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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD PANEL

OFFICE OF SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

Before Administrative Judge Peter B. Bloch, Presiding Officer

In the Matter of	)	
	)	
HYDRO RESOURCES, INC.	)	Docket No. 40-8968-ML
2929 Coors Road	)	
Suite 101	)	ASLBP No. 95-706-01-ML
Albuquerque, NM 87120	)	
	)	

EASTERN NAVAJO DINE AGAINST URANIUM MINING'S AND SOUTHWEST RESEARCH AND INFORMATION CENTER'S BRIEF IN OPPOSITION TO HYDRO RESOURCES, INC'S APPLICATION FOR A MATERIALS LICENSE WITH RESPECT TO:

ENVIRONMENTAL JUSTICE ISSUES

February 19, 1999

VOLUME II

EXHIBITS

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February 15, 1999

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WRITTEN TESTIMONY OF CHRISTINE J. BENALLY, Ph.D.

On behalf of Eastern Navajo Diné Against Uranium Mining ("ENDAUM") and Southwest Research and Information Center ("SRIC"), Dr. Christine J. Benally submits the following testimony regarding the amended application of Hydro Resources, Inc. ("HRI"), for a source materials license to conduct in situ leach ("ISL") uranium mining at three proposed sites in McKinley County, New Mexico.

Q.1. Please state your name and qualifications.

A.1. My name is Christine J. Benally. I am an environmental health scientist with the Agency for Toxic Substances and Disease Registry ("ASTDR"), an agency of the U.S. Public Health Service. Currently, I work in ASTDR's Native American outreach program, helping Native American communities conduct environmental health assessments, communicating risk issues, and serving as a liaison between ATSDR and tribal governments and communities. One of my current projects is conducting a public health assessment of two abandoned gravel pits used to dump deinking sludge from papermill processing. I am also a member of the Navajo Nation.

I have extensive education, training and experience in public health assessment, including public health issues relating to Navajo people. In 1993, I received a Ph.D. in environmental health from Colorado State University. My dissertation explored the environmental impacts of toxaphene-based sheep "dip vats" on the Navajo Nation, drawing from my academic concentration in the toxicology of environmental contaminants. I also have a B.S. in microbiology from Northern Arizona University (1986), and an A.A.S. in medical laboratory technology from Navajo Community College (1979).

I have held a number of positions that provided me with experience in epidemiology, public health, and health care management. Between 1992 and 1995, I was an injury prevention and control specialist for the Shiprock Service Unit of the Navajo Area Indian Health Service ("NAIHS"). In 1997 and 1998, I also served as a consultant on management issues for the Northern Navajo Medical Center, carrying out several evaluations of hospital services and departments. While attending graduate school and since receiving my Ph.D., I have taught various science and math classes at colleges in New Mexico, Arizona and the Navajo Nation.

As can be seen from my curriculum vitae, a copy of which is attached to this testimony as **Exhibit A**, much of my education, employment history, and community involvement is directly relevant to the areas of concern raised by ENDAUM and SRIC with respect to the proposed HRI Crownpoint Uranium Project. Most notably, I worked as a laboratory technician at the Mobil Section 9 Pilot In Situ Project located 5.5 miles west of Crownpoint for about six months in 1981, analyzing groundwater samples for a variety of trace elements, uranium oxide, and various indicator parameters. I was also a laboratory technician at coal strip mines and powerplants in the region in the early 1980s. I also spent a month at Lawrence Livermore National Laboratory in 1991 as a laboratory chemist doing uranium bioassays; this work familiarized me with bioaccumulation of radioactive materials and trace metals in human tissue.

After receiving my Ph.D., I held several positions that brought me into contact with the proposed Crownpoint Project and other uranium mining projects. Between 1994 and 1996, I served as Executive Director of Diné CARE, a Navajo public-interest environmental organization that was one of the original petitioners for hearing on the HRI license application. In 1997, I served as interim director of the Navajo Nation Office of Navajo Uranium Workers ("ONUW"). In this position, I worked closely with both medical professionals who helped determine worker radiation exposures and with the workers themselves to assist them in obtaining documentation needed to support their claims for compensation under the federal Radiation Exposure Compensation Act

("RECA") of 1990. From 1996 to 1998, I served on the Indigenous Subcommittee of the National Environmental Justice Advisory Council ("NEJAC"), which advises the U.S. Environmental Protection Agency ("EPA") regarding environmental justice issues. In that capacity, I helped develop a resolution that was adopted by NEJAC in February 1998, urging the administrator of EPA and the chair of the NRC "to ensure that all provisions of Executive Order 12898 [President Clinton's Executive Order on Environmental Justice] are fully compiled with and carried out" for the HRI Crownpoint Uranium Project.[1] In 1997, I also served as a consultant to the Community Health Services Program of the Northern Navajo Medical Center to identify environmental health concerns in Navajo communities, including concerns related to the HRI project.

My expertise in public health issues affecting Navajo people is enhanced by my own personal experience and cultural knowledge as a member of the Navajo Nation. I was born and raised in the Sanostee Chapter in northwestern New Mexico. With the exception of my current job in Georgia and the time spent earning my B.S. and Ph.D, I have lived in Sanostee all of my life. I am fluent in the Navajo language. Throughout my life, I have helped care for my family's herd of sheep and taken part in traditional Diné ceremonies and practices. As an adult, I have also raised a son in the Navajo culture, and served as the elected vice president of the Sanostee Chapter. As such, I am

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1 National Environmental Justice Advisory Council Indigenous Peoples Subcommittee. "Uranium Leach Mining in Two Navajo Communities," resolution attached to letter from Haywood Turrentine, NEJAC chairman, to Carol Browner, USEPA administrator (February 26, 1998), at 3; attached to this testimony as **Exhibit B**.

intimately familiar with the requirements and obligations of life in traditional Navajo communities: herding sheep, hauling water for livestock and domestic uses, raising children in a multicultural environment, traveling long distances over unpaved and poorly maintained roads to job sites, routinely communicating in two very different languages (Navajo and English), and having to make do without certain modern "conveniences" such as indoor plumbing, running water, electricity and telephones. Although I am currently living in Georgia while I work for ASTDR, I intend to return to *Diné Bikéyah* (Navajoland) to serve my people at some future time in my life.

Further details of my education and experience are included in my curriculum vitae, attached hereto as **Exhibit A.**

Q.2. What is the purpose of your testimony?

A.2. I have been retained by ENDAUM and SRIC as a technical expert in the fields of environmental health, public health and environmental justice in the matter of the licensing proceeding for HRI's application for a source and byproducts materials license for the Crownpoint Uranium Project ("CUP"). The purpose of this testimony is to evaluate the adequacy of the NRC's Final Environmental Impact Statement[2] ("FEIS") with respect to the cumulative, public health-related environmental impacts of the CUP on the environmental justice communities of Church Rock and Crownpoint,

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[2] Final Environmental Impact Statement to Construct and Operate the Crownpoint Uranium Solution Mining Project, McKinley County, New Mexico. NUREG-1508. U.S. Nuclear Regulatory Commission (Washington, DC), February 1997.

New Mexico, where the CUP will be located.

Q.3. What materials have you reviewed to prepare your testimony? Also, please indicate any activities you've undertaken to prepare this testimony.

A.3. In preparing my testimony, I have reviewed relevant portions of the FEIS and HRI's Church Rock Revised Environmental Report ("CRRER")[3] of March 1993; certain of HRI's responses to the NRC Staff's 1996 Requests for Additional Information ("RAI"); and correspondence among HRI, the NRC, EPA, and various Navajo Nation officials and agencies. I have reviewed President Clinton's Executive Order on Environmental Justice[4] (hereafter "Executive Order"), the Council on Environmental Quality's latest guidelines for implementing provisions of the Executive Order in federal actions taken pursuant to the National Environmental Policy Act ("NEPA") (hereafter, "CEQ Guidance")[5], and the NRC's own guidance on environmental justice ("NRC EJ Guidance").[6] I also reviewed recent papers and reports among the growing body of scientific literature on environmental justice and environmental equity research

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[3] HRI, Inc. Churchrock Project Revised Environmental Report (March 1993); transmitted by letter from M.S. Pelizza, HRI, to R.E. Hall, NRC (March 16, 1993).

[4] Executive Order 12898. Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. 59 Fed. Reg. 7629 (February 16, 1994).

[5] Council on Environmental Quality. Environmental Justice Guidance Under the National Environmental Policy Act. Executive Office of the President (Washington, D.C.) (December 10, 1997).

[6] U.S. Nuclear Regulatory Comission. Environmental Justice in National Environmental Policy Act of 1969 Documents. Appendix B of Draft Standard Review Plan for *In Situ* Leach Uranium Extraction License Applications, NUREG-1569 (October 1997).

methodology and field studies, including published papers by Dr. Robert Bullard, who is perhaps the nation's leading authority on environmental discrimination against minorities and low-income people. Furthermore, I reviewed public health data for American Indians and Alaska Natives on a national level and at the tribal, state, and county levels. I am familiar with the literature regarding the history of public health and environmental effects of uranium mining on the Navajo Nation and in New Mexico, and relevant professional literature on analysis of environmental health issues. Specially for this testimony, I directed the SRIC staff to assist me in gathering data on previous uranium mining operations in the Church Rock and Crownpoint areas. The results of that research are summarized in my testimony and presented in maps and tables appended as exhibits. Finally, I reviewed the testimonies of Dr. Robert Bullard and Dr. Douglas Brugge, given in support of ENDAUM's and SRIC's written presentations on environmental justice and cumulative effects of the HRI project, and the testimony of Mr. Bernd Franke, given in support of ENDAUM's and SRIC's written presentation on radioactive air emissions. All supporting documentation and data on which I relied to prepare this testimony are referenced in the testimony.

