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XI

RADON MEASUREMENTS IN NORTH DAKOTA SCHOOLS

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ABSTRACT

Through the Environmental Protection Agency's State Indoor Radon Grant (SIRG) Program, the State of North Dakota conducted a survey for the presence of radon in schools throughout the state, from January to April of 1990.

Two main reasons for undertaking this project were:

1. Elementary and secondary school students' theoretically higher risk from exposure to radon and its progeny;

2. Results of the 1988 state-wide random survey showed 63% of the homes tested as having screening measurements greater than or equal to 4.0 pCi/l, suggesting radon's presence in other types of structures.

The results of this school survey revealed that 6.1% of the rooms tested had radon levels greater than or equal to 4.0 pCi/l, differing from the residential survey by a factor of ten.

The position is advanced that this survey is representative of schools in the upper midwest and that its data will be important in developing testing, diagnosis, and mitigation protocols in schools and larger public buildings.

This paper has been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for presentation and publication.

BACKGROUND

In the winter and spring of 1988, the North Dakota State Department of Health and Consolidated Laboratories (the Department), in conjunction with the Environmental Protection Agency (EPA), undertook a state-wide residential radon survey. 1596 homes were measured with two-day charcoal canisters. An average concentration of 7.0 picocuries of radon per liter of interior atmosphere (pCi/l) was recorded, with 59% of these homes having concentrations in the 4.0 - 20.0 pCi/l range, and 4% having 20.0 pCi/l or greater.

These results indicated a potential for high radon levels throughout the state, with 51 of 53 counties reporting 25% or greater of home screening measurements at or above the EPA action level of 4.0 pCi/l (Figure 1).

These screening measurements were confirmed by analysis of year-long alpha-track detectors placed in addition to the charcoal canisters in 175 of the above homes. 47.4% of these homes had at least one alpha-track result above 4.0 pCi/l.

