocuries of radon per liter of air (pCi/l) [1]. Above 4 pCi/l, EPA recommends action to reduce radon levels. Primary radon sources to the home include the surrounding soil and sediment, near-surface bedrock geology, and bedrock well water.

Appropriate Use and Limitations of the Map

This map may be used for focusing interest and targeting limited resources toward areas where they will have the most impact. This map has been developed using radon measurements in combination with geological and geophysical factors. Further investigations using additional radon measurements may alter radon potential rating areas. This map is for public education, and is a statewide planning tool for health officials and environmental professionals. This map is the best available tool for evaluating radon potential statewide. The map should not be used for site specific evaluations or real estate transactions. Determination of radon levels at any particular site requires radon testing. Do-it-yourself radon test kits are available at many home stores [$10-$50]. A list of trained professionals offering radon testing and mitigation services is available from the Department of Public Health (860) 509-7367.

Determination of Radon Potential Ratings

Area radon potentials are from a computerized spatial analysis of bedrock geology, surficial materials, and surface radioactivity mapping, with indoor air and bedrock well water radon data. The radon data includes 4721 homes and 958 bedrock wells tested for radon statewide between the years 1985-1995. The testing was conducted by the CT Department of Environmental Protection, CT Department of Public Health, U.S. Geological Survey, University of Connecticut, and Stamford Health Department [3; 4; 5; 6; 7; 8; 9; 10]. Radon measurements have been correlated with geological and geophysical factors enabling the mapping of radon potential. Digital resource maps were scored separately for radon potential (see table below), and compared to indoor air analyses to determine the usefulness of each resource map for the prediction of radon. The radon potential map is a summation of radon scores developed from these earlier analyses.

Surface radioactivity measurements [11;12] provide summary information for total gamma emissions from all areas of the state. There is a direct correlation between surface radioactivity and average indoor radon [13;14]. Areas with the highest surface radioactivity correlate with areas of highest average indoor radon and are therefore scored with the highest radon potential. Surficial materials units [15] are used as a measure of surface permeability and potential radon transport to the surface. As such, surficial materials units are assigned radon scores according to their texture. Areas of coarse-grained sediments are assigned higher radon scores than areas of fine-grained sediments. Bedrock well water radon values are used as a measure of the potential radon source in the bedrock. Each bedrock unit [16] is assigned a radon score based on the average radon in the well water of that unit, or by reference to similar geologic units [16;17;18]. The scoring strategies have been tested by comparing radon scores for each component resource map with indoor air radon data [see back of map]. Each of these scoring strategies provides a positive correlation between average indoor radon and the assigned radon scores of individual mapping components (below). The areas of more permeable sediments, higher bedrock well water radon, and higher surface radioactivity have higher average indoor radon.

Scores for Component Resource Maps

Radon Potential Score	5	4	3	2	1
Surface Radiation (counts per second gamma)	≥ 900 cps	900-700 cps	700-500 cps	500-300 cps	< 300 cps
Surficial Materials	———	gravel & coarse sand	mixed sands	mixed fines	fines & clays
Bedrock Well Water	≥ 10,000 pCi/l	9,999-5,000 pCi/l	4,999-3,000 pCi/l	2,999-300 pCi/l	< 300 pCi/l

The combined scores of component resource maps create a total radon potential score for each area of the state. These scores range from totals of 4 to 13. Frequency analyses show a progressive increase in average indoor radon with total radon potential score. The total scores are grouped into 4 categories by similar average indoor radon. These categories are shown on the map as radon potential ratings. These radon potential ratings describe areas of statistically different indoor radon levels.

Sites of naturally occurring radioactive minerals referenced in the geologic literature [19;20] are approximately located on this map where possible. These sites include an assemblage of various minerals which may produce locally high radon. These sites are included on the map for reference and are not part of the development of the radon potential ratings. These mineral locations may be useful tools in the development of regional and local level radon potential evaluations.

