Preliminary Geologic Evaluation of Radon Availability in New Mexico

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Summary

The primary objective of this preliminary report is to identify and characterize areas in New Mexico where geologic factors may significantly influence indoor radon values. Areas which may have potential for generating elevated levels of indoor radon need to be identified so that a larger percentage of radon detectors can be allocated to these localities during a statewide survey conducted by the New Mexico Environmental Improvement Division in cooperation with the U.S. Environmental Protection Agency. The first step in this evaluation is to identify large areas where previous geologic studies indicate a probability of having elevated levels of indoor radon. Assessment of any health risks due to exposure of radon are beyond the scope of this study. Also, any potential exposure hazard may vary significantly from house to house. The only way to find out the extent of exposure due to indoor radon in a specific house is to test that house for radon.

In this study rocks and soils in New Mexico were initially grouped into three radon-availability categories, which are relative to each other and specific to New Mexico based on geologic interpretations. Subsequently, each county and the major cities in the state were given a radon-availability rating based on the predominant availability category established for geologic units in that area. The health risks, if any, associated with these geologically ranked areas are not known until the survey of indoor radon levels is completed.

Ten counties are assigned a high availability rating for

radon based on interpretation of available geologic and soil data; they are Doña Ana, Hidalgo, Los Alamos, Luna, McKinley, Rio Arriba, Sandoval, Socorro, Santa Fe, and Taos. Seven of the most populated cities (1984 estimates) are rated high: Santa Fe, Las Cruces, Roswell, Carlsbad, Gallup, Deming, and Los Alamos-White Rock. Thirteen counties: Bernalillo, Catron, Cibola, Chavez, Colfax, Eddy, Grant, Lea, Lincoln, Quay, San Juan, Sierra, and Union; are assigned a moderate availability rating. Six of the most populated cities are rated moderate: Albuquerque, Rio Rancho, Clovis, Hobbs, Grants-Milan, and Lovington. The remaining ten counties in New Mexico: Curry, De Baca, Guadalupe, Harding, Mora, Otero, Roosevelt, San Miguel, Torrance, and Valencia, are assigned a low availability; although, some homes in these areas may still have elevated levels of indoor radon. Six of the most populated cities are rated low: Farmington, Alamogordo, Las Vegas, Silver City, Portales, and Artesia. In addition it should be emphasized that even in counties with moderate and high availability many houses may have low levels of indoor radon.

Purpose

The U.S. Environmental Protection Agency (EPA) is conducting a nationwide survey of indoor radon levels in houses to define the scope and magnitude of health risks associated with exposure to radon and its decay products (Magno and Guimond, 1987). The actual indoor radon surveys in New Mexico will be conducted by the Environmental Improvement Division (EID) of the New Mexico Health and Environment Department. Since geology plays an important role in the EPA's study, the New Mexico Bureau of Mines and Mineral Resources (NMBMMR) was asked to provide the geologic expertise required.

The EPA will supply the EID with 2,000-3,000 radon detectors in 1988-1989 to be allocated throughout New Mexico on the basis of geologic and soil conditions, which appear to correlate with elevated radon levels, and population distribution. Radon detectors are used to measure concentrations of indoor radon. The first step in formulating a sample allocation plan and the primary objective of this report is to identify and characterize areas in New Mexico where geologic factors may significantly contribute to elevated levels of indoor radon in order to allocate a larger percentage of detectors to these areas. A secondary objective is to determine how geology and related soil conditions can be better used as a predictive tool in the identification of areas with a high probability of having elevated levels of indoor radon.

What is radon?

Radon is a radioactive, colorless, odorless, and tasteless gas that is naturally occurring in our environment. It is a short-lived radioactive decay product of radium which is in turn a radioactive decay product of uranium. The radon gas decays into a series of radioactive daughter products to which most of the health risks are attributed. Exposure to elevated concentrations of radon over long periods of time may increase chances of developing lung cancer. The radioactive decay products are particularly harmful at large concentrations, but the exact health risks are difficult to establish because the majority of lung cancer cases are thought to be caused by cigarette smoking.