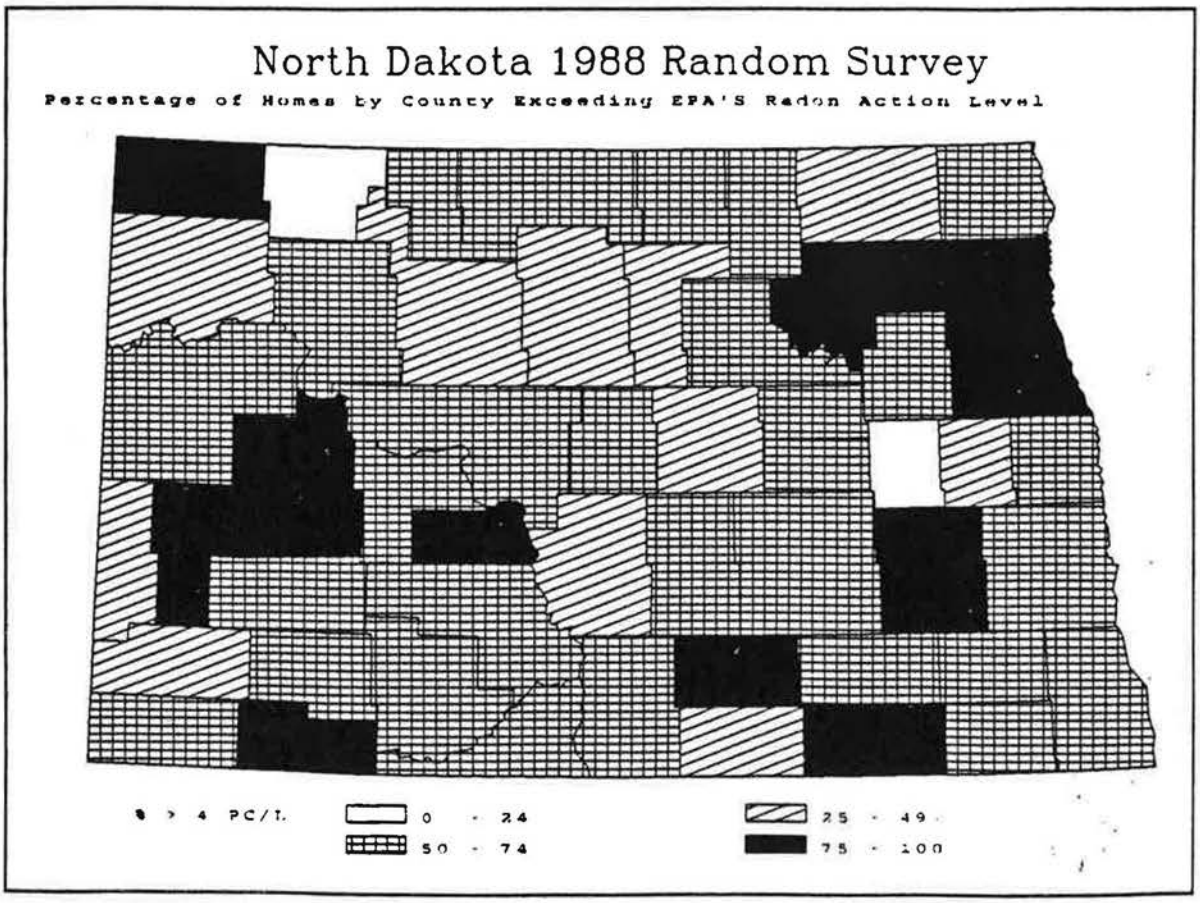

Figure 1.

Given these results, and the potentially more harmful effects of radiation from radon and it's progeny on younger people, it was decided to explore cumulative exposures to children based on where the majority of their time was spent in addition to that spent in their homes, notably their schools. A grant deviation was applied for and approved by EPA to enable screening measurements to be performed this past testing season rather than delay the study another year. This led to the Department conducting a state-wide radon in schools survey in the winter/spring of 1990 under an EPA State Indoor Radon Grant (SIRG).

STUDY DESIGN

Since the residential state-wide survey was conducted using 48-72 hour charcoal canister screening measurements, it was decided to be consistent with this approach for the initial testing in schools. The canisters were to be EPA style, cylindrical open-faced of the same testing window duration. For consistency, one vendor to supply and analyze the canisters was to be chosen. Other criteria for a vendor included: being listed in the EPA Radon Measurement Proficiency Program (RMP) and having the capacity to analyze up to thousands of canisters within a meaningful amount of time.

Bids were submitted by approximately 20 prospective vendors. The contract was eventually awarded to Home Radon Detection, Inc. (HRDI), whose bid allowed the purchase and analysis of over 7,000 canisters by funds allocated under the SIRG. Terms of the contract called for the solicitation of schools for participation in the survey by the Department. The Department was to analyze the testing plan submission by the schools for correct room placement, number, control and duplicate canisters, etc. An approved plan would then be returned to the school showing approved test room locations. The vendor was then notified as to the address of the school and the number to be sent to that address. After testing, the canisters would be returned postage-paid directly to the vendor for analysis. Results of this analysis were to be furnished to both the school and the Department.

Since the clientele to be solicited for this survey do not normally fall exclusively under the jurisdiction of a health agency, the State Department of Public Instruction was notified and informed of the proposed project and given the opportunity to be the lead agency, as a matter of professional courtesy. They declined this, and provided the Department with all school district contact individuals and mailing addresses. At that time, December 1989, the number of public and private school districts numbered approximately 350 for the entire state.

It was decided to contact school districts and make the district responsible for the individual schools within that district, rather than us contacting each individual school. This was a far more efficient method, as many districts had a considerable number of school buildings, and worked within the normal educational chain of informational flow.

METHODOLOGY

SOLICITATION

All 350 school districts within the state were contacted by mail and offered the opportunity to participate in the survey. There was no cost to the districts for this program as it was under the SIRG, 75% federal and 25% state-matching funded. However, since school testing was and is not mandated under North Dakota or federal regulation, only 130 districts submitted applications for testing under the 1990 grant year.

In September 1989, at a school administrator's conference, the Department made a radon presentation and included a copy of the EPA publication "Radon Measurements in Schools - An Interim Report" in the informational packet for each attender.

This publication was referenced in the application packet sent to each school district; pertinent sections related to testing were duplicated and included as part of the packet. Other enclosures were:

Individual school information sheets (Form 1).

Summary district application form to be dated and signed by a district official (Form 2).

Instructions on completing the above two forms.

A sample completed application.

As part of the application, floor plans of all levels of all school buildings to be tested showing proposed test locations were requested.