Q.4. Please describe the methods you use to evaluate environmental justice impacts of proposed industrial projects, such as the Crownpoint Uranium Project.

A.4. The methods I use are based in public health and environmental health science. They complement the sociological methods used by Dr. Bullard in his written testimony and the toxicological and biological analyses used by Dr. Brugge. Public health practice today is concerned with a broad range of medical, social, environmental, and political issues, all directed toward understanding the social and economic determinants of health such that adverse health conditions can be prevented first and controlled or treated second. It draws from both the "hard" sciences (i.e., biology, chemistry, toxicology, physiology, physics, etc.) and the social sciences (sociology, political science, psychology, etc.). Epidemiology, which is the study and analysis of disease occurrence, is the principal, mathematically based science of public health.

To evaluate the FEIS's treatment of cumulative impacts in an environmental justice setting, I draw from public health methods and principles, principles set forth in the CEQ Guidance, and certain criteria spelled out in recent public-health literature. These principles and criteria are discussed in more detail later in my testimony. Employing these principles, I examine the demographic, socioeconomic and health conditions of the environmental justice populations that would be affected by the proposed project. I then examine whether any of those conditions would make the population especially vulnerable or susceptible to the environmental impacts of the project.

To systematically assess population exposures to environmental contaminants documented at sites in the Church Rock area, I use a biological impact assessment strategy that was first introduced in the professional literature in 1991. This approach allows the environmental impacts of the project to be examined in light of both the local population's particular public health conditions and in light of the health risks they face from chronic exposure to contaminants associated with *existing* environmental impacts of previous uranium mining. This model can address the extent to which human health has been affected by those impacts, or can be used simply to determine if an appropriate and adequate assessment of local health risks has been conducted. Based on this exercise, I conclude that the FEIS is fundamentally deficient in its treatment of cumulative impacts of the CUP in the Church Rock area, and that these impacts are, from a public-health perspective, disproportionately high and adverse on the local low-income, Native American population.

Q.5. Looking at the Crownpoint Uranium Project, please describe the existing socioeconomic conditions in the regional "environmental justice population."

A.5. As a general matter, I agree with the NRC Staff's conclusion, that, "[b]y nearly any definition, the entire area of impact constitutes an 'environmental justice population'" (FEIS at 3-79). This determination is based largely on evidence that the Navajo communities affected by HRI's proposed Crownpoint Uranium Project meet the two most important criteria for consideration as "environmental justice populations" — they are overwhelmingly minority and extremely low-income.

The FEIS notes that Native Americans make up nearly 72 percent of the population of McKinley County, N.M., and comprise 93.5 percent and 97.2 percent, respectively, of the populations within 10 miles of Crownpoint and Church Rock. FEIS at 3-79 to 3-80. It also notes that Native Americans in McKinley County have significantly lower per capita and median household incomes than all other races, and a far greater percentage of Native Americans live below federal poverty levels than other residents of the county. See FEIS at 3-58, 3-79, and 3-80. For example, more than half (i.e., 54 percent) of all Native Americans living in McKinley County in 1989 had incomes below the poverty level, compared with 11 percent of whites and 27 percent of African-Americans. Id., at 3-58.

Navajos, who make up nearly 82 percent of the Native American population of McKinley County,[7] have even lower socioeconomic status ("SES") than suggested in the FEIS. For example, median household income in the Navajo Area IHS in 1989 was $13,984, compared with the median household income for all 12 Indian Health Service areas of $19,886 and the 1989 median household income of all U.S. races of $30,056.[8] According to results of the 1990 Census on the Navajo Nation, the median Navajo family income in 1990 was $11,885, and 56.1 percent of Navajos were below

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7 Rodgers, L. 1990 Census — Population and Housing Characteristics of the Navajo Nation. Division of Community Development, The Navajo Nation (Window Rock, Ariz.) (1993), at 16.

8 U.S. Indian Health Service. *Regional Differences in Indian Health, 1997.* Office of Public Health, USIHS, U.S. Department of Health and Human Services (Rockville, MD) (1998), at 29. See, also, the table entitled, "American Indians in New Mexico, Selected Socioeconomic Data," in **Exhibit C** attached hereto. The data in that table were taken from the USIHS publication, *Regional Differences in Indian Health 1994*.

the federal poverty level.[9]

These data are important to understand the broad national and regional contexts in which health conditions exist on Navajo or in any other Native American community. SES, race/ethnicity, and educational level are well-documented determinants of health disparities across racial and economic classes in the United States.[10] Many of these disparities exist among Native Americans,[11] including those living in New Mexico, as I have shown in the summary data tables attached hereto as **Exhibit C**. Generally, Native Americans are poorer and have less formal education than whites; they also tend to live shorter lives (this is especially true for Native American men) and die at overall rates higher than U.S. whites and all U.S. races combined.[12] See also **Exhibit C** at 3. The burden of premature death, measured in years of potential life lost, is about 32 percent higher for Native Americans than for all U.S. races, and is about 76 percent greater in the Navajo Area than in the U.S. as a

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9 Rodgers, L. *Chapter Images: 1992 Edition.* Division of Community Development, The Navajo Nation (Window Rock, Ariz.) (1993), at 3.

10 Prevalence of Selected Risk Factors for Chronic Disease by Education Level in Racial/Ethnic Populations — United States, 1991-1992. *Morbidity and Mortality Weekly Report* (U.S. Department of Health and Human Services, Public Health Service), vol. 43, no. 8 (December 9, 1994), at 894.

11 U.S. Department of Health and Human Services. *Healthy People 2000: National Health Promotion and Disease Prevention Objectives: American Indians and Alaska Natives.* USDHHS, Public Health Service (1991); DHHS publication no. (PHS)91-50212.

12 U.S. Indian Health Service. *1997 Trends in Indian Health.* U.S. Department of Health and Human Services, Public Health Service (Rockville, Md.) (1998); see, respectively, Chart 2.4 (at 33), Chart 2.5 (at 34), Chart 2.7 (at 35), Chart 4.51 (at 134), and Table 4.11 (at 66).

whole.[13]

Q.6. Does the FEIS adequately describe existing health conditions in the environmental justice communities affected by the CUP?

A.6. In my opinion, there are three key respects in which the FEIS does not give a complete picture of current health conditions in the communities most likely to be affected by the HRI project. First, the data provided in the FEIS are very general, and do not address conditions in Church Rock and Crownpoint, although community-specific data are available. Second, the FEIS fails to describe the current *vulnerability* of that population to health and environmental stressors. Third, although substantial documentation exists regarding the adverse impacts of uranium operations on Navajo workers, the FEIS provides little information about these past and ongoing impacts.

A.6.a. My first concern is that the FEIS does not report known information about health conditions in Church Rock and Crownpoint. As noted by the Safety Committee of the Crownpoint Healthcare Facility in its 1997 statement regarding the HRI project,

> Health statistics in the FEIS are incomplete, and grossly inadequate to use to accurately model the potential health risks associated with the proposed project. . . .[S]pecific data. . .[on] mortality and morbidity are not documented in the FEIS <u>for Crownpoint</u>. . . .The lack of baseline data analysis makes it impossible to predict or track the future effects of the project.

Crownpoint Healthcare Facility Safety Committee Position Statement Regarding the In-Situ-Leach Uranium Mine Proposed by Hydro-Resources, Inc. ("Safety Committee

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13 USIHS. *Regional Differences 1997*, Table 4.2 at 52.

Statement") (May 23, 1997) (emphasis added) at 2; attached hereto as **Exhibit D**. While the FEIS presented data on the leading causes of death among Navajos, Native Americans and all U.S. races, and Navajo and U.S. mortality rates for certain diseases (see, FEIS at 3-83), it did not present data specific to the Crownpoint or Church Rock areas. As the Safety Committee pointed out, service-unit specific mortality and morbidity information are available from the Navajo Area IHS office in Window Rock,[14] and cancer incidence data are available from the New Mexico Tumor Registry in Albuquerque. Safety Committee Statement at 2.

The Safety Committee was particularly concerned that the FEIS did not contain service unit-specific baseline data on deaths and diseases that might result from exposure to releases of radon, uranium, process chemicals and waste products released during mining and processing operations, or on injuries and deaths from motor vehicle accidents that might result from "[i]ncreased truck traffic" associated with the HRI project. Id. The Committee's concern was appropriate in view of the fact that "accidents and adverse effects" (including motor vehicle accidents) and "malignant neoplams" (i.e., cancers) were reported in the FEIS as the first and third leading causes of death in Navajo Area IHS during the period 1990-1992. FEIS at 3-83.