Radon is not a problem outdoors because the atmosphere dilutes the radon and associated health risks. However, radon becomes an indoor hazard when the gas leaks from the ground beneath a house into the house through cracks in the foundations and floors and around pipes and joints. Water may also be a source of indoor radon and may occur either as soil moisture or capillary-fringe water in the unsaturated (vadose) zone as well as ground water below shallow water tables. Radon becomes concentrated in the house, especially in colder months when the house is closed. The gas decays to the solid daughter products that adhere to dust particles, furniture, walls, and floors and tends to remain in the house until it is breathed into the lungs. The health risks increase in areas of poor ventilation, such as basements, where the gas tends to accumulate.

Indoor radon levels are dependent upon many variables, including geology, soil-water content, building construction, weather changes, and life styles of the occupants. The source of radon is in the rocks, soils, and shallow ground water but an adequate pathway for the gas to travel is also required. The flow of radon from the soil into the house is generally due to a pressure differential between the house, soil, and atmosphere. Thus, houses with high indoor radon levels are found not only in houses on soils with high concentrations of radium and uranium; but in houses on soils with low radium and uranium concentrations that are extremely permeable, allowing the radon gas to travel farther and more quickly than in impermeable soils.

It is extremely difficult to predict for an individual house if indoor radon may be a hazard. Regional areas of increased probability of having elevated levels of indoor radon may be identified using geologic data as in this report; but the hazard still varies from house to house. Even in areas of low risk of indoor radon hazards, a few houses in these areas may have elevated levels of indoor radon. The only way to find out the extent of the risk due to indoor radon in a specific house is to test that house for radon. If your home is above the EPA recommended action level of 4 pCi/l, there are basically two ways to mitigate the problem: prevent its infiltration by sealing cracks or dilute the gas inside the house by ventilation. For more information on radon, the associated health risks, and how to mitigate the problem, the reader is referred to Green (1988), Cohen and Nelson (1987), Hopke (1987), and U.S. Environmental

Protection Agency (1986a, b, c).

Variation in radon generation as a function of New Mexico geology

The first step in formulating a sample plan for the survey of indoor radon levels is to evaluate the rocks and soils for radon-availability. Prediction of radon-availability requires a knowledge of lithology and uranium or radium content of various rocks and soils, rock structure (shears and fractures), soil and rock permeability, and nature of the ground water. The primary sources of data used to evaluate the rocks and soils in New Mexico were 1) aerial radiometric data, 2) geologic, especially lithologic, data, 3) uranium occurrence data, and 4) soil permeability data. Other sources of information include geochemical data, ground water data, and a limited amount of indoor radon concentrations. These data were integrated to provide a preliminary estimate of radon-availability in New Mexico. Since the time spent on this assessment was relatively short (less than four weeks), due to EPA and EID constraints, this is only a preliminary assessment and will require more detailed study.

Aerial radiometric data

Aerial radiometric data provides a regional estimate of uranium concentrations in the surficial rocks and soils and correlates well with the amount of radon in the ground (Peake and Schumann, in press). However, it must be emphasized that the amount of radon that is available to enter a house from the ground is dependent upon many other variables. The primary source for aerial radiometric data in New Mexico is a series of reports prepared as part of the National Uranium Resource Evaluation (NURE) program. The NURE program was established in 1974 and terminated in 1984 and the main objectives were 1) to provide an assessment of the uranium resources in the United States and 2) to identify areas of uranium mineralization.

The NURE aerial radiometric data has been released in reports based on 1° x 2° topographic quadrangles and on magnetic tape. The quadrangle reports include a brief narrative and graphs of the flightline data, uranium anomaly maps, and histograms of the radioactivity data by lithology. A colored contour map of New Mexico showing radiometric equivalent uranium (eU) concentrations was prepared by the U.S. Geological Survey at a scale of 1:1,000,000 from the computerized aerial radiometric data. A copy of this map is available for inspection at NMBMMR. The individual quadrangle reports and the state compilation map were used in this assessment.

Several problems exist with the aerial radiometric data. Most 1° x 2° quadrangles in New Mexico were flown with east-west flight line spacings of three miles. However, parts of the Tularosa and all of the Carlsbad, Raton, and Ft. Sumner quadrangles were flown with six mile spacings. Large unmeasured areas exist between these flightlines and localized anomalies may be overlooked. In addition, not all areas of New Mexico were flown. The largest area of no data is in the vicinity of the White Sands Missile Range north of Las Cruces and west of Alamogordo.