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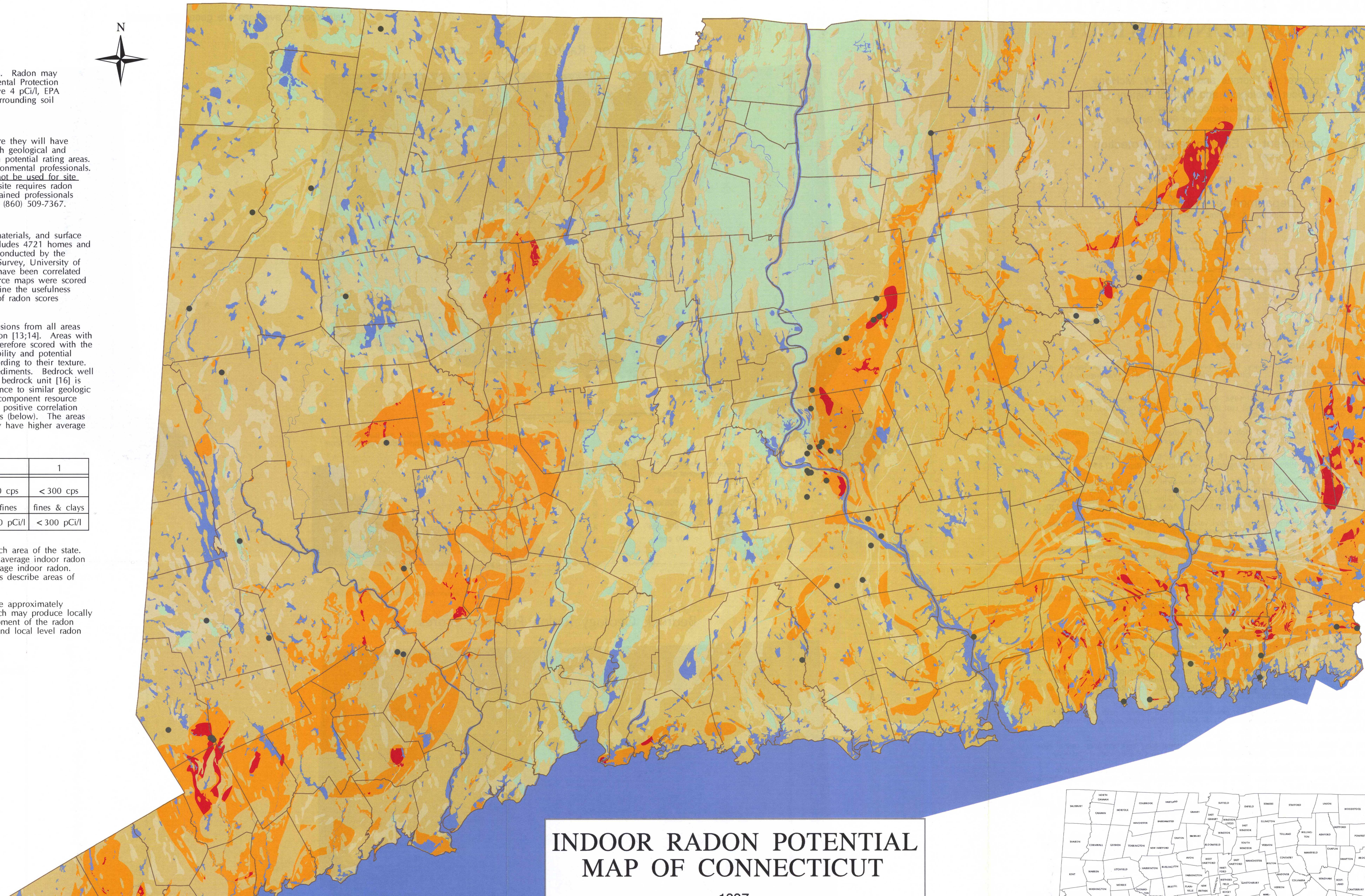


Radon Potential Rating*

The radon potential rating indicates the percentage of tested homes in these areas with basement air radon greater than or equal to 4.0 pCi/l

Low	6%
Low - Moderate	16%
Moderate	22%
Moderate - High	33%
High	48%

Water or Wetland

Towns

• Naturally Occurring Radioactive Minerals
Sites may produce locally high radon levels

NOTE: Because the presence of radon is very site specific, the Department of Public Health recommends that homes be tested regardless of whether the location is in a low or high radon potential area.