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[14] Navajo communities affected by HRI's proposed Unit 1 and Crownpoint ISL mines (including Crownpoint, Smith Lake and Mariano Lake) are located within the Crownpoint Service Unit of NAIHS. Navajo communities affected by the proposed Church Rock ISL mine (including Church Rock and Pinedale) are located within the NAIHS Gallup Service Unit. The service unit boundaries and Navajo chapters located within each service unit are shown on the maps attached to this testimony as **Exhibit E.**

Neither did the FEIS's description of existing health conditions address prevalence of infectious diseases in the Church Rock and Crownpoint areas. Infectious diseases, such as chronic gastroenteritis, can be induced by ingestion of water contaminated with bacteria found in human and animal wastes. Members of the hospital Safety Committee, who include medical professionals stationed at the Crownpoint Healthcare Facility, asserted that they observe an association between a lack of indoor plumbing, including running water, and waterborne illnesses:

> Currently, a large portion of our patients and community members do not have running water [in their homes]. . . . Households without running water do appear to have higher rates of infectious disease. Infectious diseases also present in much more aggressive fashion due to a dearth of clean water in a household for adequate sanitation, hand washing, or wound care. Dehydration and gastrointestinal illnesses are common in all ages, and unhealthy alternatives to water (e.g., soda pop) are often chosen over the less palatable "hauled water." Contaminated water containers used to haul water also increase the transmission of infectious disease.

Safety Committee Statement at 3.

Data on infectious disease prevalence in the Crownpoint Service Unit and NAIHS as a whole provide support for the Safety Committee's observation. These data, which were obtained by the SRIC staff from NAIHS in December 1996 and which I have attached to my testimony as **Exhibit F**, show that more than 4,400 cases of gastroenteritis/diarrhea were diagnosed at the Crownpoint hospital in fiscal years 1994, 1995 and 1996. That number represents an average of about 4 cases a day of an illness long associated, among other things, with inadequate sanitary conditions and lack or absence of potable water. Using those data, I calculated rates of gastroenteritis-diarrhea, per every 100 person-visits, for the Crownpoint Service Unit and NAIHS as a whole; the results are shown in **Table 1**. For each of the three years for which data are available, the Crownpoint Service Unit rate of gastroenteritis/diarrhea cases diagnosed during ambulatory care visits exceeded the NAIHS-wide rate by 23 percent in 1996, 7 percent in 1995 and 10 percent in 1994.

Table 1. Cases and Rates of Gastroenteritis/Diarrhea in the Crownpoint Service Unit (CSU) Compared with Navajo Area IHS (NAIHS) Cases and Rates Fiscal Years, 1994-1996[15]

	FY 1996		FY 1995		FY 1994	
	NAIHS	CSU	NAIHS	CSU	NAIHS	CSU
# Cases	14,377	1,445	20,478	1,669	15,155	1,297
Census Population	209,147	16,031	204,458	15,643	199,764	15,258
Rate per 100 person-visits	6.9	9.0	10.0	10.7	7.6	8.5

That many residents of the region still haul water for domestic and livestock purposes was demonstrated in a recent land-use survey that was conducted by ENDAUM staff at the direction of Dr. Bullard, and which I reviewed in preparing my

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15 Data from Navajo Area Indian Health Service, Office of Planning and Evaluation, Window Rock, Ariz., based on Ambulatory Patient Care Report 1C Annuals. Letter of transmittals and complete data set shown in **Exhibit F** attached hereto.

testimony. The results of that survey are discussed in Dr. Bullard's testimony, and the methods used to conduct it are described in the testimony Ms. Mavis Smith, ENDAUM program coordinator. Out of 45 households surveyed in the northern part of Church Rock chapter, 22 of them, or 49 percent, did not have running water. Family members of these households reported hauling water from sources in Gallup, Red Rock State Park, Rehoboth Christian School, Pinedale, Mariano Lake and Crownpoint. I assume that these water sources were from public water supplies, which are regularly tested and treated and which must periodically demonstrate compliance with federal, state and tribal drinking water standards and regulations.[16] However, even if the water is "pure" at the time it was hauled, it can become contaminated in the containers used for hauling it, or in containers in which it is stored inside the home. There, infectious agents can be spread simply because the lack of running water in the water inhibits regular hand washing and other proper hygiene practices.

A.6.b. Even though the FEIS correctly identified the Church Rock-Crownpoint region as an "environmental justice population," it failed to assess, or even describe, the population's *vulnerability* to health and environmental stressors. Additional, incremental exposures to environmental contaminants can make the local population, or individuals within that population, more vulnerable, in a biological sense, to the

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16 This assumption is based on my observation that while most of the survey respondents described the water they haul as good or very good, a few complained that the water had too much chlorine it in. It is my experience that Navajos who are not accustomed to drinking treated water often complain about water being "too chloriney."

adverse effects of those exposures. In public-health terms, this vulnerability is called *susceptibility* or *responsiveness*. Age, gender, genetic predispositions, nutritional status, and preexisting health conditions are factors that can influence an individual's or group's susceptibility to the ill effects of any disease-causing agent, chemical or infectious.[17] An individual's metabolism and the competence of her various bodily defense mechanisms can influence her response to a particular organism or environmental exposure. An individual with a weakened immune system (an example of a preexisting health condition) has a reduced capacity to fight off the agent or agents involved in the exposure.[18]

Such biological susceptibility is different and distinct from an individual's or group's *susceptibility to exposure*. In this sense, the individual or group is thought of as being "at risk" of ill health because of his, her or their proximity to the exposure. For example, African-American children growing up in innercity tentaments are more *at risk* of diminished neurological functions from their exposures to lead-based paints than children who grow up in environments where lead-based paint was not used or has

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17 Sexton, K., Olden, K., Johnson, B.L. "Environmental Justice": The Central Role of Research in Establishing A Credible Scientific Foundation for Informed Decision Making. *Toxicology and Industrial Health*, 9:5 (1993), at 709.

18 Lippman, M. *Environmental Toxicants: Human Exposures and Their Health Effects* (1992), at 26-27.

been remediated.[19] Here, then, enters race, SES, class and educational status as additional, interrelated vulnerability factors. People with less formal education, lower incomes, and belonging to the "working" class are more likely to die of heart disease than are people with more formal education, higher income, and belonging to the "upper" classes.[20] Yet, despite gains in income and educational levels among American Africans over the past 30 years, the gap in life expectancy between whites and blacks has also grown.[21]

In the Church Rock and Crownpoint areas, both biological suspectibility and suspectibility to exposure probably are at play. Not only is the health of Navajos poorer than that of the U.S. population as a whole, but certain subgroups of Navajos, such as those with diabetes and those who worked in underground uranium mines, having preexisting conditions that may make them more susceptible to adverse effects of incremental exposures. And, as I shall show in some detail later in my testimony, a portion of the population of Church Rock is at risk because of its proximity to existing sources of environmental contaminants.

A.6.c. To get a sense of the magnitude of the local population's vulnerability, I

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[19] Bullard, R.D., and Wright, B.H. Environmental Justice for All: Community Perspectives of Health and Research Needs. *Toxicology and Industrial Health*, 9:5 (1993), at 821-842.

[20] Navarro, V. Race or class versus race and class: mortality differentials in the United States. *The Lancet*, 336 (November 17, 1990), at 1238.

[21] Pappas, G. Elucidating the Relationships between Race, Socioeconomic Status, and Health. *American Journal of Public Health*, 84:6 (June 1994), at 892-893.

reviewed health data for the Navajo Nation as a whole and for McKinley County, N.M. I also reviewed published medical and epidemiological literature on mortality rates and disease incidence among former uranium miners, including Navajo miners. And I examined published data on employment levels for uranium mines and mills that were in operation in the 1970s and 1980s in the Ambrosia Lake, Smith Lake and Church Rock mining districts.

Base on my examination of these data, it appears that several factors contribute to the relatively high vulnerability of the Native American population to new health impacts. First, the leading causes of death among Navajos are different than those of all U.S. races, and reflect vulnerability particular to the Navajo population. As shown in the charts attached to my testimony as **Exhibit G**, accidents and adverse effects were the leading cause of death in the Navajo Area IHS during the period 1992-1994, comprising 22.6 percent of all deaths, but were the third and fifth leading causes of death in all IHS areas and in all U.S. races, respectively, during the same period. See **Exhibit G**, Charts 4.3., 4.4, and 4.12. Pneumonia and influenza and diabetes were the fourth and fifth leading causes of death among Navajos, but are not among the top five causes for all U.S. races combined. Id.

Second, the five leading causes of death in McKinley County during the three-year period 1994-1996 were not the five causes of death having the largest standardized mortality ratios ("SMRs"), as I have shown in **Table 2** below.[22] For McKinley County, the five causes of deaths having the highest SMRs[23] were diseases associated with low-SES and minorities, especially Native Americans: alcoholism, diabetes, liver disease/cirrhosis, accidents, and congenital anomalies. The only cause of death common to both lists was "all accidents."