In the southwestern part of New Mexico, atmospheric inversions are known to occur frequently and may result in uncompensated U-air anomalies. Atmospheric plumes generated by copper smelters in southwestern New Mexico and southeastern Arizona also may result in uranium anomalies in the surveys. The effect of these atmospheric anomalies in predicting elevated levels of indoor radon is unknown.

The extremely high uranium anomalies in the aerial radiometric data (>5 ppm eU; Fig. 1) near Grants, Cibola County, are a result of high values measured over uranium mill tailings. Four uranium mills occur in the Grants area, but only one is currently active. Two of the mills are scheduled for cleanup. The computer generated aerial radiometric map produced by the U.S. Geological Survey exaggerates the significance of these anomalies; the actual area affected by the mill tailings is small and probably has not contributed excessive indoor radon to nearby houses.

Aerial radiometric data are dependent upon a constant altitude above the ground. However, in some areas of New Mexico where there are steep mountains and deep canyons, constant altitude could not be maintained, resulting in erroneous measurements. Both airplanes and helicopters were used to collect data in New Mexico and helicopters were able to better maintain constant altitude than airplanes.

Geologic data

Information on the type and distribution of the lithologic units in New Mexico is important in identifying areas of high radon-availability for generating indoor radon. Geologic maps, especially the New Mexico Geological Society (1982) State map, were used.

Very little data exists on radon or radium concentrations in the rocks and soils of New Mexico, however data on uranium concentrations in rocks and soils of New Mexico is more plentiful. Rocks with uranium concentrations exceeding 5 ppm U are sufficient to produce elevated levels of indoor radon (Peake and Hess, 1987). In New Mexico, most rocks types could provide a source for indoor radon.

In addition to lithology, structural features also play an important role in some areas. Faults, shear zones, and areas of highly jointed rocks are likely sites of uranium mineralization; and they also provide a pathway for radon to migrate into houses (Ogden et al., 1987). Karst (rock dissolution) features in carbonate and gypsiferous terranes may also provide pathways for migration of radon.

Uranium occurrence data

Areas of uranium occurrences and mines are well known in New Mexico (McLemore, 1983; McLemore and Chenoweth, 1989). The majority of these areas are found in relatively unpopulated areas of New Mexico, however, there are a number of important exceptions. Uraniferous coals in the Gallup area, McKinley County (Fig. 1), were once mined for uranium and the host rocks are probably a good source for radon. Other areas, such as northern Santa Fe County, and White Signal, Grant County (Fig. 1), occur in areas of numerous uranium occurrences near or at the surface which could provide radon in nearby houses. Some indurated caliche (calcrete) horizons in soils and surficial geologic formations may also be sources of elevated uranium-radium-radon levels. A more detailed study of the correlation of known uranium occurrences, population distribution, and indoor radon levels is required.

Soil permeability data

Soil permeability data from soil surveys prepared by the Soil Conservation Service (SCS) of the U.S. Department of Agriculture are an important data base for this assessment. Well drained, permeable soils, typically with hydraulic conductivity measurements exceeding 6 in/hr, provide excellent pathways for radon. Many areas of elevated radiometric equivalent uranium concentrations shown on the aerial radiometric map occur in areas of permeable soils. However, the soil permeability data is generalized and based on very few actual measurements of hydraulic conductivity. Also soil-moisture regimes vary significantly on a seasonal as well as an annual basis, and they can materially affect permeability values.

Other sources of data

Other sources of data were examined to support interpretations of aforementioned data. The NURE geochemical data consists of uranium analyses of stream sediment and ground water samples (McLemore and Chamberlin, 1986). Geochemical reconnaissance maps showing the distribution of uranium for each $1^{o} \times 2^{o}$ quadrangle in New Mexico were used to identify areas of high uranium concentrations. Most of these areas correlate well with areas identified using aerial radiometric data. A few problems exist with the NURE geochemical data. Uranium concentrations in stream sediments are actually displaced and diluted values. Very little information, such as host rock and depth of the ground water samples, is available. In addition, many populated areas of New Mexico were not sampled and no data exists.

Ground water data, such as depth, flow direction, and chemical composition, provide additional information on hydrogeologic conditions which may affect the levels of indoor radon. Other data such as distribution and character of geothermal areas were also used in this assessment. In Idaho, houses built in geothermal areas have higher levels of indoor radon (Ogden et al., 1987). This relationship has not been tested in New Mexico.

Only a limited amount of actual indoor radon measurements are available. Most of the past studies of EID are confidential. These published and unpublished data were examined for this assessment.

