#5500

Radon In Illinois: A Status Report

by: Richard Allen
Melanie Hamel-Caspary
Illinois Department of Nuclear Safety
Springfield, Illinois 62704

ABSTRACT

The Illinois Department of Nuclear Safety (IDNS) has performed radon screening measurements in approximately 4,100 homes in 98 counties. Results indicate about 39 percent of the basements tested have radon levels that exceed the U.S. Environmental Protection Agency (EPA) guideline of 4 picocuries per liter (pCi/L) and 1 percent have levels greater than 20 pCi/L. About 11 percent of first floor areas tested have levels greater than 4 pCi/L and less than 1 percent have levels greater than 20 pCi/L. In total, about 31 percent of all homes tested have radon levels greater than 4 pCi/L. If these results represent the entire state, this could mean as many as one million homes in Illinois have levels above EPA guidelines.

The screening program has not indicated any areas in Illinois that face a serious health risk from radon, but there are some areas with a significant percentage of homes with screening results in excess of 4 pCi/L, which merit additional study. Radon may, however, cause significant economic problems for those homeowners with homes greater than the action level. Comparisons between house construction characteristics and radon concentrations show no particular feature or combination of features clearly contributes to high radon concentrations.

Although radon concentrations in Illinois are not as high as in some other states (e.g., Pennsylvania), there is still the potential for a health hazard needing to be addressed by IDNS and other agencies. Publicity has increased public concern about radon, proper methods for measuring radon levels and the ability of private companies to provide effective services for reducing levels of radon. There is also considerable concern over the need for and quality of radon measurements conducted when required for real estate transactions. IDNS is assisting the public in coping with these issues. Additional efforts which should be undertaken by IDNS include follow-up studies in neighborhoods identified as potentially exhibiting elevated levels of radon, and the sponsorship of a training and certification program for radon mitigation contractors.

INTRODUCTION

Because of the significance of radon, Governor James R. Thompson established a task force in June 1986, to investigate the problem of indoor radon in Illinois and report its findings and recommendations. The task force recommended that IDNS be designated the lead agency in the development, implementation and coordination of a comprehensive statewide indoor radon monitoring program. Since the task force recommendations were announced IDNS has conducted studies to 1. locate houses in Illinois with high radon levels; 2. estimate the number of houses in Illinois that might have elevated radon levels; 3. assess the range of indoor radon exposure to Illinois citizens; and 4. determine if any geographic regions that, because of particular geological or other conditions, have greater potential to increase public radon exposure (1). The current Illinois radon program also addresses the question of radon exposure potential in nonresidential structures such as schools and is involved in radon reduction projects, public education programs, and training and registering individuals that place radon detectors in structures.

NOTES ON 1990 UPDATE

This report is an update of the November 1988 version of "Radon in Illinois, A Status Report" (2). The Radon Mitigation Act of 1989 requires IDNS to submit a report to the General Assembly describing its findings and recommendations regarding the existence and nature of the risk from radon in dwellings and other buildings in Illinois. This update is intended to serve that purpose. The 1990 report contains new information on:

- Illinois residential screening project;
- Illinois legislation;
- IDNS sponsored training; and
- the State Indoor Radon Grant program

THE ILLINOIS RADON SCREENING PROGRAM

IDNS designed its radon program as a joint state/local effort wherever possible. To facilitate this effort, training programs for local government personnel were held in areas where these groups were interested, and radon monitoring was conducted as a joint study. IDNS completed such training programs in the city of Chicago and in more than 80 counties throughout the state, usually involving local or regional public health or environmental health agencies or the Illinois State University or the University of Illinois Cooperative Extension Service.

The first phase of the program was screening Illinois residences using alpha track detectors. The detectors were deployed for no less than two weeks, but no greater than three months. For logistical purposes, the statewide screening was conducted on a county-by-county basis. The number of detectors placed in each county was determined by using geographical and population density considerations but limited by the resources of the department. A minimum of 30 homes were monitored in each county screened with at least one home per township. In counties with city populations representing a majority of the county, the city was allocated detectors for an additional 30 homes. Greater numbers of detectors were allocated to the six northeastern counties, due to a high population density. The number placed was proportional to the county population.

IDNS SCREENING PROTOCOL

Detectors were placed in the lowest livable area of the home whenever possible according to EPA protocols (3). Houses with no livable basement were screened using first floor measurements. Most of the measurements were taken during the heating season. Although homeowners were not instructed to create artificial closed-house conditions, as they would during a 2-day charcoal screening, it is assumed that most homeowners kept their doors and windows closed during the heating seasons.

Homeowners participating in the screening were interviewed using a questionnaire that included questions on the structural features of their homes and use of living areas and appliances. The results of the interviews were compiled and related to the results of the screening measurements. Screening measurement results were forwarded to the homeowners and to IDNS.

EPA recommends follow-up measurements for any house which has a screening result at or above 4 pCi/L and a decision to mitigate be made on the basis of the follow-up measurement results (4). The higher the exposure rate, the sooner mitigation should be performed. IDNS recommended homeowners conduct annual follow-up measurements in any home which had a screening result of 4 to 20 pCi/L. Annual measurements can be made by using alpha track detectors for a year or can be made using a series of seasonal shorter measurements (4). For homes which had a screening result greater than 20 pCi/L, follow-up measurements were offered by the department to verify the screening result and to determine whether radon mitigation efforts should be recommended.

To standardize this process, an averaged annual living area exposure of the residents was calculated using the wintertime basement screening results and the ratio of spring living area to basement follow-up measurements. Three annual living area exposures were calulated then averaged for each home. The annual living area calculations were based on comparisons of 728 three-month measurements with year-long measurements made in the Reading Prong area and seasonal data collected in Illinois homes (5). If the averaged annual living area exposure was estimated to be greater than 8 pCi/L, then the homeowner was advised to take remedial action without further delay. If this average was between 4 pCi/L and 8 pCi/L, then an additional six-month measurement was recommended. Combined results of all measurements were then used to determine whether mitigation was indicated.

SCREENING RESULTS AND DISCUSSION

As of September 1990, IDNS had performed screening measurements in 4,063 homes in 98 Illinois counties, as illustrated in Figure 1. These screening data are summarized in Table 1. The indivual county radon averages are shown on Figure 2. The current data indicate 39 percent of the basements tested have radon levels that exceed the EPA guideline of 4 pCi/L and 11 percent of the first floor areas have such levels. In all, 1,263 homes sampled taken exceeded 4 pCi/L. This is about 31 percent of the total.