These mortality data are important because they show that deaths occur in McKinley County from causes and at rates that would be considered unusual in the general national population. Not surprising, 84 percent of the county's 1990 population was comprised of people of color, including 72 percent who were Native Americans, and McKinley County had the second lowest per capita personal income among New Mexico's 33 counties in 1995.[24,25]

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[22] These data were taken from "1996 New Mexico Selected Health Statistics Annual Report," published by the New Mexico Department of Health, Public Health Division, Vital Records and Health Statistics (November 1998), at 108; copies of relevant pages from this document are attached to my testimony as **Exhibit H**.

[23] The SMR is defined as the ratio of deaths observed in a given population, such as McKinley County, to the number of deaths that would be expected in a "standard" population, such as that of the United States as a whole, times 100 percent. Hence, an SMR of 833 percent, or 8.33, means that the number of deaths *observed* in the study population is 8.33 times greater than the number of deaths that would be *expected* in a standard population. The SMR is a basic tool of epidemiology that allows comparisons of populations having very different age, gender, racial/ethnic and SES distributions.

[24] See, 1996 New Mexico Selected Health Statistics, at 11-12; attached hereto as **Exhibit H**. Per capita income in McKinley County in 1995 was $11,323, or about half of the U.S. level, and about 62 percent of New Mexico's per capita level.

[25] The state health department does not report death counts and SMRs by race for each county in its annual report. However, at my direction, SRIC staff obtained from the NMDOH Vital Records Bureau the number of deaths of Native Americans, by cause, age and gender, in

Table 2. Causes of Death in McKinley County, N.M. (1994-1996)
By Deaths Observed and by Standardized Mortality Ratio for All Races
(based on N.M. Department of Health data)

Leading Cause, by Observed Deaths	Deaths Observed/ Deaths Expected	SMR (%)	Leading Cause, by SMR	Deaths Observed/ Deaths Expected	SMR (%)
1. Heart disease	235/299	79	1. Alcoholism	25/3	833
2. Cancers	211/237	89	2. Diabetes	89/25	356
3. All Accidents	158/59	268	3. Liver Disease /Cirrhosis	43/13	331
4. Cerebrovas-cular Disease	52/62	84	4. All Accidents	158/59	268
5. COPD	32/42	76	5. Congenital Anomalies	19/12	158

And third, there are potentially hundreds of residents of the Church Rock-Crownpoint region who experienced occupational exposures to radon, uranium and other contaminants from their work in the underground uranium mines and uranium mills of the area in the 1960s, 1970s and 1980s.[26] More than 7,000 people were

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McKinley County. Time constraints did not allow me to calculate SMRs for each cause of death among Native Americans. However, a close examination of the *number* of deaths by cause revealed that the proportion of those who were Native Americans was greater than their percentage of the county's population. For instance, Native Americans accounted for 88 percent (86 out of 98) of the country's motor vehicle accident deaths, 76 percent (68 out of 89) of the county's diabetes deaths, and 82 percent (23 out of 28) of the county's deaths from alcoholism, while making up only 72 percent of the county's population. See, **Exhibit H** at 108, and attached death-count spreadsheets.

[26] Exactly how many former Navajo uranium workers live in the Navajo chapters between Church Rock and Crownpoint is unknown. According to data obtained by SRIC staff

employed in various aspects of the New Mexico uranium industry in 1977,[27] and about 4,400 were employed in 1981.[28] Between 618 and 829 workers were employed at the two largest underground mines in the Church Rock district in the 1970s.[29]

A.6.d. On a regional basis, the adverse health effects of uranium operations on Navajo workers are well-documented and substantial. Yet, almost none of this information is provided in the FEIS.

In the most recent published followup of the Navajo underground miner cohort,[30] death from lung cancer and certain nonmalignant respiratory diseases, most notably pneumoconioses, occurred at rates 3.3 times and 2.6 times that of the U.S. population as a whole, respectively. The results of this study, which is appended to my testimony as **Exhibit J**, confirmed previous long-term studies that showed the Navajo

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from the Office of Navajo Uranium Workers, 307 of the 2,831 individuals who had registered with the office through January 22, 1999, were from Eastern Agency chapters. Chapter-specific data were not available at the time I completed this testimony.

27 U.S. Department of the Interior. Uranium Development in the San Juan Basin Region, A Report on Environmental Issues. San Juan Basin Regional Uranium Study, Office of Trust Responsibilities, U.S. Bureau of Indian Affairs (Albuquerque, N.M.) (Fall 1980), at IX-7; relevant pages attached hereto as **Exhibit I.**

28 New Mexico Energy and Minerals Department. Annual Resources Report. NMEMD, (Santa Fe, N.M.) (1982), at 74; relevant pages are incorporated in **Exhibit I.**

29 Employment figures for the United Nuclear Corporation and Kerr-McGee Nuclear Corporation Church Rock-area mines were obtained from SRIC's "New Mexico Uranium Inventory" (1978), which was based on state reports of that time; relevant pages are incorporated in **Exhibit I.**

30 Roscoe, R.J., Deddens, J.A., Salvan, A., Schnorr, T.M. Mortality among Navajo Uranium Miners. *American Journal of Public Health*, 85:4 (April 1995), at 535-540; attached hereto as **Exhibit J.**

miners had SMRs for lung cancer of 4.2 to 4.8.[31]

An even more recent study showed that Native American underground uranium miners have more nonmalignant respiratory disease from underground mining and less disease from smoking than Hispanic and non-Hispanic White miners.[32] Importantly, the study, which is attached to my testimony as **Exhibit K**, found that 24 percent of Native American miners, including many Navajo miners, were excluded from RECA compensation criteria because the criteria themselves systematically underestimated obstructive lung disease among the Native Americans. This finding led the authors to conclude that "current compensation programs are biased against Native Americans."[33] Uranium workers' occupational exposures engender widespread perceptions among Native Americans, particularly Navajos, that their health problems are related to their work in mines and mills or to the close proximity of their homes to uranium mining and processing facilities.[34]

These documented health impacts among Navajo uranium miners resulted, in

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31 Id., at 539.

32 Mapel, D.W., Coultas, D.B., James, D.S., Hunt, W.C., Stidley, C.A., Gilliland, F.D. Ethnic Differences in the Prevalence of Nonmalignant Respiratory Disease among Uranium Miners. *American Journal of Public Health*, 87:5 (May 1997), at 833-838; attached hereto as **Exhibit K**.

33 Id., at 838.

34 Madsen, G.E., Dawson, S.E., Spykerman, B.R. Perceived Occupational and Environmental Exposures — A Case Study of Former Uranium Millworkers. *Environment and Behavior*, 28:5 (September 1996), at 571-590; attached hereto as **Exhibit L**.

large part, from their exposure to radon and radon progeny while working in the unvented or poorly vented "dog holes" of the early uranium mines in the Four Corners Area.[35] For an environmental standpoint, most of the early uranium mines on the Navajo Nation were abandoned and never reclaimed, and today remain in largely uncontrolled and unmitigated conditions.[36] This was apparent from my recent review of mine-site inventories and site-specific environmental assessment data obtained by SRIC staff from the Navajo Abandoned Mine Lands Reclamation Department ("NAMLRD") in Shiprock, N.M., and from other published sources. According to data provided by NAMLRD, less than 40 percent of some 1,200 abandoned mine sites has been assessed and remediated, and some 670 sites, and perhaps as many of 800, need initial or follow-up environmental assessments, remedial construction plans, and actual construction.[37] Another three to six years, or more, is needed to address the remaining sites, at a cost now estimated at more than $7 million. The status of abandoned uranium mine assessment and remediation is shown in **Table 3**.

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[35] See, e.g., Mapel, et al., at 837. For a historic overview of conditions in the underground mines of the 1940s-1960s and the development of the medical evidence of respiratory disease among the miners, consult *If You Poison Us — Uranium and Native Americans* by P. H. Eichstaedt (Red Crane Books: Santa Fe, N.M.) (1994).

[36] Four uranium mills and tailings sites located on the Navajo Nation that operated in the 1950s and 1960s also were abandoned by 1970. Their impacts, however, have been mitigated by federally authorized and financed decommissioning, reclamation and remediation carried out by the U.S. Department of Energy pursuant to provisions of Title I of the Uranium Mill Tailings Radiation Control Act of 1978 (42 U.S.C. 7911-7925).

[37] These figures were provided by Mr. Perry Charley, manager of the NAMLRD Shiprock office, on February 4 and 5, 1999.

Table 3.
Abandoned Uranium Mines, Exploration Sites and Uranium Claims on the Navajo Nation
(Data from Navajo Abandoned Mine Lands Reclamation Department, February 1999)

Site Category	Navajo Nation-wide # Sites (% of total)	Eastern Agency Only # Sites (% of total)
All sites (includes uranium mines, processing sites, exploration sites, claims)	≈1,200 (100%)	96 (8%)
Principal Inventory Dates	1990-1991	1995, 1996
Sites having extreme physical hazards resulting in death, injury, loss of property, loss of livestock	≈960 (80%)	at least 24 (≥2%)
Sites having environmental assessments, remedial actions	441 (37%)	13 (1%)
Cost of remedial measures to date	$11.2 million	(included in TNN-wide amount)
Sites needing new or additional environmental assessments, remedial actions, and number of years to completion of work	670 (56%) at least 3 years	at least 30 (2.5%) at least 3 years
Estimated cost of new or additional EAs, remedial actions	$7.07 million	(included in TNN-wide amount)
Sites needing initial assesments	80-100 (7-8%)	(included in TNN-wide amount)
Estimated years to completion of initial assesments, remediation	at least 6 years	at least 6 years

"TNN" = The Navajo Nation.