REVIEW

Current EPA school testing protocols call for testing in all frequently used rooms at or below ground level. Ten percent of these rooms were to be tested with duplicate canisters; an additional five percent of canisters were to be set aside as controls. To maximize the radon levels obtained under screening measurements, it is also suggested the testing be performed during periods of relative inactivity, such as over a weekend. The Department followed these protocols with the following exceptions:

Testing in rooms or areas of high humidity such as bath or locker rooms was strongly discouraged due to the effects of moisture on canister analysis accuracy;

To maximize the number of tests to be performed under the grant, not all support rooms, such as offices, conference rooms, etc., were tested, but a representative sampling thereof - virtually all classrooms were tested, however - this was felt to be a more critical area of concern;

These protocols call for placement of a canister for every 2,000 square feet of area in an "open-classroom" school or gymnasium. In this survey, canister placement in gymnasiums was often for areas of greater than 2,000 square feet.

A two stage, primary and secondary, review process was performed on each application. If more information or clarification was needed, the district official was contacted by mail or phone. Upon approval, written notification to the district was provided along with approved floor plan showing test locations and room summary enclosures. At this time, the vendor (HRDI) was also notified and given the district contact, mailing address, and total number of canisters to be delivered.

Care had to be exercised so as to time the approval of schools so that the number of canisters to be analyzed would not exceed the capacity of the vendor. This technique was negated to some degree by the school districts not testing as soon as possible after receipt, but waiting until the "perfect" testing weekend. Canisters were therefore delayed in being sent to some schools until "outstanding" ones were returned for analysis.

RECORD MANAGEMENT

To maintain a quality assurance program, the vendor was not informed as to which canisters were duplicates and controls until after analysis. The Department sent separate quality assurance forms to each district for each school, to be returned to the Department upon completion of testing, listing canister numbers and locations of controls and duplicates. This procedure established an accounting redundancy between the Department, the schools, and the vendor.

Upon receipt of results from the vendor, data was input to personal computers utilizing a dBASEIV software system. Rationale for database structure was one main district record; multiple schools per district; and multiple results per school.

Radon results were further broken down by the type of room use category and organized in such a manner that results for a particular category could be split and analyzed separately. This was done to allow for the theoretically variable harmful effects of radon based on age of incidence of exposure. It is, therefore, beneficial to know whether a particular classroom was in a primary or secondary school.

RESULTS

Due to widely variant climatic extremes within North Dakota, all buildings, including schools, are well insulated, well sealed, and generally energy efficient. Some of the schools tested during this survey were constructed around the time of admission to statehood, in 1889, while others were built within the past year. A wide range of construction styles and techniques are, therefore, encompassed. The majority of existing school structures appear to be slab-on-grade or "ranch" style, primarily to achieve lower construction costs and to allow for handicapped accessibility.

130 out of the 350 school districts participated in the 1990 school survey; however, virtually all of the larger districts did so. It is estimated that radon exposures to 50% of the state's students were analyzed. In these 130 districts, 273 buildings were tested. Out of 7,011 approved test locations in these 273 buildings, 6,983 canisters were placed and analyzed - a rate of 99.60 %.

Results showed mean levels to be considerably less than those discovered for residences - less than 2.0 pCi/l for any room use category - resulting in a extremely skewed distribution to the lower end of the scale. These results are further delineated in Tables 1, 2, and 3.

Table 1. Canister Use

Control canisters	323	(323/6052 = 5.34%)
Duplicate canisters	608	(608/6052 = 10.05%)
Room canisters*	6,052	
Basement	156	
1st Floor	5,896	
Total	6,983	

* Definitive rooms or 2,000 square feet of floor area.

Table 2. Placement and Results
by Room Category

Room category	Number	% of 6052	Number ≥ 4.0 pCi/l	% of room cat. ≥ 4.0 pCi/l
Classrooms:				
Elementary	1,981	32.7	137	6.9
Secondary	1,856	30.7	94	5.1
	3,837		231	
Support rooms:				
General*	426	7.0	22	5.2
Physical Ed	32	0.5	4	12.5
Kitchen	204	3.4	12	5.9
Lunchroom	128	2.1	6	4.7
Lounge	185	3.1	12	6.5
Library	192	3.2	11	5.7
Office	581	9.6	43	7.4
Multi-purpose	119	2.0	8	6.7
Gymnasium	348	5.8	20	5.7
	2,215		138	
Totals	6,052	100.1	369**	

* General support rooms include: conference, counselor, bath, auditorium, locker, apartment, custodial, storage, etc.