Classification of Radon-Availability

The rocks and soils in New Mexico were grouped into three radon-availability categories according to interpretations of available geologic data. Radon-availability categories are relative to each other and specific to New Mexico. Because the risk of inhaling or ingesting a dangerous amount of radon is due to complex architecture, atmospheric, and geologic factors, we refrain from using the term "risk" in evaluating areas for availability of radon. The actual health risks associated with each availability category are not known until the actual indoor radon surveys are completed. The geologic character of each category is described below.

High radon-availability category

The high radon-availability category includes areas where the rocks and soils are believed to have the greatest potential for generation of indoor radon. These areas consist of rocks which typically exceed 2.7 ppm eU on the aerial radiometric map and, generally, but not always include well drained, permeable soils. The limit of 2.7 ppm eU was chosen on the basis of prior experiences of EPA elsewhere in the country (T. Peake, USDOE, personal commun., Sept., 1988).

This category includes many outcrop areas of Proterozoic granitic rocks with average uranium concentrations of 3-17 ppm (Sterling and Malan, 1970; Brookins and Della Valle, 1977; Brookins, 1978; Condie and Brookins, 1980; McLemore, 1986; McLemore and McKee, 1988). Tertiary rhyolitic and andesitic volcanic rocks in southwestern New Mexico contain anomalously high uranium concentrations (Walton et al., 1980; Bornhorst and Elston, 1981) and are included in this high category. For example, a sample of the Alum Mountain andesite near Silver City, Grant County, contained 35.1 ppm U (Bornhorst and Elston, 1981). The outcrop area of the Bandelier Tuff in the Jemez Mountains in north-central New Mexico is rated high; a sample contained 14.8 ppm U (Zielinski, 1981). Tertiary alkalic rocks in central and eastern New Mexico (New Mexico Geological Society, 1982) are also rated high; many uranium and thorium occurrences are associated with these intrusive rocks (McLemore and Chenoweth, 1989). Some Paleozoic and

Mesozoic sandstones, shales, and limestones locally contain high concentrations of uranium (Brookins and Della Valle, 1977; Dickson et al., 1977) and are rated high availability for generating indoor radon. Some Cretaceous coals in the San Juan Basin contain 3-9 ppm U (Frank Campbell, NMBMMR, pers. Commun., Oct. 3, 1988) and are rated high. Areas of permeable valley-fill sediments of Tertiary to Quaternary age are high, although only very few analyses of these rocks are reported. Areas of intense shearing and faulting, especially in areas of uraniferous rocks, are ranked high.

A few areas in New Mexico contain rocks with greater than 5 ppm eU from the aerial radiometric map (Fig. 1). These areas typically constitute a high availability ranking, with one exception, the Grants area. The Grants anomaly is a result of uranium mill tailings and has been assigned a moderate availability.

Most of the aerial radiometric anomalies (>5 ppm eU) can be explained geologically. The Gallup anomaly is the only one near a major city. It is a result of uraniferous coals, some of which were mined for uranium. The other anomalies occur in sparsely populated areas. The Vermejo Park anomaly is associated with a uraniferous Proterozoic granite and pegmatites; epithermal uranium veins may occur in the area (Goodknight and Dexter, 1984; Reid et al., 1980). The anomalies in the Cornudas Mountains, Otero County and at Laughlin Peak, Colfax County are associated with Tertiary alkalic intrusives; uranium and thorium veins occur in the area (McLemore and Chenoweth, 1989; Zapp, 1941; Staatz, 1982, 1985, 1986, 1987). Several anomalies occur in southern Socorro

County, east of Las Cruces in Dona Ana County, west-central Hidalgo County, and in the Black Range (Fig. 1) that are associated with Tertiary rhyolitic and andesitic volcanics. Only two of these anomalies are associated with known uranium occurrences: the Nogal cauldron in Socorro County (Berry et al., 1982) and Bishop Cap in Dona Ana County (McLemore and Chenoweth, 1989; McAnulty, 1978).

One of the aerial radiometric anomalies, north of Gallup in McKinley County, cannot be readily explained by geological interpretations. It correlates with the Tertiary Chuska Sandstone, Cretaceous Menefee Formation, and associated surficial cover; no mining activity is in the area. Field examination of this area is required.