The sample of houses screened to date is a small fraction (about 0.16 percent) of the 2.5 million privately owned houses in Illinois, but if this sample is representative, about 975,000 of the houses in the state may have elevated basement levels and 275,000 houses may have elevated first floor levels. Since this is a significant number of homes from both a public health and an economic standpoint, and since there are yet no methods that reliably predict the radon concentration in a given house, IDNS continues to recommend that all homeowners conduct radon tests. The frequency distribution of the data is shown in Figure 3. The data suggest a log-normal

distribution. This is consistent with Cohen's analysis of data taken nationwide (6).

RESULTS OF OTHER STUDIES

The EPA conducted a thirty four state joint EPA/state radon screening program (7). This study indicated that from 0.4 to 70 percent of the houses in those states have the potential for elevated radon levels, as compared to the current Illinois combined estimate of 31 percent. IDNS plans to participate with the EPA in a joint screening during the 1990-91 heating season. The results obtained during the EPA study cannot be compared directly to those obtained by IDNS because the EPA studies are performed using charcoal canisters.

Earlier results compiled by a major supplier of alpha track detectors showed 30 percent of all radon measurements across the country were above the 4 pCi/L level (8). These results are in good agreement with the radon levels in Illinois homes. The average concentration of indoor radon in this national study, 3.9 pCi/L, is approximately equal to the EPA guideline.

EFFECT OF HOUSE CONSTRUCTION CHARACTERISTICS ON INDOOR RADON

A closer examination of the distribution of radon results by house construction characteristics was done to develop a better understanding of the behavior of radon in various types of homes. The following information was provided by homeowners and compiled in a database along with the screening results:

- age of house;
- type of substructure (basement, slab or crawlspace);
- primary heating source (gas, oil, electric, others);
- basement characteristics such as cracks or drains; and
- crawlspace characteristics such as exposed earth.

Homeowners were also asked to rate their home subjectively according to its energy efficiency on an arbitrary linear scale.

An attempt was made to compare these features and characteristics with either high or low radon concentrations. Results are presented in Table 2.

The age of the house was not a good indicator. Homes less than 15 years old should be more energy efficient than older homes but no increase in radon concentration was found in these homes. On the other hand, homes greater than 50 years old are thought to be drafty but on the average they were not lower in radon concentration. Unfortunately more than 86 percent of the homeowners in the study rated their home energy efficiency as "good" or "excellent;" so little could be drawn from this information, although the average level in these houses (4.0 pCi/L) was slightly higher than those rated "not at all" or "somewhat" energy efficient (3.1 pCi/L).

Although successful radon mitigation efforts almost always depend on a well-sealed basement floor, there was little evidence that houses with basement floor leaks and cracks automatically have high radon concentrations. The presence of exposed earth either in a basement or accessible crawlspace seemed to be a common factor in many of the higher concentration homes. Homes with crawlspaces that are fully ventilated and not accessible from the basement tended to be lower in radon than the average.

Several studies have failed to show a correlation between certain home construction features and high radon concentrations. A survey conducted by Cohen of 453 houses in 42 states found only weak correlations between radon levels and home construction features (6). One of Cohen's conclusions was that geological factors might control radon levels to a greater degree than construction features. This poor correlation precluded public health officials from focusing efforts on specific types of houses or ruling out radon problems for significant numbers of homeowners.

EFFECT OF GEOLOGICAL FACTORS ON INDOOR RADON

It is not clear whether there are any particular geological formations in Illinois which contribute to high radon exposures. There is no evidence of any areas with radium concentrations similar to those in the Reading Prong area, but radium levels do vary across the state and Illinois soils do exhibit varying permeability and moisture content. Some investigators tried to link the National Uranium Resource Evaluation (NURE) data with indoor radon levels, but the NURE data is useful only for locating uranium and other nonspecific gamma ray anomalies.

Since IDNS did not have the resources to study geological factors directly on a statewide basis, the original approach was to rely on the statewide screening program to identify clusters of homes with elevated radon levels. This was to be done by screening neighborhoods around homes with confirmed radon levels above 20 pCi/L. It was then planned to study the geology in these local areas. Due to lack of resources, this neighborhood screening program was postponed. As indicated in Table 1, the department identified about 44 neighborhoods that should be studied.

There are no known areas of the state which exhibit consistently elevated radon levels, such as those found in Pennsylvania. The highest result recorded was 75.6 pCi/L in DeWitt County. Although no other homes in that county were above 20 pCi/L, the average result for the county was about 7 pCi/L. Other very high values were found in the state but they were due to the disposal of radium wastes and not due to natural conditions.

Illinois screening data identified regions of the state that exhibit higher than average radon concentrations. These regions are in north central and northwestern Illinois. IDNS identified 18 counties where the majority of the screening measurements were greater than 4 pCi/L (see Figure 4). The Chicago area was not identified as a problem area relative to the rest of the state, but there may be small local areas of higher than average radon. IDNS has attempted to develop a simple description of the geographical boundary of the area of greatest concern. This proved difficult. Note, however, that the area with zip codes beginning with "61" are about twice as likely to have a screening measurement in excess of 4 pCi/L than areas with zip codes beginning with "60" and "62".

RADON IN SCHOOLS

Not all personal radon exposure can be attributed to private residences. Studies are in progress to determine what fraction of personal radon exposure is due to exposure at home. Some factors that allow radon to enter houses also apply to commercial and public buildings. Some public buildings are of particular concern due to potential radon exposure to children. Because of this concern, IDNS initiated a screening program for schools. The program has had two phases thus far. In the first phase, for each of 21 counties screened, two elementary schools were selected for participation. Six detectors were placed in each school with at least two detectors placed on each level. Detectors were placed only in areas frequented by students, such as classrooms,

libraries and lunchrooms. Some basement areas fell into this category. Detectors were left in place between one and two months. Screenings, conducted on this limited basis, indicate about 25 percent of the student areas contained radon levels exceeding 4 pCi/L.

Most recently, IDNS performed long term alpha track measurements in all public schools in Clark and Wayne counties. A total of 25 schools were tested. Only one student area had radon levels in excess of 4 pCi/L. Data for all schools are listed in Table 3.

IDNS has been involved in screening, follow-up and diagnostic measurements at a group of Peoria schools since February 1989. At that time, IDNS placed 125 EPA charcoal detectors in six schools for a three-day test. The results ranged from 0.5 to 19.6 pCi/L. Follow-up tests were conducted by IDNS using alpha track detectors in 26 student areas that had screening results in excess of 4 pCi/L.