* Individual Home Indoor Air Radon Values May Differ

The area radon potential ratings are developed using statistical analyses which provide information on the likelihood of elevated radon in homes located within particular types of geologic situations. Within area radon potential ratings there will be both low radon homes and high radon homes. Basement [or ground level] fall and winter air radon tests are used in the analyses in order to provide 'worst case' radon potential estimates. Homes with elevated radon in the basement are more likely to have elevated radon in an upstairs living area. An exception to this is in a situation where high radon bedrock well water is a dominant contributor to the indoor air radon of the home. Typically the radon level in the first floor of a home is lower than the basement radon value. Homes served by public water supplies where the water is derived from stratified drift aquifers or held in reservoirs typically have a lower water radon potential [4;21].

INDOOR RADON POTENTIAL MAP OF CONNECTICUT

1997

Margaret A. Thomas and Nancy W. McHone
Connecticut Geological and Natural History Survey
Natural Resources Center
Richard C. Hyde, Director and State Geologist

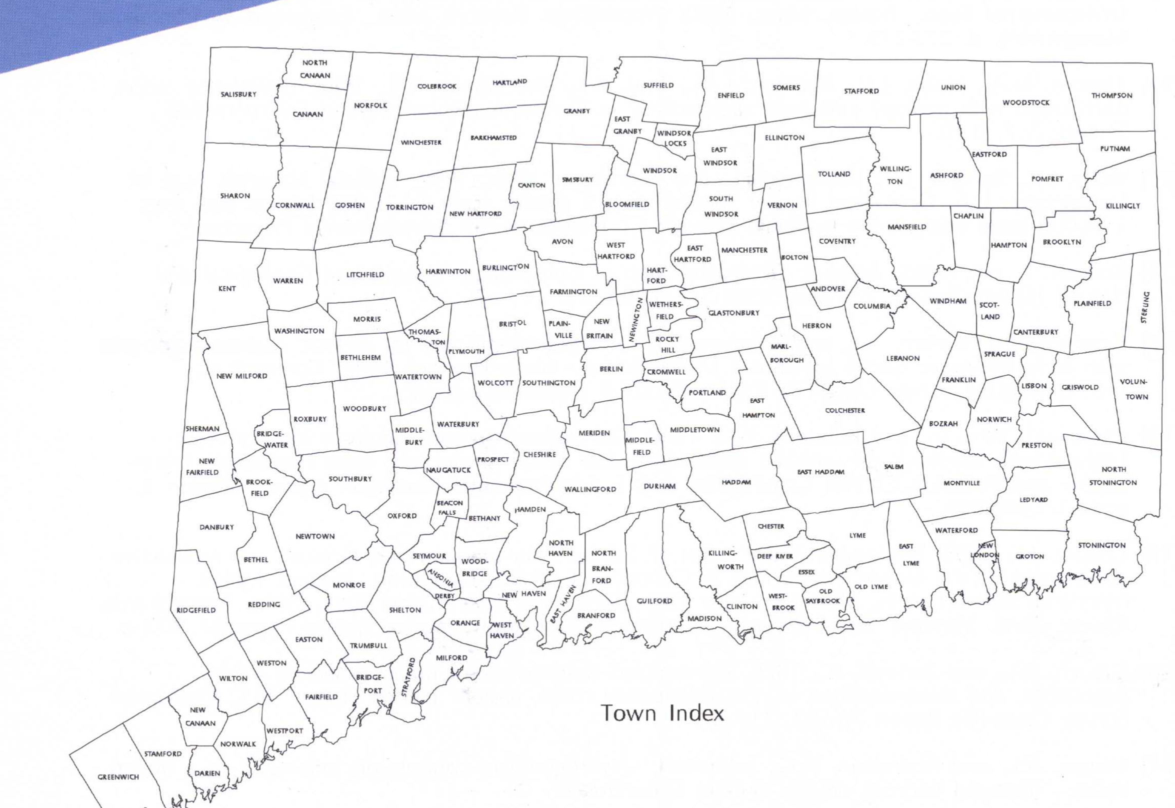
Department of Environmental Protection
Sidney J. Holbrook, Commissioner