Moderate availability category

This category includes areas where the rocks and soils only have a moderate availability for radon. These areas include rocks with 2.3-2.7 ppm eU on the aerial radiometric map and generally consist of moderately permeable soils. This category includes many outcrop areas of Proterozoic metamorphic rocks, Paleozoic and Mesozoic sedimentary rocks, and Tertiary-Quaternary sedimentary rocks. Some rocks and soils in the Pecos Valley area in eastern New Mexico are rated moderate even though they have less than 2.3 ppm eU because numerous high uranium ground water anomalies occur in the area, suggesting that uranium is highly mobile and could result in elevated levels of indoor radon.

Low availability category

This category includes the remaining areas of New Mexico where the rocks and soils are believed to have a low availability for radon. These areas include rocks with less than 2.3 ppm eU on the aerial radiometric map and include areas of impermeable soils. Some houses in these areas may still have elevated levels of indoor radon, but there are no obvious geologic reasons for predicting their existence in the low availability areas. In addition, it should be emphasized that even in counties with moderate and high availability potential many houses may have low levels of indoor radon.

Classification of Counties

The EPA's nationwide survey of indoor radon levels in houses requires that each county be ranked for radon-availability. Rankings by counties are required for two reasons: 1) population statistics required to establish a sample allocation plan are available for each county throughout the United States and 2) to standardize the reporting of indoor radon surveys throughout the country.

New Mexico is the fifth largest state in the United States, yet it contains only 33 counties. Some of these counties are as large or larger than some states in the eastern United States (Table 1). The geology and terrain of New Mexico are quite diverse (New Mexico Geological Society, 1982), and major geologic and landform units cut across most county boundaries, creating obvious problems in ranking counties for radon-availability.

For the purpose of this assessment, each county in New Mexico is ranked according to the predominant availability category established for geologic units in the state (high, moderate, or low). If a county is represented by more than one availability category, the county is assigned the highest classification, if that category represents more than 25% of the total county area. Some exceptions are explained below. Final county rankings are listed in Table 2. Similar procedures were used in evaluating counties in Tennessee (Tennessee Department Health and Environment, written commun., Nov. 17, 1986).

Since New Mexico is sparsely populated in most places and is geologically diverse, the major cities in terms of population (Vigil-Giron, 1987-1988) were also assessed for radon-availability (Table 3). Some cities were rated higher than the rest of the county. In order to emphasize population distributions, the counties were assigned the higher classification (Table 2).

Results

Ten counties are assigned a high availability for radon (Table 2; Fig. 2). Large areas of these counties typically contain rocks and soils with greater than 2.7 ppm eU and the soils are permeable. Two counties, Dona Ana and Santa Fe Counties, were assigned a high ranking even though the majority of the rocks in the county contain 2.3-2.7 ppm eU, because major cities in both counties (Las Cruces and Santa Fe, Table 3) were ranked as having a high radon-availability. Gallup in McKinley County is probably the most likely area in New Mexico to encounter a large number of houses with elevated levels of indoor radon. It must be emphasized that the health risks associated with these geologically ranked areas are not known. In order to determine the health risks associated with a specific house, that house must be tested for radon.

Thirteen counties are assigned a moderate availability (Table 2, Fig. 2). Large areas of these counties contain rocks and soils with 2.3-2.7 ppm eU. Soil permeabilities and lithologies vary. Three counties, Chavez, Eddy, and Lea, are assigned a moderate rating even though most geologic evidence suggests a low ranking because cities in these counties are rated moderate. In addition, NURE ground water data suggest that uranium in ground water is highly mobile and could contribute radon. A study of uranium and radium mobility in ground water in southeastern New Mexico indicates uranium and radium concentrations correlate with high chloride concentrations, but higher radium concentrations occurred in chemically reducing ground water (Hecrzég et al., 1988).

Four counties, Colfax, San Juan, Grant, and Sierra, contain large areas of rocks that exceed 2.7 ppm eU and could be assigned a high rating. A moderate rating was assigned to these counties because 1) the uranium in the rocks and soils of many areas are in moderately permeable to impermeable ground, 2) the cities in these areas are rated moderate, not high, and 3) the areas containing rocks exceeding 2.7 ppm eU are in sparsely populated portions of the county.

Ten counties were assigned a low availability. These counties are underlain by rocks with less than 2.3 ppm eU. The lithology and permeability of the rocks vary. Undoubtedly, some houses in these counties will exceed the EPA's recommended action level, but there are no obvious geologic reasons for predicting their existence.