In November 1989 the EPA Office of Research and Development (ORD) proposed a project to perform diagnostic measurements in schools to develop effective mitigation strategies. EPA Region V suggested a group of Peoria schools that were tested during the February 1989 study be considered for the ORD School Diagnostics and Mitigation Strategy Project. IDNS contacted Peoria School District 150 administration, who agreed to participate. EPA and IDNS representatives conducted a walk-through audit and made radon diagnostic measurements at the Harrison, Tyng and Calvin Coolidge schools and determined these schools were suitable for the ORD project.

In February 1990, the IDNS officially proposed to ORD that the Peoria schools should be considered for the project. IDNS staff recommended the radon levels in one room of Harrison and Tyng and three rooms in Calvin Coolidge be reduced to below 4 pCi/l based upon their three-season averages. In May 1990, the ORD team performed the diagnostic measurements in Harrison, Tyng and Calvin Coolidge schools. The team reviewed the diagnostic data and developed a report that recommends an optimum radon mitigation strategy for each school. The report suggests the radon problems are caused to some degree by inoperable HVAC systems.

Schools are not yet required by either federal or state law to test for radon. However, IDNS encourages all schools to conduct screenings for the same reasons home testing is recommended. Some school districts voluntarily tested for radon, but many others are reluctant to do so for two reasons. First, while radon screening costs may be relatively low, school officials do not believe they have sufficient resources to mitigate radon problems if they are discovered. Secondly, since there are no mandatory protocols for radon testing, school officials are concerned that tests conducted now may not be valid once mandatory protocols are adopted. Even when voluntary tests are conducted, school officials are reluctant to disclose results to IDNS. As a result, IDNS has little information regarding the scope and results of voluntary testing.

RADON IN PUBLIC BUILDINGS AND IN THE WORKPLACE

Very little testing in public buildings and workplaces has been conducted. As with private residences, commercial properties are being tested for radon when sold, but there is not a significant effort on the part of employers to characterize employee workplaces. To our knowledge, the Occupational Safety and Health Administration has not made radon exposure a high priority compliance item. More research is needed to determine the nature and extent of radon problems in commercial and industrial structures.

The Illinois Secretary of State (SOS) is the custodian of many of the state government buildings in Springfield. IDNS and SOS conducted a screening study of 26 buildings in Springfield in 1989. The results ranged from 0.3 to 15.2 pCi/L. As a result of this screening,

IDNS recommended follow-up measurements be made at three locations. SOS took follow-up steps at all three locations. The most interesting mitigation was conducted in the basement of the state capitol. Grab samples in the electrical shop of the capitol ranged from 13.4 to 21.7 pCi/L. The capitol is a complex structure with underground passageways and ventilation plenums exposed to soil. Very little fresh air was being routed to the shop area. In this case, changes in the HVAC system were needed to solve the radon problem in the shop and bring radon concentration down below 4 pCi/L.

REDUCING RADON EXPOSURE

The objective of the statewide radon program is not only to identify any problems related to radon exposure, but to provide recommendations for remedial action to reduce radon exposure. Most IDNS follow-up studies in houses with elevated radon levels involve evaluating causes, as well as confirming screening measurements. Radon is not only a significant public health issue, but also an economic issue. If 31 percent of Illinois residences ultimately prove to have levels greater than 4 pCi/L, this translates to about one million homes. The cost of reducing radon levels could range from $200 to $2,000 or more per home, meaning a potential cost of $200 million to $2 billion to Illinois citizens. These cost estimates apply only to private residences and do not include public or commercial buildings.

IDNS EXPERIENCE IN RADON MITIGATION EFFORTS

In 1988 IDNS staff completed a remediation project at a home in Schaumburg. At the request of the village of Schaumburg, IDNS provided technical assistance including evaluation of the radon levels; diagnosis of the source; and routes of entry and recommendations on a reduction method. Grab sample measurements indicated that a basement sump and the heating ductwork beneath the slab-on-grade portion of the house which penetrated the adjacent basement wall were the major entry routes. Sealing the sump hole and other minor radon entry routes was not effective in reducing the basement radon levels to below 4 pCi/L. A drain tile ventilation system using the existing drain tile loop and sump hole was then installed. This active system reduced the radon levels to about 2 pCi/L. Details of this mitigation effort are reported elsewhere (9).

At the request of the Illinois Department of Energy and Natural Resources (ENR), IDNS monitored radon levels and assisted in a remedial action project at the Springfield Energy House. This house was designed and built by ENR to demonstrate the value of energy efficient building techniques and features. The features include a super-insulated shell to reduce heat loss and an underground ice storage cooling system to provide air conditioning in the summer (10). Since it is suspected that homes with low air exchange rates have high radon levels, the house was screened and found to have high concentrations in localized areas. The main route of entry for radon was the penetration from the basement to the ice storage unit. Once this penetration was sealed, an annual follow-up measurement was made. The average general living area concentration was found to be 3.8 pCi/L.

IDNS is concerned about the availability and reliability of radon mitigation contractors. Currently there is no requirement for radon mitigation contractors to register with the state, nor is there a mandatory certification program run by the federal government. IDNS recommends that homeowners employ contractors who have successfully completed the EPA Radon Contractor Proficiency Program. This program is available to Illinois contractors through the Midwest Universities Radon Consortium (MURC). Some radon mitigation work is currently being done by contractors with previous experience in home renovation and remodeling, but whose education and

experience in radon detection and mitigation techniques are not known.

PUBLIC EDUCATION PROGRAMS

A major objective of the Illinois program has been to inform and educate the public about radon. As part of this program, IDNS provides basic information about indoor radon and its associated health risks, together with information about radon monitoring. A total of 30 presentations were given between January 1989, and July 1990, on general radon awareness. Another 30 presentations were given in conjunction with the statewide residential radon screening study. These presentations were designed to train local volunteers to place radon detectors in accordance with IDNS protocols and to complete the documentation needed for the study. Because the results of the statewide monitoring program cannot be used to predict radon levels in specific houses, IDNS encourages occupants to monitor their own houses and to report high results to IDNS.

In order to facilitate this process, IDNS distributes a list of firms supplying devices that passed the EPA radon monitoring proficiency test. A variety of additional radon-related instructional materials have been distributed to the public, including over 15,000 copies of the "Citizens Guide to Radon" (1986 edition) prepared by the EPA and reprinted by IDNS.