The FEIS provides no detailed listing or even descriptive summary of the extent of the abandoned uranium mine problem on Navajo lands, including areas within the

Eastern Agency where HRI will conduct its operations. Later in this testimony, I will review in some detail the locations and conditions at abandoned and inactive uranium facilities in the Church Rock area.

A.6.e. Based on my review of the FEIS and on the foregoing analysis of relevant socioeconomic and health data and relevant epidemiological studies of Navajo and Native American uranium workers, I conclude that the FEIS did not fully consider the economic, social or medical vulnerability of the population that will be directly affected by HRI's operations. The public health data I reviewed show Navajos, as a general matter, are less healthy than the average U.S. citizen and experience certain diseases at rates substantially higher than those of the U.S. population. Additionally, Navajos have suffered adverse health effects at disproportionately higher rates than the U.S. population as a whole from occupational exposures to radioactive and toxic substances encountered in uranium mining and milling operations. There are also a substantial number of former underground uranium miners who still live in the area affected by the HRI project, and whose health has likley been affected by past and ongoing exposure to radiological contamination. In my opinion, therefore, the high level of disease, mortality, and occupational exposures makes this population especially biologically more susceptible to additional health impacts from new sources of chemical and radiological contamination. This vulnerability is further exacerbated in the Church Rock-Crownpoint region where many former Navajo uranium workers once worked and still live, and who are at risk of exposures to existing environmental contaminatio there.

Q.7. In your professional opinion, does the FEIS provide an adequate evaluation of the impacts of uranium mining on public health in the the Church Rock-Crownpoint region?

A.7. The FEIS does not adequately evaluate the impacts of uranium mining on public health in the Church Rock-Crownpoint area. In fact, the FEIS does not even attempt to quantify health risks from *existing, abandoned* uranium operations, especially in Church Rock Chapter where ambient radiation levels are at least an order of magnitude higher than in Crownpoint and where many of the abandoned uranium mines present unmitigated and largely uncontrolled environmental risks. On top of impacts to the Church Rock-area population, there is evidence that estimated releases of radon from HRI's Church Rock ISL mine will not be "neglible" as asserted in the FEIS (at 4-117).

That the FEIS does not assess the cumulative impacts of *existing* health risks in addition to those posed by HRI's operations is inexcusable in light of current federal guidelines and public-health recommendations. Allow me to explain.

First, the President's Executive Order on Environmental Justice recognizes the importance of research, data collection, and analysis in situations, like this one, where multiple and cumulative exposures to environmental hazards exist in a low-income, Indian population.[38] Furthermore, the CEQ Guidance[39] contains explicit direction regarding analysis of multiple exposures in environmental justice populations:

> Agencies should consider relevant public health data and industry data concerning the potential for multiple or cumulative exposure to human health or environmental hazards in the affected population and historical patterns of exposure to environmental hazards, . . .Agencies should consider these multiple, or cumulative effects, even if certain effects are not within the control or subject to the discretion of the agency proposing the action.

CEQ Guidance at 9.

The FEIS "considers" the impacts of past uranium mining and milling operations in the Church Rock-Crownpoint region, but only in a cursory and nonanalytical way. For instance, the FEIS makes only general references to the impacts of previous uranium mining and milling operations on the health of Navajos reservationwide,[40] and alludes, only in a qualitative way, to certain impacts of past mining and milling in the Church Rock area, including the July 1979 dam breach and mill tailings spill at the United Nuclear Corporation Church Rock mill.[41] But the FEIS

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38 Executive Order 12898, Section 3-3, 59 Fed. Reg. 7631.

39 Copies of the Executive Order and the CEQ environmental justice guidelines are attached to Dr. Bullard's testimony as Exhibits B and C, respectively.

40 See, e.g., the FEIS's discussion of the "sensitivity" of Navajos to uranium mining because of the documented increased risk of lung cancer mortality among Navajo miners, the 1979 United Nuclear Corporation tailings spill, and the 1992 Navajo Nation Executive Order Moratorium on Uranium Mining. FEIS at 3-86 to 3-87.

41 See, e.g., references to "residual radioactivity" from previous operations on Section 17 (FEIS at 4-86) and contamination of the Puerco River from the tailings spill and past mine dewatering (id., at 4-116).

ignores the substantial body of information on the impacts of uranium mining and milling in Navajo country generally, and in the Church Rock-Crownpoint region specifically, and fails to "determine if the impacts disproportionately impact the minority or low-income population" as recommended in the NRC's own environmental justice guidelines.[42]

Citing the study by Mapel, et al. (1997), as an example of "'environmental (in)justice' against Native American [uranium] miners,"[43] Northridge and Shepard, writing in a commentary in the May 1997 edition of the *American Journal of Public Health*, proposed three steps "to best protect the public from environmental health risks":

> First, rigorous studies are required to fully address the distribution of environmental hazards by locality and their relationships with suspected health risks. . . .Second, appropriate environmental interventions need to take account of the social and cultural dimensions of affected communities. . . .Funds are necessary to. . .support community-driven research. . .Third, careful monitoring of specific environmental hazards and exposures as well as overall surveillance of potential risks is required. . . .[O]ccupational surveillance can serve as a useful model for environmental surveillance.

Northridge and Shepard at 731 (references omitted); attached hereto as **Exhibit M.**

As I shall demonstrate in the remainder of my testimony, the NRC Staff failed to

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42 See, Draft Standard Review Plan at B-3, attached to Bullard Testimony as Exhibit 1E.

43 Northridge, M.E., and Shepard, P.M. Comment: Environmental Racism and Public Health. *American Journal of Public Health*, 87:5 (May 1997), at 730-732; attached hereto as **Exhibit M**. The authors stated that the Mapel study makes clear that "deliberate discrimination on the basis of race has contributed to an undue burden of respiratory disease among Native American uranium miners." Id., at 730.

conduct "rigorous studies" of environmental hazards in the Church Rock area, and did not undertake any additional monitoring of those hazards and the exposures they represent.

Q. 8. How should the NRC have evaluated the environmental and public health impacts of the Crownpoint Project in the Church Rock area?

A.8. A relatively simply method the NRC Staff could have, and should have, used to analyze the environmental and potential public health impacts of existing uranium operations in the Church Rock area is called the Biological Impact Pathway Model ("BIPM"). This method was developed by researchers interested in exploring an individual's exposure to indoor air pollutants,[44] but it can and has been adapted to population-level exposures in the ambient environment. The model, which is shown graphically in its original form in **Exhibit N** (at 111) and in its modified forms developed by Sexton, et. al. (also in **Exhibit N**),[45] allows the investigator to begin by identifying all sources of outdoor and indoor contaminants and measuring their presence in the environment, subject to certain physical and environmental factors that

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44 Ryan, P. B., Lambert, W.E. Personal Exposure to Indoor Air Pollution, in: *Indoor Air Pollution: A Health Perspective* (J.M. Samet and J.D. Spengler, eds.), The Johns Hopkins University Press, Baltimore, Md. (1991), at 109-127; attached hereto as **Exhibit N.**

45 Two versions of the "modified" BIPM are presented in **Exhibit N**. Both are from the paper by Sexton, Olden and Johnson (see, supra, n. 17) . The first of the two, identified as Figure 7, adds exposure assessments and susceptibility factors to the BIPM to facilitate identification and evaluation of individuals and groups potentially at greater risk. The second of the two, identified as Figure 9, analyzes the differential effects of race and class on risk and related susceptibility factors to inform the BIPM process.

affect the fate and transport of the pollutants. Human exposures can then be estimated from available environmental monitoring data, subject to consideration of the time-activity patterns of the exposed population. This consideration is extremely important in most Navajo communities, and especially in the Church Rock area, where, according to the results of ENDAUM's land-use survey as reported by Dr. Bullard, the residents have lived on their lands literally for several generations, and will continue to live there well into the future, regardless of the degree of environmental contamination that surrounds them. Hence, they represent an exposed population that is captive to the exposure. Doses to critical human organs can be estimated from each of the three principal pathways (i.e., inhalation, ingestion and dermal contact), subject to certain physiological factors and mitigated or enhanced by the exposed population's susceptibility to disease. The final "block" of the model is used to estimate or measure health effects of the subject pollutant exposures. Being linear, the model can be reserved; health problems can and often are measured first and then assessed, through epidemiological techniques, against different exposures.

As I noted in Answer 6.d. above, the FEIS provides no detailed description or analysis of the impacts of existing and abandoned uranium operations in the Church Rock and Crownpoint areas, nor does it employ a methodology like that of the BIPM to assess exposures in the Church Rock area. To ascertain the extent of those impacts, I carefully reviewed the documentation that SRIC staff obtained from the NAMLRD files in Shiprock, and other published reports on past uranium operations in northwestern New Mexico. I examined NAMLRD lists of uranium claims, mines and processing sites in the Eastern Agency of the Navajo Nation, field investigation papers and environmental assessment data contained in NAMLRD files, and information on mining history at several dozen sites in the Eastern Agency and beyond.