** Results (x) of 6,052 rooms in pCi/l

$x < 4.0$	5,683	93.90%
$4.0 \leq x < 20.0$	363	6.00%
$x \geq 20.0$	6	0.10%

66.2 pCi/l was the highest measurement.

74 districts (74/130 = 56.9%) had at least one test result ≥ 4.0 pCi/l.

102 buildings (102/273 = 37.4%) had at least one test result ≥ 4.0 pCi/l.

Table 3. Statistical Analysis

Room Category	Number*	Arith Mean pCi/l	Arith Std Dev pCi/l	Geom Mean pCi/l
Total	6,660	1.53	1.95	0.98
Elem class	2,206	1.61	1.56	1.04
Sec class	2,068	1.40	1.96	0.87
Support	2,386	1.58	2.24	1.01

* Including duplicate canisters, but not controls.

School districts were sent results by the vendor soon after project completion. Confirmatory correspondence was also sent to each district, listing the schools, and the rooms within the schools that had screening measurement results $\geq$ 4.0 pCi/l. Procedures were referenced from "Radon Measurements in Schools"; additionally, the Department recommended retesting at 5 - 10 year intervals and following school building remodeling or additions. No mitigation was recommended at this stage, but rather confirmatory testing for rooms with screening measurements $\geq$ 4.0 pCi/l. Suppliers of alpha-track detectors were listed in the Department's letter along with the statement that there was currently no funding anticipated for this follow-up testing under future state grants.

EVALUATION

RESULTS

In participatory studies such as this, a great deal of trust must be placed in the personnel on site to properly place canisters, record data, and maintain qualitatively and quantitatively effective sampling techniques. Placement of the canisters in this study was performed by administrators, building superintendents, selected educators, and school science clubs.

The Department was available to answer questions from the project inception until its conclusion, greatly reducing the number of errors that inevitably occur. The high analysis percentage (99.6) is indicative of this effort.

METHODOLOGY

The following are ways in which it is thought the survey could have been run more effectively:

1. In addition to the sample completed application forms, it would have been illustrative to include a sample floor plan showing correct canister placement.

2. Consistency between the approved test locations and their identity on the vendor analysis forms should have been stressed. Oftentimes a room was identified by number (101, 102, etc.) or use (Math, English, etc.) and then reported by educator (Ms. Smythe, Mr. Johnson, etc.).

3. Some extraneous information was asked for on Form 1. The total number of classrooms in a school was requested, not just those at or below ground level. This was asked to get an idea of the construction style of a building, but this could be inferred from the floor plans we requested. This data was also thought to have informational value in the event a school chose to conduct optional testing. While this would have been useful, this Form would not appear to be the appropriate place to bring up the point of optional testing. Questions 3, 5, and 7 on Form 1 could therefore have been eliminated.

4. A split on Form 1 between class and support rooms was asked for without a great deal of delineating criteria. Some additional definition would have been helpful.

5. Some school officials took the protocols for testing in all frequently occupied rooms literally, and submitted plans showing placement in all areas, including closets, storage, boiler rooms, etc. A list of types of rooms not to test would have been helpful.

6. Testing of some schools did extend into April, which even in North Dakota is at or beyond the end of the heating season. This was brought about by the earlier noted tendency by some school officials to wait for the "perfect" weekend, delaying the entire queue, and by the timing of the grant approval after the first of the year, so that the survey began somewhat advanced into the testing season. Starting the SIRG programs at the beginning of the Federal fiscal year (October 1) would help to increase the length of the testing season as opposed to delaying a study until the beginning of the next school year.

7. Some school officials were reluctant to sign the summary application Form 2 as they were unsure as to what they were committing to by signing. Form 2 should have stated that they were agreeing to follow the protocols for screening measurements only.

8. North Dakota has an open records law; the results of any school would be open to examination by anyone, compromising the implied confidentiality between the Department and the school district. The policy was to refer questions on results to the district, but if pressed, the Department would have had to release them. A statement on the application summary form to this effect would have explicitly stated this position and avoided future misunderstandings.