Information about radon mitigation contractors has been only recently avaiable though the EPA radon contractor proficiency program. At the federal level, the EPA has started a radon contractor proficiency program, but participation is voluntary and therefore limited. IDNS has received citizen complaints against contractors, but the department does not have any regulatory authority over radon mitigation contractors. Both specific regulatory authority and the resources to sponsor training to contractors would provide significant consumer protection and increase public confidence in the program.

From July 1986, to February 1988, the department funded and staffed a toll-free radon information "hotline" to provide information on radon to Illinois citizens. During this period, an average of 500 calls per month were received. Funding and staffing were suspended for this program in 1988 but resumed in August 1990.

In March 1987, the department sponsored a conference on radon, radium and environmental radioactivity. One full day was devoted to talks on radon in homes, radon risk evaluation, geological considerations, monitoring procedures and mitigation techniques. The conference was designed for Illinois citizens, public health agencies and environmental groups, and was attended by about 500 people.

County and other local government agencies have expressed interest in assisting with public education, but have limited resources to conduct large scale programs. IDNS supplies these agencies with speakers, technical advice and printed information for distribution by their offices.

ILLINOIS LEGISLATION

Two key pieces of radon-related legislation were passed during 1989. The Radon Mitigation Act authorizes the IDNS to establish and coordinate a comprehensive program for detecting and reducing the amount of radon in homes and other buildings in Illinois. The act exempts radon results obtained by IDNS from disclosure requirements of the Freedom of Information Act. This is an important step forward allowing IDNS staff to continue radon studies while protecting the

participants' property values. The bill also enabled IDNS to secure independent general revenue funding from the Illinois General Assembly for radon related projects.

House Bill 1611, "An Act in Relation to Radon Testing", authorizes IDNS to establish a registration program for persons selling any device or performing any service for compensation to detect radon or its decay products. The program is intended to regulate those who place passive detectors in structures or who perform measurements using working level monitors, grab samplers and other active methods. Rules for implementation of this program (32 Illinois Administrative Code 420) were published in the Illinois Register on November 30, 1990. IDNS estimates there will be 300 registrants in this program.

IDNS SPONSORED TRAINING

In anticipation of the implementation of these rules, IDNS and the MURC co-sponsored three training sessions on radon measurements for potential registrants. The sessions were held in Mt. Vernon, Bloomington and Des Plaines during the week of April 9, 1990. A total of 110 people attended, but the sessions were overbooked by a considerable margin. IDNS plans to repeat the sessions as soon as the rules are final.

EPA GRANT

On May 1, 1990, IDNS was awarded a grant under the State Indoor Radon Grants program administered by the EPA. Under the provisions of the grant, IDNS will undertake a greater number of projects than it would using only state funding. Some of these projects include participating in the EPA/state screening program; providing a limited number of free radon detectors to low income school districts identified by the state Board of Education; coordinating a school mitigation demonstration project; conducting a follow-up study in neighborhoods identified as potentially exhibiting elevated levels of radon and conducting a study of Illinois building codes as they relate to radon resistant new construction.

CONCLUSIONS

1. IDNS has performed radon screening measurements in approximately 4,100 homes in 98 counties. Results indicate about about 31 percent of all homes tested have radon levels greater than the EPA standard of 4 picocuries per liter. The screening program identified certain areas in Illinois with significant percentages of homes with screening results in excess of the standard that merit additional study.

2. Schools are not yet required to conduct radon testing. IDNS has little information regarding the scope and results of voluntary testing, but is concerned that the uncertainties regarding costs of mitigation and testing are forcing school officials to postpone testing until it is mandatory.

3. IDNS is providing a wide variety of educational information in response to public inquiries. This effort is, for the most part, a reactive effort and therefore limited in scope. Although radon has received considerable publicity, most members of the public still need basic information about radon. News reports and public service announcements provided by the media have been

either misleading or ineffective.

4. The registration and training of persons performing radon measurement services are good initial steps toward assuring consumer confidence in radon services in Illinois. Radon mitigation services are still not covered under the program.

5. Radon reduction in homes is still primarily a post-construction activity in Illinois. There is no significant effort on the part of builders or architects to incorporate radon resistant features in new construction.

6. Radon measurements made for the purpose of satisfying provisions of a real estate contracts are not being conducted according to any specific protocols or quality assurance guidelines. This causes considerable difficulty for homeowners whose transactions depend on accurate results. Erroneous results may cause delays in the transaction, or may force a homeowner to install costly mitigation equipment where it is not needed.

RECOMMENDATIONS

1. Complete the radon screening of all Illinois counties. Four counties remain to be screened before the project is considered complete.

2. Conduct follow-up studies in neighborhoods where local clusters of homes with potential radon problems are suspected. This would help to identify localized areas where the geological conditions could be studied.

3. Encourage and support voluntary testing by schools. This could be done by conducting briefings for school administrators, conducting mitigation demonstration projects and by providing free detectors to a limited number of low-income school districts.

4. Continue to develop more active approaches to public education. This might include providing radon information to large numbers of schools and libraries. More effort is needed to educate the media as well. IDNS staff should continue to respond by sending radon information to members of the media and by making department representatives available for interviews.

5. Develop and implement a certification program for persons or companies who perform radon mitigation services. Although EPA conducts a voluntary program, Illinois has no mechanism for formally recognizing participation in the program. In conjunction, IDNS should continue to develop and conduct training programs for those who offer mitigation services as well as measurement services.

6. Evaluate the need for changes in building codes in Illinois, since the construction of radon resistant structures is the only long term solution to the indoor radon problem. Illinois should follow the lead of states in the eastern U.S. that have adopted radon resistant features in building codes.

7. Work with the EPA and with the Illinois Association of Realtors to arrive at a consensus regarding protocols and quality assurance associated with radon measurements made for real estate transactions.

The work described in this paper was not funded by the U.S. Environmental Protection Agency and therefore the contents do not necessarily reflect the views of the Agency and no official endorsement should be inferred.

ACKNOWLEDGEMENTS

For their assistance in providing the field staff for the Illinois radon screening program the authors thank the Illinois State University, the University of Illinois Extension Service and local county health departments.

REFERENCES

1. Illinois Department of Nuclear Safety, Radon in Illinois: A Report to Governor James R. Thompson from the Governor's Task Force. 1986.