produced for

Department of Public Health
Stephen A. Harriman, Commissioner

Scale 1 : 250,000
1 inch equals approximately 4 miles

4 0 4 8 12 Miles
4 0 4 8 12 Kilometers



Town Index

Acknowledgements

This analysis could not be possible without the work of those who produced the digital data used in the development of this map: these people are Larry Colbert Jr., Paul Davis, Mary DiGiacomo-Cohen, Jeff Hollis, Kurt Kress, Bill Penn, John Seifert, and Maria van der Werff. Cindy Barber provided technical expertise in the ways of GIS. The University of Connecticut Center for Environmental Health provided a pilot grant to help digitize surficial materials data and fund student labor for fieldwork. Helpful consultations were provided by many, including Sigrid Asher Bolinder, Gene Boudette, Denis Healy, Richard Hyde, Kip Kolesinskas, Sid Quarrier, Roy Shook, Janet Stone, and Zoltan Szabo. Locational verification of indoor air analyses was provided by members of the Yale Radon Study. The Connecticut Department of Public Health supported and promoted this project for several years through administration of the U.S. EPA, State Indoor Radon Grant Program for Connecticut.

Developed using U.S. EPA State Indoor Radon Grant Program and State of Connecticut funds. This map is available from the Connecticut Department of Public Health, Indoor Air Program, 410 Capitol Avenue, Hartford, CT 06134-0308, (860) 509-7367, or the Connecticut Department of Environmental Protection, Natural Resources Center, 79 Elm Street, Hartford, CT 06106-5127, (860) 424-3555.

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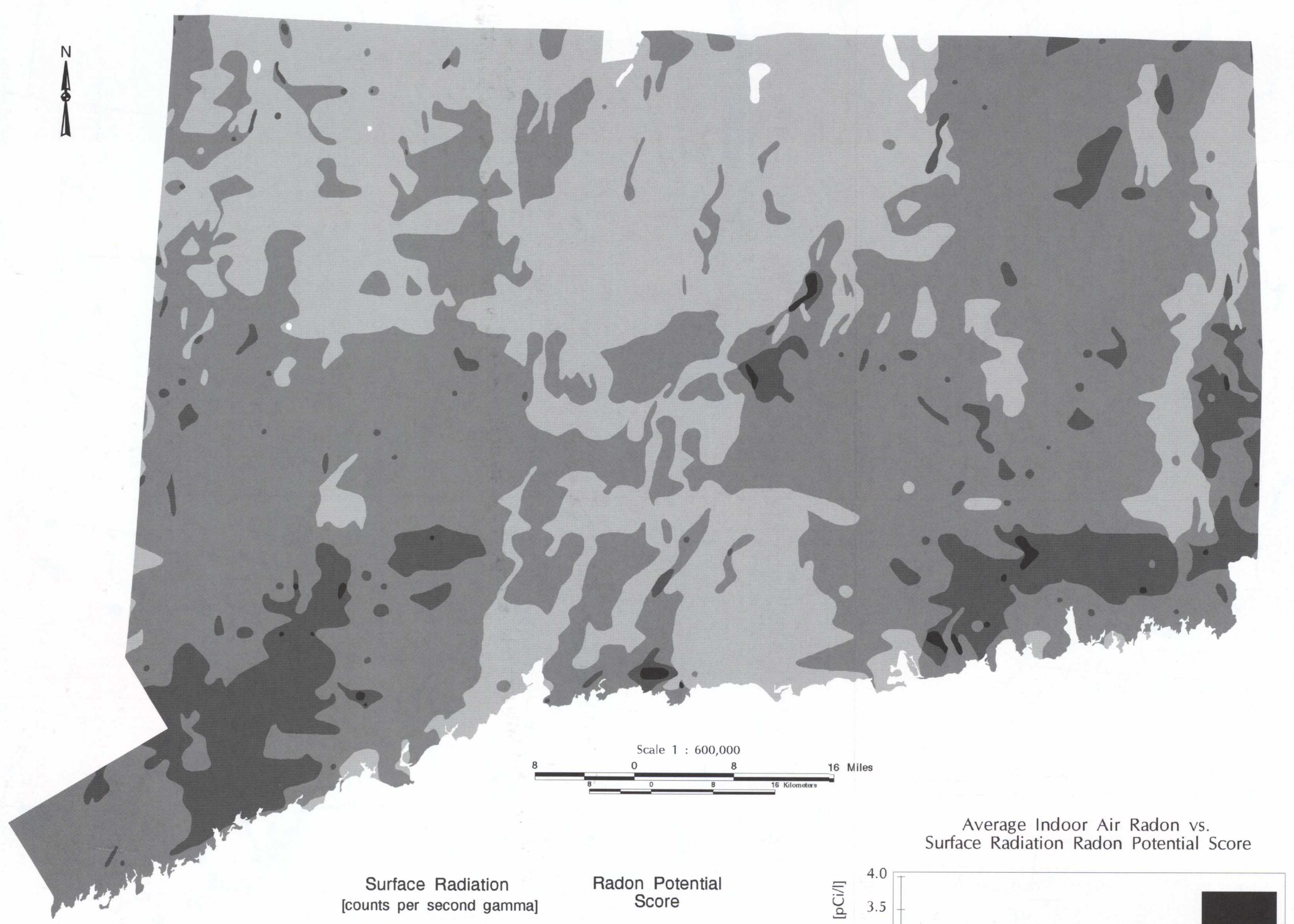
Radon Potential Scores and Comparison of Scores with Average Indoor Radon