CONCLUSIONS

There would appear to be an anomaly between the results of the residential state survey and the radon in schools survey. The initial assumption was that much higher levels of radon would be found in the schools and that more rooms would have been identified as being above the action level. A variety of reasons may have an effect on this situation:

1. School rooms generally have a larger volume than residential rooms.

2. School rooms are generally better ventilated as a result of increased traffic and more effective HVAC (Heating, Ventilating, and Air Conditioning) systems.

3. Whereas it is estimated that 95% of all homes in North Dakota have basements[1], the majority of schools in the state appear to be of slab-on-grade construction. Only 156 tested rooms (156/6052 = 2.6%) were basement rooms. Of these 156, 16 (10.3%) had levels greater than or equal to 4.0 pCi/l.

In May 1990, an EPA diagnostic/mitigation team headed by Mr. Gene Fisher, Washington D.C., examined three Minot, North Dakota area schools where elevated levels had been indicated by the SIRG screening measurements. Diagnostic work was linked to a possible correlation between elevated radon levels and elevated CO_2 levels within the rooms in question. Mitigation recommendations were made to the individual schools by this team. HVAC supply-exhaust air flow adjustments were recommendations common to all schools.

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[1] U.S. Environmental Protection Agency, Radon-Resistant Residential New Construction (EPA/600/8-88/087 July 1988), p. 4.

FUTURE ACTIONS

To continue the logic behind the impetus for school testing, future grant applications will be directed toward completion of screening measurements in schools and licensed day care centers across the state. Confirmatory measurements were recommended to schools prior to potential mitigation. These results will be illustrative in determining the actual exposure to students and young people from radon gas.

REFERENCES

1. Radon Reference Manual, U.S. Environmental Protection Agency, Washington, D.C., EPA 520/1-87-20, 1987.

2. Radon Measurements in Schools - An Interim Report, U.S. Environmental Protection Agency, Washington, D.C., EPA 520/1-89-010, 1989.

3. Radon-Resistant Residential New Construction, U.S. Environmental Protection Agency, Washington, D.C., EPA/600/8-88/087, 1988.

4. Bergsten, J., White, S.B., Hoffman, M., Alexander, B., Holt, N., Pantulla, J., Branson, S., and Kooyman, C. Support of the State Radon Assessment Program, Volume II. RTI/7804/06-02F, Research Triangle Institute, Research Triangle Park, NC, 1989.

5. Fisher, Gene, U.S. Environmental Protection Agency, Office of Radiation Programs, on-site, Minot, ND area school investigations.

Form 1.

RADON IN SCHOOLS TESTING QUESTIONNAIRE/APPLICATION

1. Name of School District and Address/Location (including City and County):

_____

2. Name of School building and Address/Location (including City and County):

_____

_____

3. Total number of classrooms in building: _____

4. Total number of classrooms on or below the ground level: _____

5. Total number of support rooms:
(e.g. library, cafeteria, administrative, etc.): _____

6. Total number of support rooms on or below the ground level: _____

7. Total number of classrooms/support rooms (add Items 3 & 5 above): _____

8. Total number of classrooms/support rooms on or below the ground level:
(Add Items 4 and 6 above): _____

9. Subtotal number of test devices required for this building
(minimum-1 classroom in contact with the ground): _____

10. Number of control test devices required
(5% of total shown in Item 9): _____

11. Number of duplicate test devices required
(10% of total shown in in Item 9): _____

12. Total number of test devices required for testing this
school building (Items 9 + 10 + 11): _____

13. Attach sketches/drawings of the school buildings showing proposed placement of test devices for radon testing.

Please refer to pages A-1 to A-5 when planning the placement of your test devices.

14. School district contact for radon in schools testing program:

_____ (Contact Person) _____ (Contact Telephone No)

Form 2.

SCHOOL DISTRICT SUMMARY OF RADON TESTING REQUIREMENTS

School Building/ Location (City and County)	Subtotal Devices Required (Item 9)	Controls Required (Item 10)	Duplicates Required (Item 11)	Total Devices Required For School
TOTALS				

CERTIFICATION

I _____ hereby certify that the _____ School District will follow the EPA protocols, referenced in "Radon Measurements in Schools - Interim Report."

_____ _____

Typed Name of School District Official — County

_____ _____

Signature of School District Official — Date