2. Illinois Department of Nuclear Safety, Radon in Illinois: A Status Report. IDNS Internal Report, 1988.

3. U.S. Environmental Protection Agency, Office of Air and Radiation, A Citizen's Guide to Radon: What It Is and What to Do About It. Draft, March 1986.

4. Ronca-Battista, M., Magno, P., Nyberg, P., Applications of Radon and Radon Decay Product Measurement Protocols For Screening and Confirmatory Purposes. U. S. Environmental Protection Agency, Office of Radiation Programs, Draft, March 1986.

5. Granlund, C. and Kaufman, M., "Comparison of Three Month Screening Measurements with Year Long Measurements Using Track Etch Detectors in the Reading Prong," Pennsylvania Department of Environmental Resources, Bureau of Radiation Protection, 1988.

6. Cohen, B. L., "A National Survey of ^{222}Rn in U.S. Homes and Correlating Factors," Health Physics Vol. 51, Number 2, 1986.

7. U.S. Environmental Protection Agency, Office of Radiation Programs, Notice to IDNS, September 1990.

8. Terradex Corporation, Personal Communication, 1988.

9. Hamel, M. A., "Radon Mitigation in a Schaumburg, Illinois House: A Case History," IDNS Internal Report, 1988.

10. Illinois Department of Energy and Natural Resources, "The ENR Springfield Energy Home", "The Springfield Energy Home: 2544 Greenbriar," 1987.