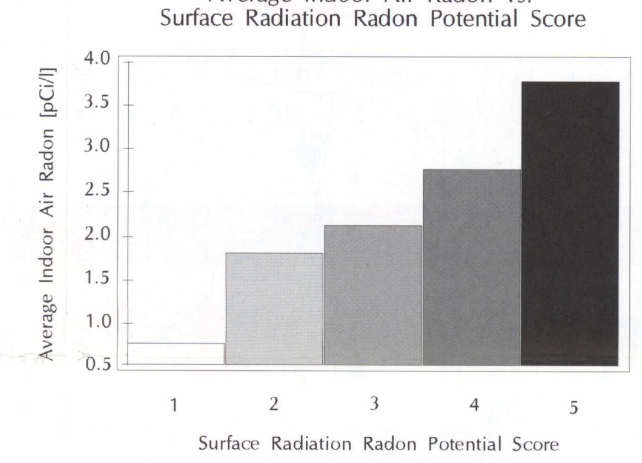
[all reported averages are geometric means]

Surface Radiation Radon Potential Scores

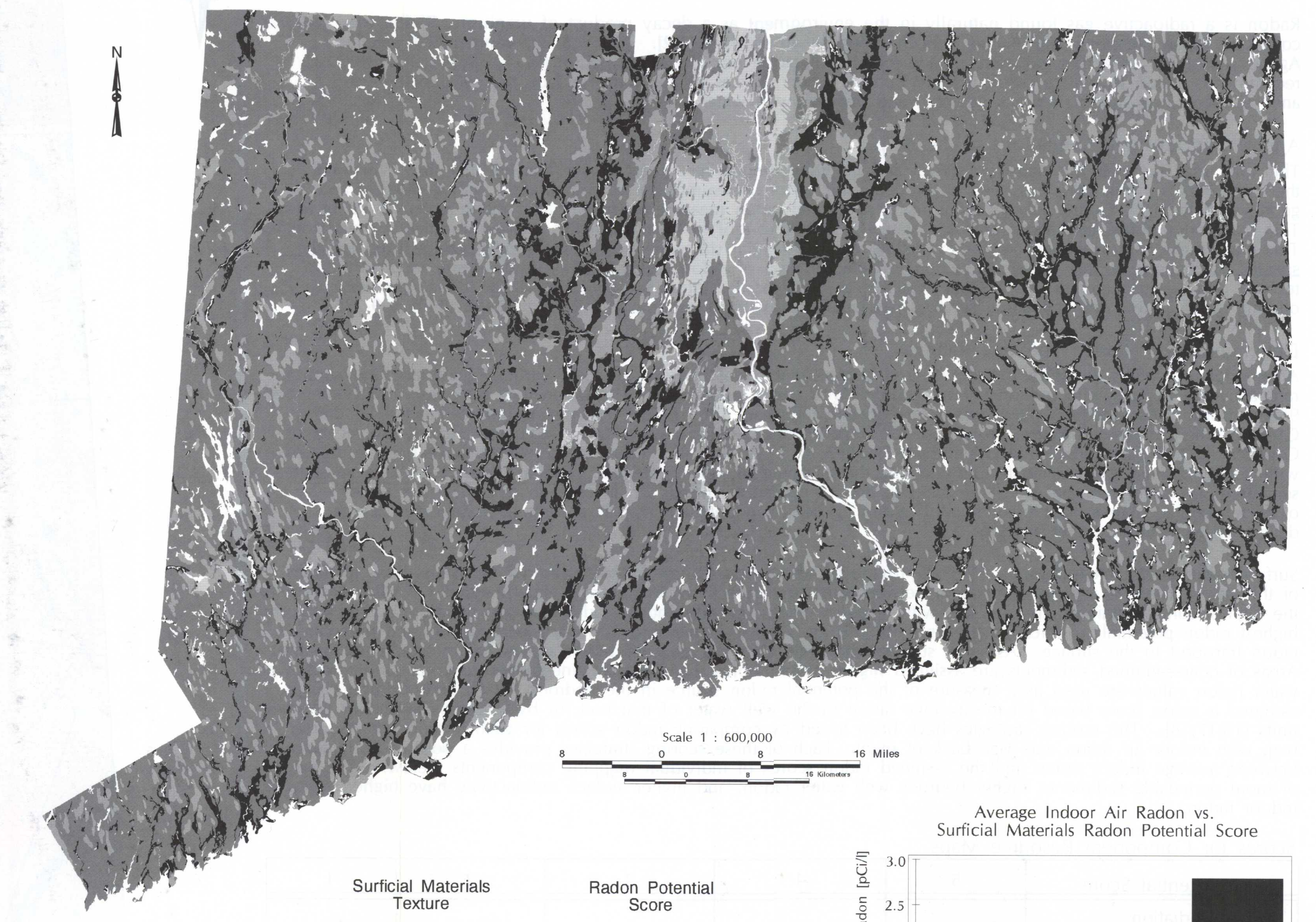


Surface Radiation [counts per second gamma]	Radon Potential Score
< 300 cps	1
300 - 500 cps	2
500 - 700 cps	3
700 - 900 cps	4
> 900 cps	5