From these data sources, I directed SRIC staff to summarize relevant data for sites having evidence of prior exploration, mining, processing or any combination of the three anywhere in the Eastern Agency. These data are presented in a spreadsheet entitled "Preliminary Inventory of Uranium Mines, Processing Sites and Exploration Sites in Southern Eastern Agency, Navajo Nation," which is attached hereto as **Exhibit O.**[46] For each mine or uranium claim, the following information is given, if it is known:

- Location coordinates (i.e., township, range, section, quarter-section)
- Approximate distance from HRI's proposed Church Rock ISL mine
- Measured gamma radiation rates and ranges of gamma rates
- Type of mining operation and period of operation
- Estimated numbers of homes near each mine site
- 7.5-minute USGS topographic map upon which claim or mine is located
- NAMLRD site number

Copies of the primary data sources and pertinent pages from reference documents that

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46 This inventory is "preliminary" in the sense that conflicting information in the primary references, inconsistent location information, and uncertainties in the periods of operation of some of the mines still must be resolved. Additionally, radiological surveys of several sites are ongoing, and new or additional environmental assessment and monitoring data will be generated in the coming months and years.

form the basis for the inventory are attached hereto as **Exhibit P** (NAMLRD February 1995 Eastern Agency Inventory and 1996 field assessment reports[47]), **Exhibit Q** (New Mexico Bureau of Mines and Mineral Resources Open-file Report 353[48]), and **Exhibit R** (excerpts from Hilpert, 1969[49]).

Q.9. Please describe the results of your evaluation of environmental exposures in the Church Rock area.

A.9. The uranium mine inventory shown in **Exhibit O** contains 13 sites at which mining and/or uranium processing was previously conducted in the northern portion of Church Rock Chapter within 4 to 6 miles of HRI's proposed Church Rock ISL mine. These sites were then plotted on a 1:100,000 scale U.S. Geological Survey topographic map,[50] a copy of which is attached to my testimony as **Exhibit S**[51] and which I will refer to as the "Church Rock Mining Map". Ranges of gamma radiation readings are shown on the map for eight of the 13 sites. Ten of the sites were

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47 Navajo Abandoned Mine Lands Reclamation Program. Eastern Agency Inventory (February 1995); Mine Site Visit reports, January-May 1996; attached hereto as **Exhibit P.**

48 McLemore, V.T., Chenoweth, W.L. Uranium Mines and Deposits in the Grants District, Cibola and McKinley Counties, New Mexico. New Mexico Bureau of Mines and Mineral Resources (Socorro, N.M.), Open-file Report 353 (December 1991); attached hereto as **Exhibit Q.**

49 Hilpert, L.S. Uranium Resources of Northwestern New Mexico. U.S. Geological Survey Professional Paper No. 603 (Washington: U.S. Government Printing Offce) (1969); attached in relevant part hereto as **Exhibit R.**

50 The base map is the 30x60 minute series Gallup quadrangle, dated 1981.

51 This map, entitled "Abandoned Uranium Mining & Milling Sites, Northern Church Rock Chapter, Navajo Nation, McKinley County, New Mexico," was prepared by ENDAUM and SRIC staff at my request and under my direction.

underground mines, including three mines from which tens of millions of tons of uranium ore were mined between the late 1960s and early 1980s: Church Rock #1 and #1E, operated by Kerr-McGee Corporation; Northeast Church Rock #1, operated United Nuclear Corporation; and Old Church Rock Mine, operated initially between 1960 and 1962 and again between 1978 and 1982 by UNC. Two of the sites were ISL-related: the Teton Exploration ISL test site in Section 13 of Township 16 North, Range 17 West, and the Grace Nuclear Section 23 ISL project, which was operated in the mid-1970s. The largest of the 13 sites in the UNC Church Rock uranium mill and tailings impoundment located in Section 2 of Township 16 North, Range 16 West. This site is an NRC-licensed uranium byproduct disposal facility and an EPA-designed Superfund site that is subject to an ongoing and extensive groundwater cleanup program.[52]

To assess potential exposures to the local population, I prepared **Table 4**, which applies portions of the BIPM to radiological and population characteristics of each of the 13 sites shown on the Church Rock Mining Map contained in **Exhibit S**. Under the "source" and "presence" blocks, I listed the sites and their radiological characteristics. Surficial gamma radiation activity rates were taken from the preliminary mine

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52 See, Five-Year Review Report, United Nuclear Corporation Ground Water Operable Unit, McKinley County, New Mexico. U.S. Environmental Protection Agency, Region VI (September 1998). This report recommends that UNC seek increases in groundwater cleanup goals (called "alternative concentration levels") on the grounds that certain contaminant levels still exceed their respective cleanup standards after six to seven years of pumping and treating of contaminated groundwater in three different aquifers at the site.

Table 4.
Radiological Contaminant Sources, Presence and Human Exposure in the Northern Portion of Church Rock Chapter, McKinley County, N.M.

Contaminant Source(s) (Location in T-R-S-qs)	Contaminant Presence-Land (gamma activity[53] in μR/hr)	Contaminant Presence-Air (ave. Rn-222 in pCi/l-air)	Exposed Population w/in 1 mile (# residences)
CD & S Mine (16.17.35.SE)	no data	no data	3-5
Christian Mine (15.16.04.SE)	no data	no data	1
Church Rock #1, #1E (17.16.35.NE; 36.NW)	150-180	2.54 ± 1.72;[54] min-max: 1.22-6.74 n=9 (10/80-7/81)	20-27
Foutz #2 Mine (15.16.05.NE)	14-38	no data	1
Foutz #3 Mine (16.16.31.SE)	50-280	3.42 ± 3.52;[55] min-max: 1.19-12.19 n=9 (10/80-7/81)	6
Grace Nuclear ISL (16.17.23.NE)	100-240	no data	5-10

[53] Gamma activities from NAMLRD site assessments (see, **Exhibit P**), unless otherwise noted.

[54] Radon data for the Church Rock #1 and #1E location derived from Franke Testimony, Exhibit E, Table D-3 (radon monitoring data for Site B1 located in Section 36 northeast of UNC uranium mill).

[55] Radon data for Foutz #3 derived from Franke Testimony, Exhibit E, Table D-3 (radon monitoring data for Site "Springstead," which is located appx. 0.75 mile northwest of Foutz #3).

NE Church Rock #1 (17.16.35.NE)	150-300	4.25±3.78;[56] min-max: 1.27-13.54 n=9 (10/80-7/81)	15-20
Old Church Rock Mine (16.16.17.NE)	22-350[57]	3.60±3.23;[58] min-max: 1.25-10.77 n=8 (10/80-7/81)	18-35
Section 3 (Santa Fe Christensen) (15.16.03.SW)	42-1,400	no data	2-5
Teton Exploration Test (16.17.13.SW)	no data	no data	5-8
UNC Uranium Mill/ Superfund Site (16.16.02)	no data	3.86±3.14;[59] min-max: 1.45-11.34 n=9 (10/80-7/81)	20-30
Westwater #1 Mine (15.16.02.S½)	no data	no data	unknown
Williams & Reynolds (15.16.04.SW)	13-100	no data	1-3

inventory in **Exhibit O**; ambient radon data were derived from Mr. Franke's testimony and report in support of ENDAUM's and SRIC's written presentation on radioactive

[56] Radon data for NE Church Rock #1 derived from Franke Testimony, Exhibit E, Table D-3 (radon monitoring data for site "A", which is located in 16.16.02.NW within 0.25 mile of the NE Church Rock Mine and the UNC millsite).

[57] Gamma activity for Old Church Rock Mine derived from HRI CRRER, Figure 2.9-1.

[58] Radon data for the Old Church Rock Mine derived from Franke Testimony, Exhibit E, Table D-3 (radon monitoring data for site "OCR/IX").

[59] Radon data for UNC mill and tailings site derived from Franke Testimony, Exhibit E, Table D-3 (radon monitoring data for site "F").

air emissions.[60] For several of the sites, I calculated means and standard deviations for radon concentrations, using the data contained in the exhibits attached to the Franke Testimony. Under the "exposure" block, I assigned a number or range of numbers of residences located within approximately 1 mile of each site. I derived this exposure data by examining the ENDAUM-SRIC map entitled, "Residential Character and Land Status in Vicinity of HRI Church Rock ISL Site," which is attached to Dr. Bullard's testimony as an exhibit. This map shows approximately 170 residences in an area consisting mostly of Township 16 North, Range 16 West, and also including portions of Township 17 North, Range 16 West on both sides of the Navajo Reservation boundary, and portions of Township 15 North, Range 16 West.

In addition to the ambient radon monitoring data shown in **Table 4**, Mr. Franke also reported that HRI had measured radon at three monitoring stations located on the eastern boundary of its Church Rock Section 8 site. Average radon concentrations for the period August 1987 through September 1988 at the three stations were 3.06, 1.19 and 2.22 pCi/l, with an overall average concentration of 2.16 pCi/l and a range of 0.10 pC/l to 13.4 pCi/l..[61] Franke Testimony, Exhibit 2 at 5, and Exhibit D, Table 2.9-3

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[60] Eastern Navajo Diné Against Uranium Mining's and Southwest Research and Information Center's Brief Regarding Radioactive Air Emissions at the Crownpoint Project. In the matter of Hydro Resources, Inc., NRC Docket No. 40-8968-ML; ASLBP No. 95-706-01-ML (January 11, 1999); testimony and report of Bernd Franke, Exhibit 1 and Exhibit 2, respectively.