Recommendations

1) Nonrandom surveys should be conducted in areas of high availability, especially in areas containing greater than 5 ppm eU (Fig. 1), although many of these areas are sparsely populated.

2) Detailed geologic maps and soil survey maps should be completed for the major cities in New Mexico.

3) Site specific studies of individual houses with elevated levels of indoor radon should be completed. These studies should include detailed examination of lithology, mineralogy, and structural features and analyses of soil permeability, soil gas composition, concentrations of uranium and radium in the soil, and radioactivity.

4) This preliminary assessment must be revised as new data is collected and analyzed. Continued detailed interpretation of the data used in this preliminary assessment may also require revision of this report. Correlation of known uranium occurrences, population distribution, and indoor radon levels should be examined. Indoor radon measurements are required from houses in geothermal areas to test this relationship. A more complete data base of uranium concen-

trations in rocks and soils, especially Tertiary and Quaternary sedimentary rocks, is needed. Eventually, when the indoor radon surveys are complete, the health risks associated with each availability category may be determined.

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Table 1--Size and population of counties in New Mexico and several states (Williams, 1986; A-W Publishers, Inc., 1983).

County	Land Area (square miles)	Population 1987	Population Density per square mile
Bernalillo	1,169	479,000	409.8
Catron	6,929	2,800	0.4
Chaves	6,066	58,100	9.6
Colfax	3,762	14,500	3.9
Curry	1,408	42,400	30.1
De Baca	2,323	2,400	1.0
Dona Ana	3,819	126,600	33.2
Eddy	4,184	53,900	12.9
Grant	3,969	27,200	6.9
Guadalupe	3,032	4,300	1.4
Harding	2,122	1,000	0.4
Hidalgo	3,445	6,200	1.8
Lea	4,390	68,000	15.5
Lincoln	4,832	15,000	3.1
Los Alamos	109	18,600	170.6
Luna	2,965	18,000	6.1
McKinley	5,442	63,300	11.6
Mora	1,930	4,700	2.4
Otero	6,626	51,000	7.7
Quay	2,874	12,000	4.2
Rio Arriba	5,856	33,100	5.7
Roosevelt	2,453	16,700	6.8
Sandoval	3,707	47,200	12.7
San Juan	5,522	94,000	17.0
San Miguel	4,709	25,400	5.4
Santa Fe	1,905	87,500	45.9
Sierra	4,178	9,800	2.3
Socorro	6,625	13,900	2.1
Taos	2,204	22,600	10.3
Torrance	3,335	9,000	2.7
Union	3,830	5,200	1.4
Valencia and Cibola	5,616	64,700	11.5
TOTAL NEW MEXICO	121,336	1,498,100	12.3
<u>STATE</u>			
Rhode Island	1,055	947,154	897.8
Delaware	1,932	638,432	
Connecticut	4,872	3,107,576	637.8
Massachusetts	7,824	5,737,037	733.3
Maryland	9,837	4,216,975	428.7
Vermont	9,273	511,456	55.2
New Hampshire	8,993	920,610	102.4
New Jersey	7,468	7,364,823	986.2

Table 2--Preliminary radon-availability rating for counties in New Mexico.

High	Moderate	Low
Dona Ana	Bernalillo	Curry
Hidalgo	Catron	De Baca
Los Alamos	Cibola	Guadalupe
Luna	Chavez	Harding
McKinley	Colfax	Mora
Rio Arriba	Eddy	Otero
Sandoval	Grant	Roosevelt
Santa Fe	Lea	San Miguel
Socorro	Lincoln	Torrance
Taos	San Juan	Valencia
	Sierra	
	Quay	
	Union	

Table 3--Preliminary radon-availability rating for some the largest cities in New Mexico (population from Vigil-Giron, 1987-1988).

