

AN ASSESSMENT OF THE RADON CONCENTRATIONS IN AIR
CAUSED BY EMISSIONS FROM MULTIPLE SOURCES IN A
URANIUM MINING AND MILLING REGION. A CASE STUDY
OF THE AMBROSIA LAKE REGION OF NEW MEXICO

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December 1981

Prepared for
the U.S. Environmental Protection Agency
under an Interagency Agreement with the
U.S. Department of Energy under
Contract DE-AC06-76RLO-1830

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ABSTRACT

Uranium mining and milling operations result in the release of radon from numerous sources of various types and strengths. The Ambrosia Lake mining and milling operations were selected to characterize the relative importance of these sources on ambient atmospheric radon concentrations. All uranium mines at Ambrosia Lake are underground. The comparisons of interest were both between the sources and between the sources and background concentrations.

Source strengths for mine vents were estimated from field measurements made in previous studies. Emission rates for active and inactive mill tailings piles were estimated using data from several of the sites. Emission estimates were made for sites with no data. Other sources from uranium mining and milling were assumed to be small relative to these emissions.

Annual average radon concentrations were computed from the over one hundred vent and four mill tailings pile sources using a sector average Gaussian dispersion model. Ground level point source releases were assumed for vent emissions and ground level virtual point source releases were assumed for the tailings piles.

The results show that vents are by far the greatest source of the computed radon concentrations in the immediate area of the operations. The computed radon concentrations at receptor points were largely influenced by the closer sources, rather than by more distant stronger sources. The area where computed radon concentrations significantly exceed the background is confined to the general area around the vents and mills.

A comparison between computed radon concentrations and monitoring data at selected points demonstrates order of magnitude agreement. The comparison is limited by different time periods for the computed and monitored values, but does not show that the elevated radon concentrations monitored in such regions are of the same order as computed from the uranium mining and milling emissions.

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SECTION I
INTRODUCTION

Uranium mining and milling operations result in the release of radon from numerous sources of various types and strength. EPA, under the Clean Air Act, is assessing the health impact of air emissions of radon from various sources, including uranium mines. In the case of uranium mines, multiple sources of radon emissions are often located relatively close together. Therefore, it is necessary for EPA to know the extent to which these multiple sources increase the radon concentration in the air in the mining region and particularly at locations where people may be living. To obtain this type of information, the Ambrosia Lake District of New Mexico was chosen as a "case study". This area was selected because it contained a large number of radon sources for which emission data are available. In addition, radon monitoring data are available for a number of locations in this region.

This region has intensive underground mining with shafts and vents located on a low broad flat area located between several mesas. The geographical features of the Ambrosia Lake area are shown in Figure 1. The dashed area encloses the intensive mining area. Four mill tailings piles are outlined and labeled by letters, A, B, C, and D. Piles A and B are within the mining dashed area, C and D occur below and to the left of the mining area.

Relative contributions of radon are evaluated based on atmospheric modeling of the combinations of the many radon sources. This involves characterization of the source in terms of location and emission rate for input to an atmospheric dispersion model. This model incorporates the local dispersion characteristics to compute atmospheric radon concentrations from the various sources at selected locations.

Annual average radon concentrations are selected for study as being appropriate to EPA interests. In addition, this permits use of models that allow inclusion of a large number of sources without requiring excessive computations.

In addition to releases from various facets of mining and milling, radon is also released from natural sources. The latter occur largely as soil emissions over the entire region. Natural outcroppings of uranium deposits may result