[61] These data, which are now 10 to 11 years old, represent the most recent ambient radon monitoring information available in the vicinity of the proposed HRI Church Rock site.

The 1987-1988 HRI radon data for Section 8 and the 1980-1981 UNC radon data for the Old Church Rock Mine site and Springstead site demonstrate quite clearly that many of the 170 residences[62] in the area are routinely and chronically exposed to ambient radon concentrations in air that range from about 5 times to as much as 42 times higher than the background levels that were measured in Crownpoint in the late-1970s and early-1980s. Franke Testimony, Exhibit 2 at 13.[63]

Assuming, then, that the true natural background radon level in the Church Rock area is 0.2 pCi/l, which yields an annual dose equivalent of 100 mrem, and the overall background radon concentration inclusive of all sources is 3 pCi/l, than the non-background exposure is 2.8 pCi/l, or a TEDE of 1,400 mrem/yr — or, 14 times NRC's maximum allowable dose to the public!

External gamma radiation also adds to the residents' total exposure. For the 56

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[62] The 1990 Navajo Census found that there are about 4.1 persons per Navajo household. (Navajo Nation Division of Community Development, Population and Housing Characteristics of the Navajo Nation [1993], at 41.) The 170 residences in the northern part of Church Rock Chapter represent, therefore, an exposed population of about 700 persons. While that number compares favorably to the FEIS's estimate of 575 persons living in a 3.1-mile radius of HRI's Church Rock site (FEIS at 4-83), both are probably low. For example, the average "family" size derived from the ENDAUM land-used survey was 5.05 persons, based on 42 responses of the 45 households surveyed. Similarly, the average number of persons in a Navajo family in the 1990 Census was 4.54. Hence, the estimated exposed population in the area ranges from 700 to 850 people.

[63] Mr. Franke concluded that average natural background in the Church Rock area is probably around 0.2 pCi/l radon in air and that existing non-background radon there already exceeds the NRC's 10 CFR Part 20 compliance limit of 100 millirems per year ("mrem/yr") TEDE ("total effective dose equivalent"), which is equivalent to 0.2 pCi/l. Id. at 7.

sites in the Preliminary Uranium Mine Inventory (**Exhibit O**) that did not have actual uranium mining or milling, I calculated an average gamma level of 12.5 μR/hr, which is the midpoint in the background range of 10 μR/hr to 15 μR/hr cited by Mr. Franke. Franke Testimony, Exhibit 2 at 7. Each μR/hr yields an annual dose of 8.75 mrem. Id. The range of gamma values reported at eight mining sites in Table 4 equates to a dose of 122.5 mrem/yr (at 14 μR/hr) to 12,250 mrem/yr (at 1,400 μR/hr), or 12.3 rems/yr, which is about 2.5 times that of NRC's annual limit exposure limit for nuclear workers. While a resident would have to occupy a mining site having those external radiation levels continuously for a year to receive such doses, it is not out of the question that some residents may have used mining wastes from the abandoned mines in the area for construction material, as has been the case at many sites in the Four Corners Area. There has been, to my knowledge, no radiological surveys of homes in the Church Rock area to ascertain if hazardous materials were used as construction materials. It is also quite likely that some local residents have traversed those sites in pursuit of stray livestock, game or simply for recreation. While exposures of this nature would be short-term, they nonetheless add to an individual's total exposure and therefore her overall risk.

There are other sources of exposure that I did not include in **Table 4**. Most notably, there are two abandoned mine sites — Diamond 2 (Largo) and Hogback #3 and #4 — that are located outside of the area covered by **Exhibit S,** the Church Rock

Mining Map. These sites are also located near Navajo residences several miles southeast of Gallup and just a mile east of the Gallup city limits.[64]

Environmental resources affected by past uranium mining-related discharges also are sources of contaminants. Sediments in the bottom of the Puerco River may still contain elevated concentrations of radionuclides and trace metals left over from 20-plus years of releases of uranium mine dewatering effluent and from the one-time "shock" loading of 94 million gallons of accident mill process effluent in the July 1979 UNC tailings spill.[65,66] Studies by contractors to the NRC in 1979-1980[67] and by the New Mexico Environmental Improvement Division in 1982[68] documented concentrations of thorium-230, a uranium-238 decay series radionuclide, in river-bottom sediments several times greater than measured background concentrations.

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64 See, **Exhibit O** for locations of these sites.

65 Shuey, C. Historic Contaminant Loading on the Puerco River. Presented at Puerco River Symposium, Navajo Nation Environmental Protection Agency (Window Rock, Ariz.) (October 12, 1992).

66 Wirt, L. Radioactivity in the Environment — A Case Study of the Puerco and Little Colorado River Basins, Arizona and New Mexico. U.S. Geological Survey (Tucson, Ariz.) Water-Resources Investigations Report 94-4192 (1994).

67 Weimer, W.C., Kinnison, R.R., Reeves, J.H. Survey of Radionuclide Distributions Resulting from the Church Rock, New Mexico, Uranium Mill Tailings Pond Dam Failure. Prepared for U.S. Nuclear Regulatory Commission by Pacific Northwest Laboratory, NUREG/CR-2449 (December 1981); attached in relevant part as **Exhibit T** hereto.

68 Millard, J., Buhl, T., Baggett, D. Radionuclide Concentrations and Doses Resulting from the United Nuclear Uranium Mill Tailings Spill at Church Rock, New Mexico. New Mexico Environmental Improvement Division, Draft Report (April 1982); attached hereto in relevant part as **Exhibit T.**

Relevant data tables from these reports are attached to my testimony as **Exhibit T**.

Other 1980s-era studies addressed radionuclide accumulation in the muscle, organs and bone of animals that grazed in the Ambrosia Lake and Church Rock uranium mining districts.[69,70] In the first study by Lapham, Millard and Samet (1986), the executive summary of which is attached hereto as **Exhibit U**, cattle that grazed on two ranches in the Ambrosia Lake area and on open range in the Church Rock area all had statistically elevated concentrations of specific radionuclides in muscle, bone and various organs, compared with radionuclide concentrations in tissues of control cattle taken from the Crownpoint area. Church Rock cattle had statistically higher levels of uranium-238 (in liver and femur), uranium-234 (in muscle, liver and femur), and radium-226 (in femur) than control cattle. In finding that the study "documents the transfer of radionuclides through the food chain," NMEID officials recommended that the liver and kidneys of cattle raised in Ambrosia Lake "should not be consumed at any time" and recommended that cattle owners in Ambrosia Lake and Church Rock exercise "caution" "to avoid increasing their risk, however small it might be."

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69 Lapham, S.C., Millard, J.B., Samet, J.M. Radionuclide Levels in Cattle Raised Near Uranium Mines and Mills in Northwest New Mexico. New Mexico Environmental Improvement Division (Santa Fe, N.M.) (June 1986); "Executive Summary and Recommendations" attached hereto as **Exhibit U**.

70 Millard, J.B., Lapham, S.C., Hahn, P. Radionuclide Levels in Sheep and Cattle Grazing Near Uranium Mining and Milling at Church Rock, N.M. New Mexico Environmental Improvement Division (Santa Fe, N.M.) (October 1986); "Executive Summary" attached hereto as **Exhibit V**.

Exhibit U, Recommendations at 2.

The second animal study by Millard, et al. (1986), the summary of which is attached to my testimony as **Exhibit V**, determined that radionuclide concentrations in sheep and cattle that grazed in the Church Rock area had statistically higher concentrations of uranium-234 and uranium-238 "in most tissues sampled" than did control animals. "This finding corresponded to higher observed levels of U-234 and U-238 in water samples from the Church Rock area as compared to control samples." **Exhibit V** at ii.

Cleanup of the abandoned mining and processing sites in the Church Rock area has been limited, according to documentation I have reviewed. The most extensive remedial work has been at the UNC millsite where an earthen cover was installed on the tailings impoundment several years ago and windblown tailings were excavated from adjacent lands to achieve federal radium-in-soil cleanup standards. It is also my understanding that mining equipment has been removed from the Quivira Mining (formerly, Kerr-McGee) Church Rock #1 and #1E sites and waste piles graded and revegated. According to NAMLRD files, remedial measures also have been taken at the Grace Energy Section 23 site. Still, most of the environmental and physical hazards remain at these sites, typified by the residual surface contamination still present at the Old Church Rock Mine site now controlled by HRI. No other Superfund sites have been declared in the area, and as I noted above, it will be several more years before the Navajo AML program will undertake remedial actions to reduce the hazards at these sites and isolate them from human intrusion.

As set forth in the ENDAUM's and SRIC January 11, 1999, brief on radioactive air emissions and in the testimony of Mr. Franke in support thereof, there is a strong possibility, ranging between 10 perecent and 50 percent, that radon releases from HRI's Church Rock facility will be substantially *greater* than estimated in the FEIS, such that they will exceed the NRC's 10 CFR Part 20 Appendix B limits. As such, the total radiological effect of the project may not be "neglible," as NRC asserted in the FEIS (at 4-117), and would be *additive* to doses from existing "background."