City	County	Population 1984 estimates	Classification
Albuquerque	Bernalillo	350,575	moderate
Santa Fe	Santa Fe	52,274	high
Las Cruces	Dona Ana	50,275	high
Roswell	Chaves	45,702	high
Farmington	San Juan	37,332	low
Hobbs	Lea	35,029	moderate
Clovis	Curry	33,424	moderate
Carlsbad	Eddy	28,433	high
Alamogordo	Otero	27,485	low
Gallup	McKinley	20,959	high
Los Alamos-White Rock	Los Alamos	19,040	high
Las Vegas	San Miguel	15,364	low
Grants-Milan	Cibola	12,823	moderate
Rio Rancho	Sandoval	12,310	moderate
Artesia	Eddy	11,938	low
Lovington	Lea	11,704	moderate
Silver City	Grant	11,014	low
Portales	Roosevelt	10,456	low
Deming	Luna	10,609	high

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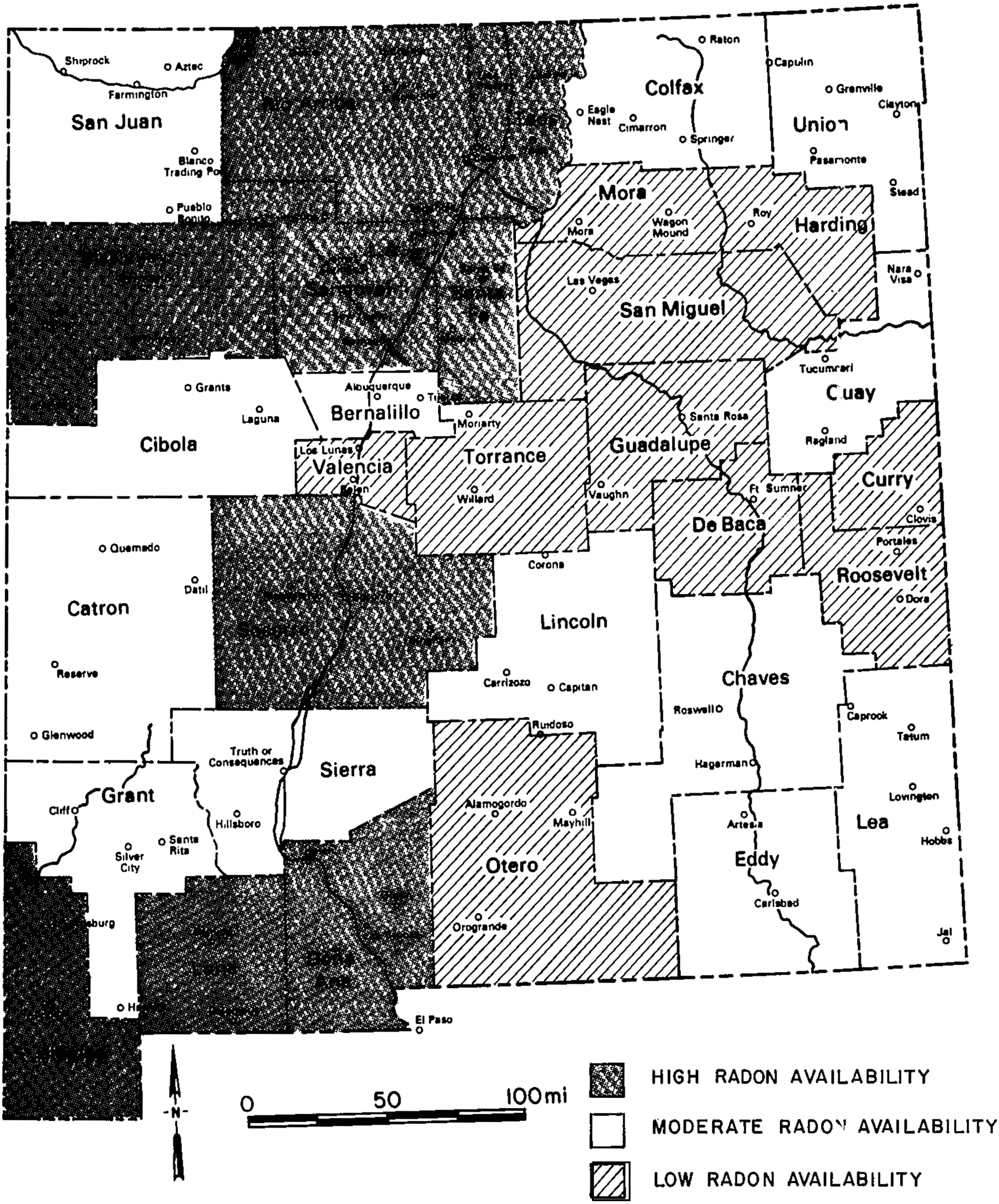

FIGURE 2: RADON AVAILABILITY IN NEW MEXICO

NOTE: THE ACTUAL HEALTH RISKS ASSOCIATED WITH EACH AVAIL. CATEGORY ARE NOT KNOWN UNTIL THE ACTUAL INDOOR RADON SURVEYS ARE COMPLETED.