Average Indoor Air Radon vs. Surface Radiation Radon Potential Score

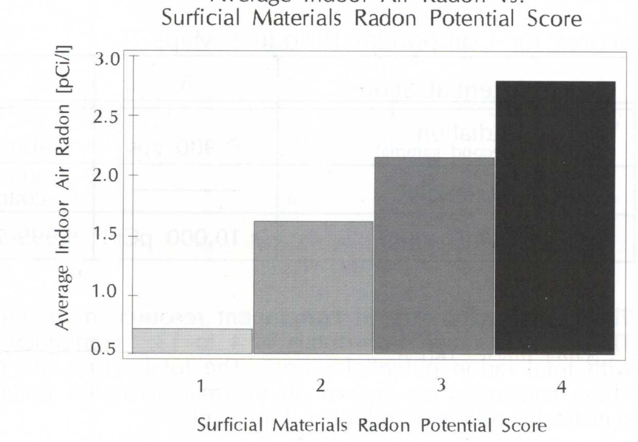


Surficial Materials Radon Potential Scores

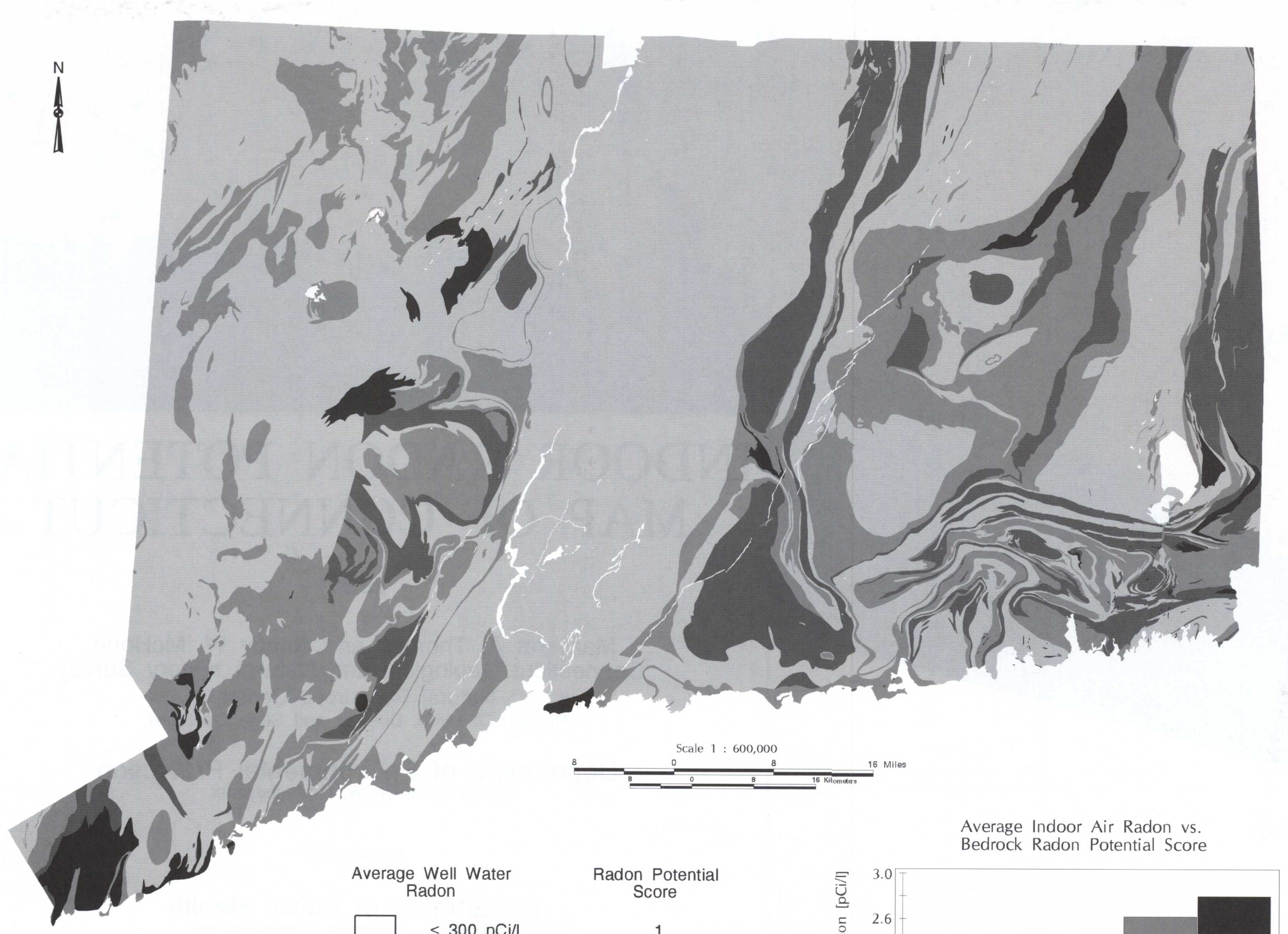


Surficial Materials Texture	Radon Potential Score
fines & clays	1
mixed fines	2
mixed sands	3
gravel & coarse sands	4
water & wetlands	