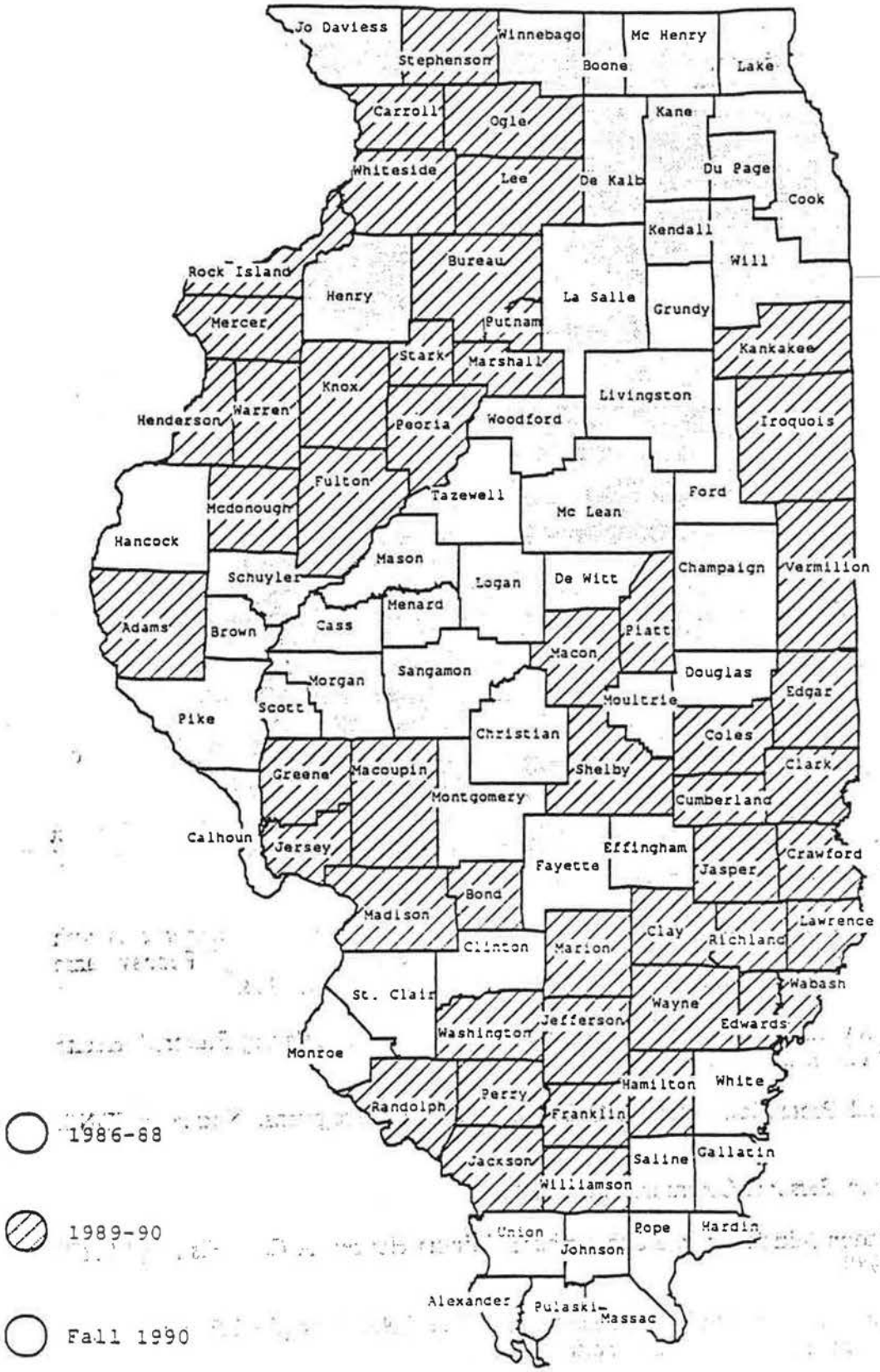

Figure 1. Illinois Radon Screening Status September 1990

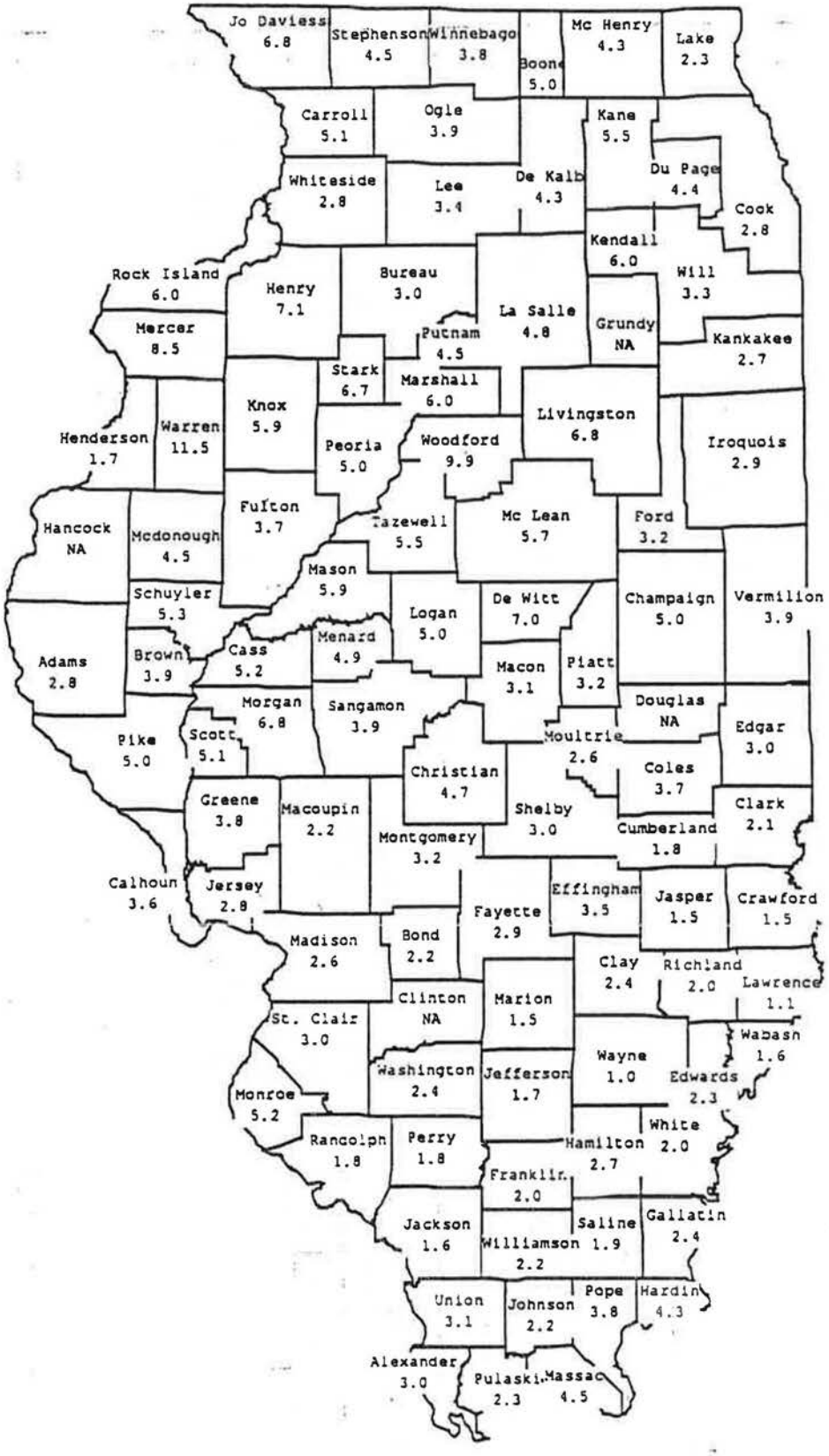

Figure 2. Average Radon Concentration (pCi/L) by County

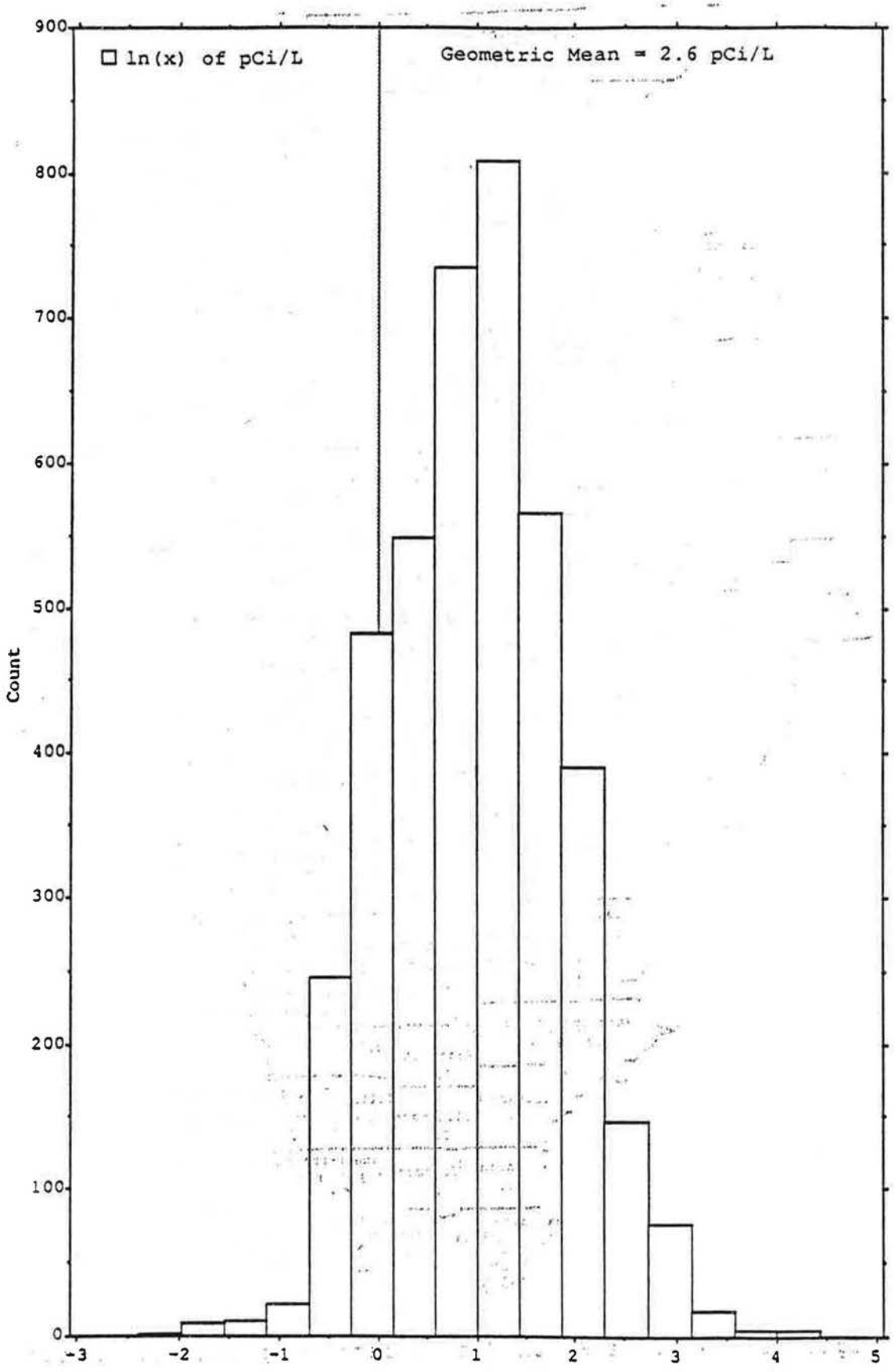

Figure 3. Frequency Distribution of Radon Results

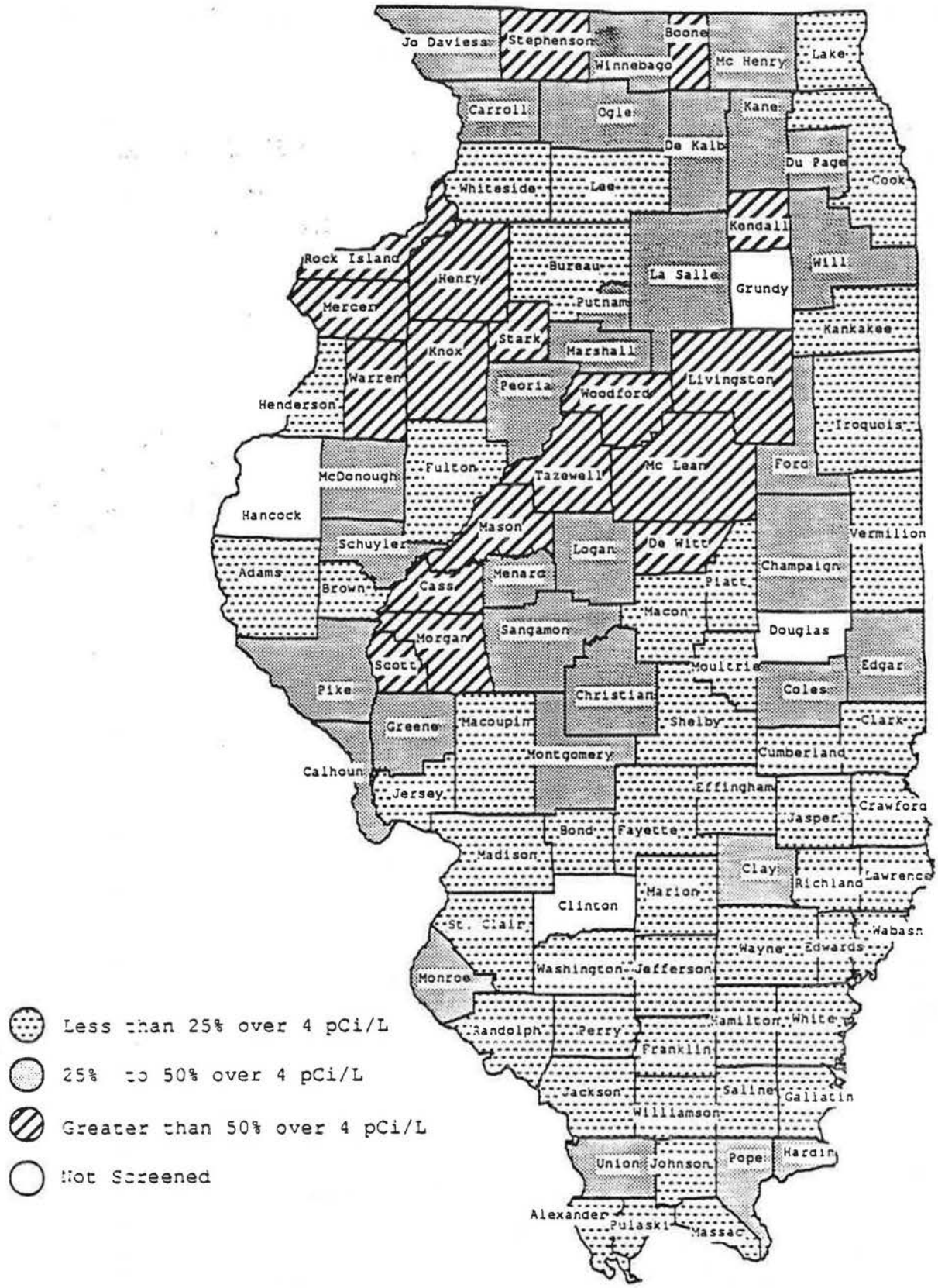

Figure 4. Illinois Screening Program December 1990

Table 1

SUMMARY OF ILLINOIS RADON SCREENING RESULTS BY LIVING AREA

Living Area	Number	Min Result	Avg Result	Max Result	#>4 pCi/L	%>4 pCi/L	#>20 pCi/L	%>20 pCi/L
Basement	2920	0.1	4.6	75.6	1132	39	43	1
First Floor Bedroom	650	0.3	2.3	19.3	81	12	0	0
First Floor Living Area	467	0.1	2.1	23.2	47	10	1	0
Other	26	0.6	2.3	12.2	3	12	0	0
Total	4063	0.1	3.9	75.6	1263	31	44	1