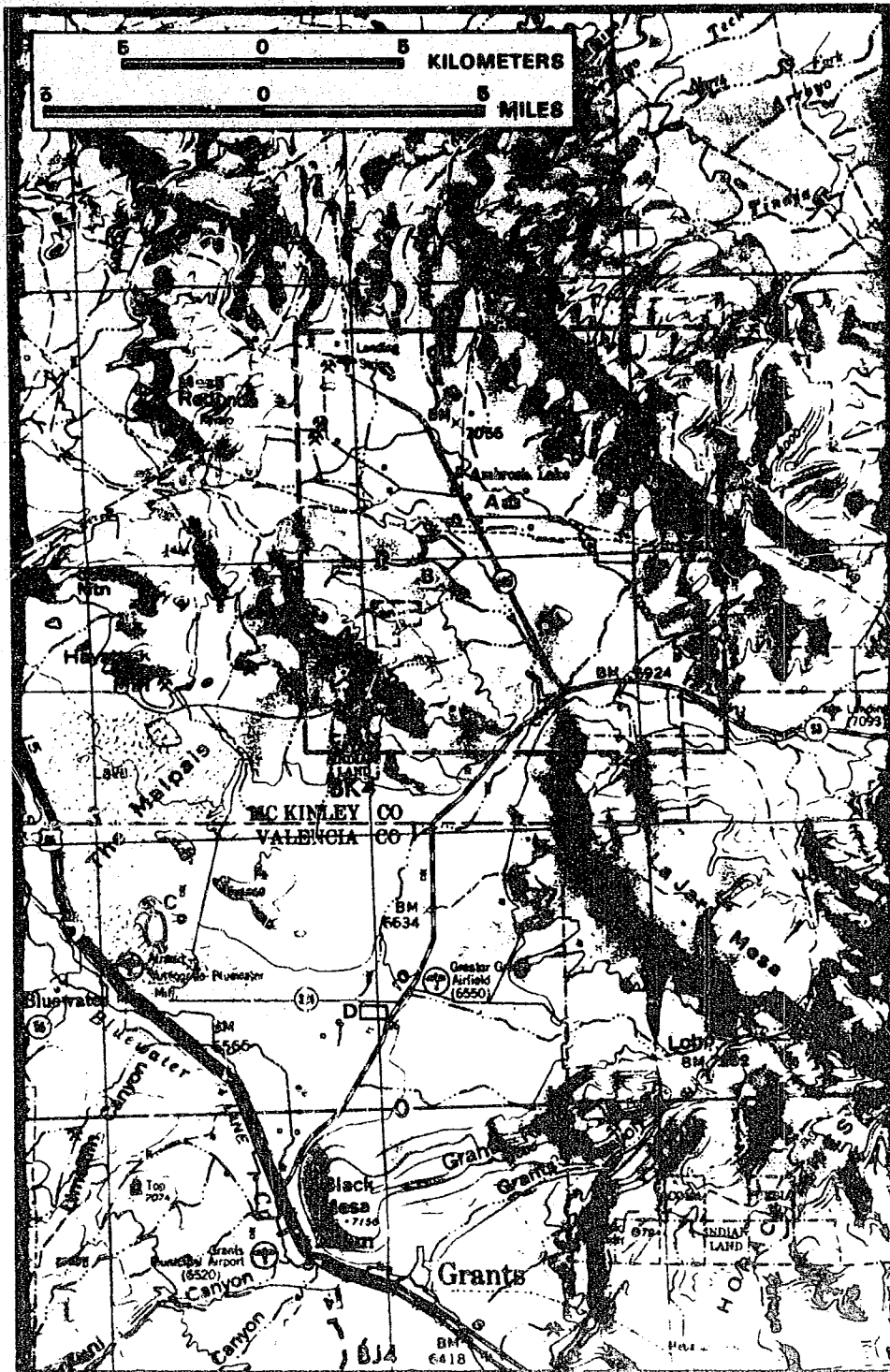


FIGURE 1. GEOGRAPHICAL FEATURES OF THE AMBROSIA LAKE DISTRICT

in higher local emissions. Natural emissions maintain a background radon concentration to which the radon contributions from the uranium mining and milling are assumed to be additive.

Although the natural radon emissions through the soil and rocks represent a large total emission over the region, the lack of data on spatial variability precludes inclusion in the radon modeling. Instead, the natural emissions are characterized in terms of an estimated range of background radon concentrations based on monitoring data.

The mine vents and mill tailings piles have by far the greatest total annual radon releases related to the mining and milling operations. In the next section these two groups of sources are used to characterize the radon emissions. Other sources (i.e., ore storage piles, subore and waste rock piles, etc.) are assumed to be sufficiently small that they can be neglected without changing the results.

The large number of sources in the region dictates using relatively simple models and assumptions to keep the required computations within the scope of this evaluation. Although this will limit some aspects of the results, sufficient detail is maintained to meet the objectives related to the comparison of the relative importance of various radon emissions.

SECTION II

METHODOLOGY

Annual average radon concentrations from the multiple radon sources are computed using a Gaussian dispersion model. The following is a description of this dispersion model and the preparation of input data. This involved characterization of local dispersion, identification of radon source locations and emission rates, and selection of receptor locations.

Atmospheric Dispersion Model

The modeling of atmospheric dispersion and transport is kept within reasonable computational limits by selecting appropriate but efficient models and assumptions. Hence from a range of possible dispersion models, a relatively simple model is selected to study relative radon concentrations. The sector averaged Gaussian plume model used to compute average annual radon air concentrations is based directly on many of the algorithms documented by Busse and Zimmerman (1973) as applicable to a rural region.

The sector average concentration \bar{C}_n resulting from point source n is given by

$$\bar{C}_n = \frac{16}{2\pi} \sum_{\ell=1}^6 \sum_{m=1}^6 \frac{\phi(k_n, \ell, m) G_n S(\rho_n, z; U_\ell, P_m)}{\rho_n} \quad (1)$$

where

k_n = wind sector appropriate to the n^{th} point source

G_n = emission rate of the n^{th} point source

ρ_n = distance from the receptor to the n^{th} source

ℓ = index identifying the wind speed class

m = index identifying the class of the Pasquill stability category

$\phi(k, \ell, m)$ = joint frequency function of wind speed, wind direction, and stability

$S(\rho, z; U_\ell, P_m)$ = dispersion function defined in Equation 3

z = height of receptor above ground level

U_ℓ = class interval wind speed

P_m = Pasquill stability category