Average Indoor Air Radon vs. Surficial Materials Radon Potential Score



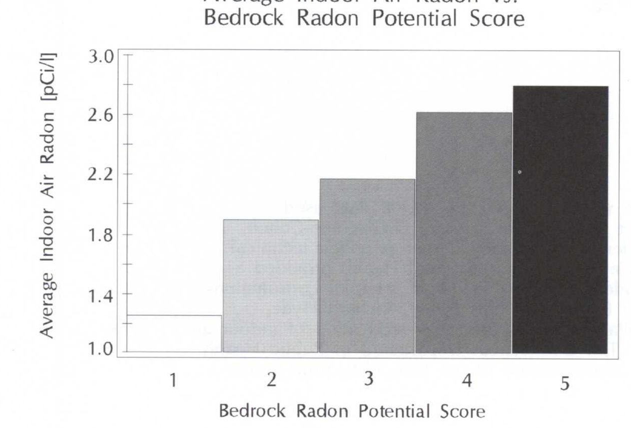
Bedrock Geology Radon Potential Scores



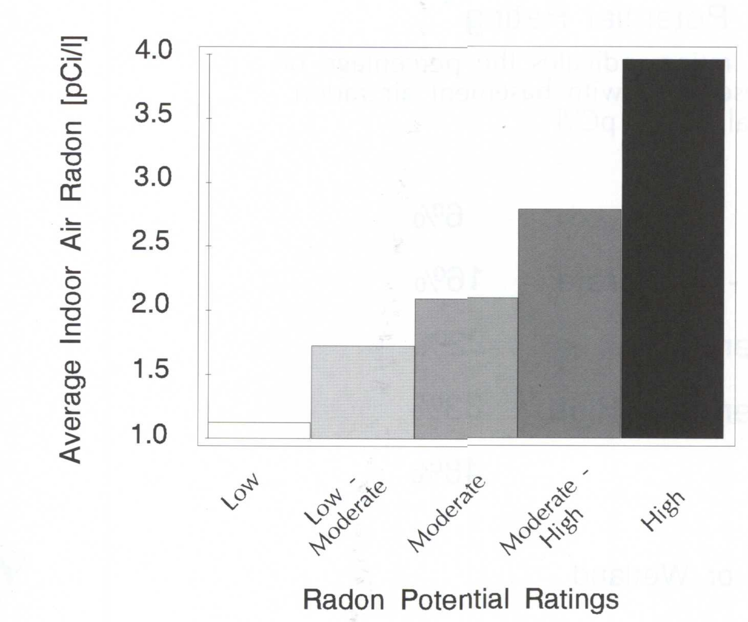
Average Well Water Radon	Radon Potential Score
< 300 pCi/l	1
300 - 2999 pCi/l	2
3000 - 4999 pCi/l	3
5000 - 9999 pCi/l	4
> 10,000 pCi/l	5

The overall statewide average bedrock well water radon for 938 wells is 3022 pCi/l. However, temporal variation of radon levels in well water has been found to be as much as 61% of the arithmetic mean. [10]

Average Indoor Air Radon vs. Bedrock Radon Potential Score



Indoor Radon Potential Map of Connecticut
Radon Potential Ratings vs. Average Indoor Air Radon



Radon potential ratings were developed from the summation of radon potential scores of component resource maps. The total scores were compared to average indoor radon and grouped according to similar radon levels. These groups comprise the radon potential ratings. Kruskal-Wallis ANOVA and Mann-Whitney Rank Sum numerical tests have shown the radon values within these rating areas to be statistically different from each other. Additionally, there is a progressive increase in the percentage of homes above the EPA action guideline of 4 pCi/l in the areas identified with higher radon potential ratings. This analysis therefore provides a meaningful tool for the statewide assessment of indoor radon potential.

Radon Potential Ratings	Average Indoor Radon [pCi/l]	Number of Homes Tested	Percent 4 pCi/l or Above
Low	1.13	214	5.6
Low-Moderate	1.73	768	16.3
Moderate	2.10	2648	21.8
Moderate-High	2.79	1026	33.0
High	3.96	65	47.7

The overall statewide basement air radon average for 4721 homes is 2.12 pCi/l.

Generalized soils mapping [22] and depth to the water table data [23] have been investigated as possible radon potential mapping tools, but have not been included in the scoring strategy because comparisons of soil transmissivity and water table depths with indoor air radon data do not yield discernable trends. Surficial materials thickness mapping [24] shows a significant decrease in radon values overlying sediment greater than 50 feet; however, this finding does not contribute to the radon potential mapping.

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