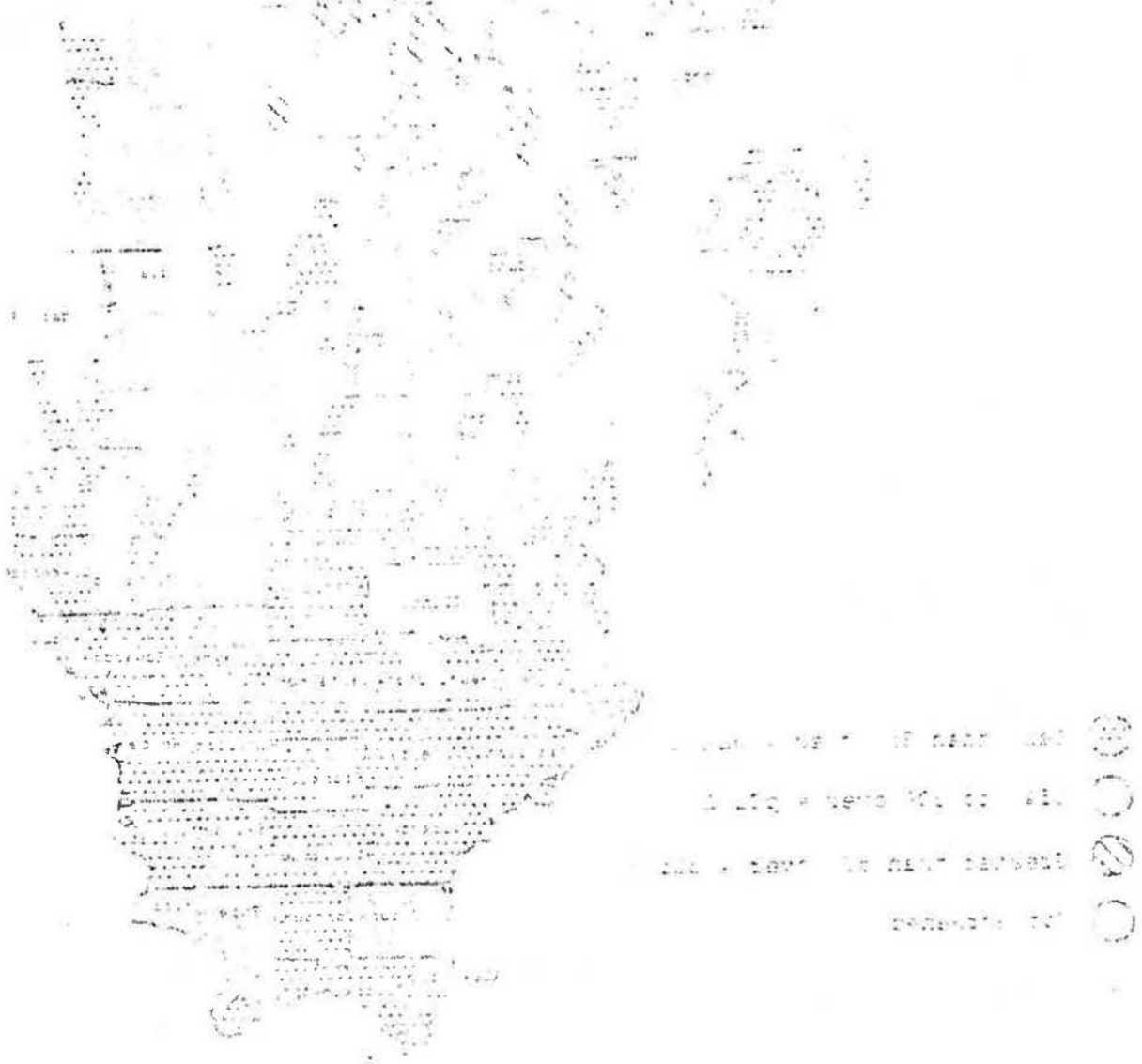

Table 2

COMPARISON BETWEEN RADON CONCENTRATIONS AND BUILDING CHARACTERISTICS

Age of House	Number	Average (pCi/L)
Less than 15 years old	919	3.9
Greater than 50 years old	1388	4.1

Substructure Type	Number	Average (pCi/L)
100% Basement	1760	4.1
100% Slab	164	3.4
100% Crawlspace	535	2.0
Basement and Slab	223	5.1
Basement and Crawl Space	880	4.6

Subjective Energy Efficiency	Number	Average (pCi/L)
Not at all	184	3.2
Somewhat	37	2.5
Adequate	333	3.6
Good	1302	3.9
Excellent	2272	4.0

Basement Characteristics	Number	Average (pCi/L)
Exposed Earth	239	5.3
Sump(s)	885	4.5
Crack(s)	784	4.6
Drain(s)	1660	4.6
None of the above	50	3.5
All of the above	39	5.6

Crawlspace Characteristics	Number	Average (pCi/L)
Crawlspace Entry & Exposed Earth	480	4.7
Crawlspace Vented	504	3.1

Primary Heating Source	Number	Average (pCi/L)
Solar	5	7.5
Oil	174	4.8
Electric	421	3.8
Natural Gas	2689	4.0
Propane	448	3.8
Wood	174	3.0
Coal	6	1.5

Other Factors	Number	Average (pCi/L)
Central Air Conditioning	1367	4.2

Table 3

SCHOOL RADON SCREENING RESULTS
pCi/L

County	Basement		1st Floor		2nd Floor		3rd Floor	
	n	Range	n	Range	n	Range	n	Range
Calhoun	3	2.1-3.8	13	1.1-3.3	2	0.5*-1.9	0	
Champaign	2	3.2-4.5	3	1.7-4.2	3	1.4-3.7	2	0.8*-1.2
Clark	0		204	0.1*-4.3	0		0	
DeWitt	2	3.4-3.9	6	1.4-3.2	2	2.0-2.8	0	
Effingham	0		4	0.8*-1.2	4	0.8*-1.2	0	
Ford	1	4.6	7	1.5*-2.9	2	0.8*-1.4	2	0.7*-2.4
Gallatin	0		4	1.3-2.1	2	1.4-1.7	2	1.4-1.5
Henry	0		8	1.2*-10.0	2	0.8*-2.2	2	1.1-1.5
LaSalle	1	2.3	10	0.8*-2.2	1	0.8*	0	
Livingston	0		7	0.7*-1.5	2	1.9-3.8	2	0.7*-0.7*
McLean	0		5	4.3-9.2	5	3.3-8.0	2	3.2-5.0
Monroe	0		6	0.9-3.0	6	1.0-2.7	0	
Montgomery	0		8	1.6-3.2	2	1.7-1.8	2	1.0-1.5
Moultrie	0		2	2.3-4.5	2	1.0-1.2	2	1.7-1.8
Pike	2	2.3-6.0	15	0.2*-5.8	1	1.3	0	

Table 3 (cont'd)

SCHOOL RADON SCREENING RESULTS
pCi/L

County	Basement		1st Floor		2nd Floor		3rd Floor	
	n	Range	n	Range	n	Range	n	Range
Saline	3	1.5-4.4	3	0.7-1.6	3	0.7*-1.4	0	
Sangamon	1	25.8	1	1.9	1	3.1	0	
Schuyler	0		8	1.1-6.3	2	1.1-2.2	2	1.5-1.7
St. Clair	0		6	1.6-3.1	0		0	
Wayne	36	0.1*-1.4	241	0.1*-3.6	0		0	
White	0		4	0.7-1.6	4	0.7-2.2	0	
Will	0		8	0.9*-2.3	2	0.5*-0.9*	2	1.4-1.4
Woodford	0		4	0.8*-5.6	4	1.0-3.4	3	1.2-2.7

* Less Than Minimum Detectable Concentration
n = Number of rooms measured.