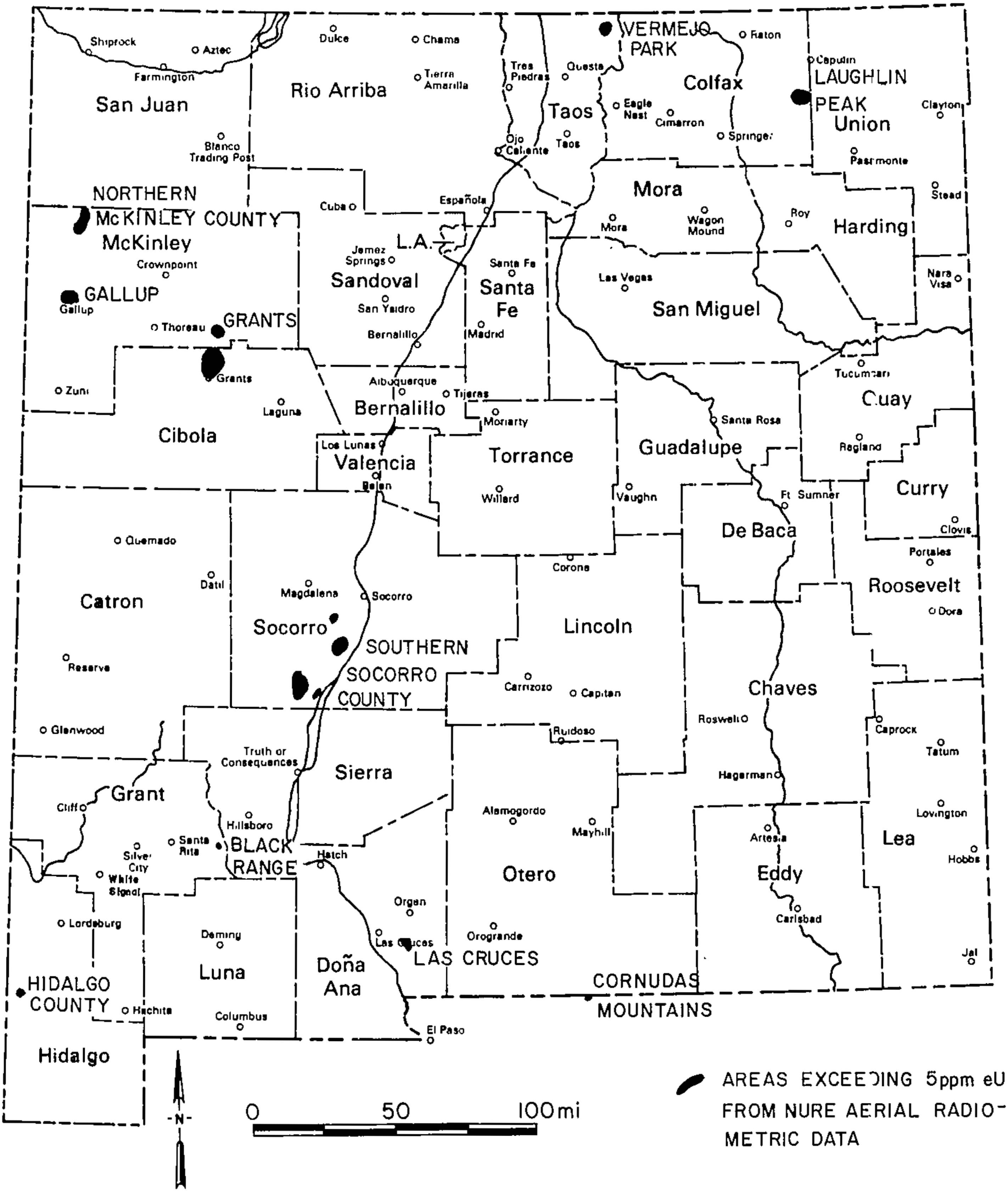

FIGURE 1: AREAS EXCEEDING 5 ppm eU FROM NURE AERIAL RADIOMETRIC DATA