The preliminary exposure assessment that I was able to conduct using *existing* environmental monitoring data and published and unpublished reports leads to me conclude there remains extensive, unmitigated environmental impacts from previous uranium mining and milling operations Church Rock area, and that local residents are chronically exposed to high ambient radon concentrations that exceed NRC limits. There is little ongoing mitigation of the risks posed by the existing sites, and to my knowledge, no environmental monitoring for radon (either outdoors or indoors) is occuring anywhere in the vicinity of the proposed HRI Church Rock ISL mine. To my knowledge, there are no human health studies of the exposed Church Rock population ongoing or planned to ascertain current health conditions on a localized basis.

This lack of fundamental environmental health assessment in an obviously at-risk population is egregious in light of the world's extensive literature on the health effects of exposure to radon and radon decay products in occupational and in-home environments. One of the scientific community's preeminent authorities on radon, Dr. Jonathan Samet, summarized the reasons why indoor-outdoor radon studies are needed in areas of high ambient levels of radon in a 1994 manual published by the American Society for Testing and Materials:[71]

> Exposure to radon decay products has been shown to increase mortality from lung cancer of underground miners working in mines with high concentrations. An increased risk of lung cancer must be presumed to result from indoor exposure as well. . .Dosimetric analyses suggest that nearly comparable risks of lung cancer should be associated with indoor exposure to radon. Although the principal risk projection models differ substantially, each shows that radon in indoor air poses a public health threat of substantial magnitude.

Furthermore, there is strong evidence, presented by Mr. Franke, that HRI's projected radon releases will violate NRC limits, thereby adding to and quite likely exacerbating existing environmental risks.

Q.10. What should NRC have done to address the existing environmental risks in the Church Rock area?

A.10. As I stated previously in my testimony, NRC should have conducted a quantitative analysis of the effects of previous mining in the Church Rock area, and even beyond.[72] The CEQ Guidance (at 9-10) recommends such study in situations just

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[71] Samet, J.M. Health Effects of Radon. *Manual on Radon.* American Society for Testing and Materials (Philadelphia, Pa.), ATSM Manual 15 (1994), at 44-45.

[72] I have not discussed in detail here the *existing* environmental hazards attendant at another dozen abandoned uranium mining sites in the Mariano Lake-Smith Lake-Thoreau area,

like this one. Additionally, there are at least two technical reasons why a quantitative analysis was needed.

First, as I previously explained in some detail, there is *extensive, ongoing* and largely *unmitigated* radiological impacts of previous uranium mining and milling operations in the northern portion of Church Rock Chapter. At least 700 residents of the area and perhaps as many as 850 are likely being exposed to ambient radiation levels several times greater than the "background" dose estimated by the NRC Staff in the FEIS, and that such doses are cumulative with those the residents would receive should HRI's Church Rock ISL mine go forward. And second, this elevated background from previous mining represents an exposure of a captive, susceptible population made more vulnerable by its lower socioeconomic status and existing burden of health problems, and by the fact that there are former underground uranium miners in the local population who already have been subject to occupational exposures.

When taken as a whole, it is my professional opinion that the current environmental situation in Church Rock, and perhaps also in the Mariano Lake-Smith Lake area, represents an urgent public health problem that the NRC Staff all but ignored in the FEIS. The NRC's description of the existing impacts of previous

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which is located from 12 to 25 miles from the HRI Church Rock site. Several of the mines in this area have physical hazards, such as dangerous highwalls, and extensive surficial radiological contamination. (See, Uranium Mine Inventory, **Exhibit O** attached hereto.) At least two of the mines were operated into the early 1980s. Hence, residents of the affected Navajo communities of this area are not only exposed to residual environmental risks from these sites, but may have had occupational exposures from working in the local mines.

mining was superficial and void of any quantitative, cumulative analysis. This failure on the part of the NRC Staff to dig deeper in its examination of the cumulative impacts of the HRI project would be inexcusable in *any* population. However, because the affected community is a low-income, Native American population, NRC's failure represents the kind of ongoing environmental injustice that the Executive Order and CEQ guidelines were intended to prevent. Without a more extensive analysis, the FEIS could not determine if "disproportionately high and adverse impacts" affect the Church Rock-Crownpoint area.

Q.11. Do you have an overall opinion about the FEIS's and NRC Staff's eview of the Crownpoint Uranium Project from an environmental health perspective?

A.11. Yes, I do. It is my professional opinion that the FEIS fails to justify the NRC Staff's decision to issue a source materials license for the HRI Crownpoint Uranium Project, that the CUP will present an undue risk to the health and safety of the local Navajo communities, especially in the northern part of Church Rock Chapter, and that the NEPA process for the CUP did not advance or serve the environmental justice goals of President Clinton's Executive Order 12898 or fulfill the NRC's NEPA obligations to analyze the cumulative impacts of the project.

Q.12. Does this conclude your testimony?

A.12. Yes.

AFFIRMATION

I declare on this 15 day of February, 1999, at Albuquerque, New Mexico, under penalty of perjury that the foregoing is true and correct to the best of my knowledge, and the opinions expressed herein are based on my best professional judgment.

Christine J. Benally

Christine J. Benally

Sworn and subscribed before me, the undersigned, a Notary Public in and for the State of New Mexico, on this 15 ~~th~~ day of February, 1999, at Albuquerque, New Mexico.

My Commission expires on 7-29-02.

Notary Public

Curriculum Vitae

Christine J. Benally, Ph.D.
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Personal Information

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My background and interest are to work with Native America on public health related projects in epidemiology, environmental health, research, and education.

Education

Ph.D. from Colorado State University in Environmental Health, 1993
Dissertation: *Navajo Nation: Insecticide Application and Environmental Impacts*;
1986-1990 — Graduate Student at Colorado State University, Fort Collins, Colo.

B.S. in Microbiology from Northern Arizona University, 1986.
Participated in the Minority Biomedical Research Support, NIH grant;
1984-1986 — Undergraduate at Northern Arizona University, Flagstaff, Ariz.

A.A.S. in Medical Laboratory Technology from Navajo Community College, 1979.
Completed rotation at Gallup and Phoenix Indian Medical Centers.

Employment Experience

6/98-present, Environmental Health Scientist, Agency for Toxic Substances and Disease Registry, Centers for Disease Control and Prevention, U.S. Public Health Service, Atlanta, Ga.

I work with Native Nations, consortia, communities, colleges, organizations and other governmental agencies, which have affiliations with Native Americans, in responding to specific toxic or hazardous exposures and health effects that are of concern to local people; conduct public health assessments, consultation, risk communication and review petitions; and establish tribal intergovernmental relationship policies and guidelines for cooperative and partnerships. Leslie Campbell is my supervisor and can be contacted at 404-639-0683. I am presently at this job.

7/97-6/98, Management Analyst, Northern Navajo Medical Center, U.S. Indian Health Service, U.S. Public Health Service, Shiprock, New Mexico.

The Management Analyst position involved serving as an administrative assistant to the

Clinical Director and the Medical Division Chairs of the medical center. Duties included finance, personnel, contract and scheduling; data analysis, evaluation, reporting, summarizing, and community/ professional presentations. Research included literature/publication review, data management, and epidemiological analysis; and strategic planning in customer satisfaction and resource development, including employee training, recruitment and retention. I worked with critical needs in medical services required by the Joint Commission standards. I worked with all the departments in the medical center for points to measure efficiency and assisted some departments with flow charting of services. I was responsible for insuring that contract requests are completed, and issued purchase order numbers. As a liaison, I assisted the clinical division and personnel with filling vacant positions that need to be announced, certificates issued and occupied. I researched the literature on surgical procedures for bench marks and baseline in quality services and care, customer satisfaction, medical screening, data collection, and management and analysis for performance improvement. I reviewed the obstetric patient tracking system software for the OB department. This software provides a computerized database of OB customers and replaced the current log books. The database allows more efficient analysis and reporting. NNMC-OB department will implement the use of the updated version of the software by becoming a beta test site. The appointment was a 60-day temporary assignment, from July to September 1997. Following that period, from October through November 1997, I was retained a consultant, and was hired as a full-time employee in November 1997 until transferring to CDC in Atlanta in June 1998. George Baacke, MD, acting clinical director, and Arnold Wyse, MD, clinical director, were my supervisors and can be contacted at 505-368-7000.

8/97-5/98, Adjunct Faculty, San Juan College, Farmington, N.M.

I taught Introduction to Biology (Bio 102), and completed the contracts for two semesters. Elaine Benally, director of San Juan College West, was my supervisor and can be contacted at 505-598-5897.

3/97-7/97, Interim Director, Office of Navajo Uranium Workers (ONUW), Navajo Nation Division of Health.

ONUW is a program established in 1990 within the Navajo Nation's Division of Health to assist Navajo uranium workers in making compensation claims in accordance with the federal Radiation Exposure Compensation Act of 1990. During my tenure with the program, I was responsible for all administrative duties, including establishing program priorities, goals and objectives; managing personnel (including advertising the director position for permanent employment status); financial management, proposed budget forecast for contracts, proposals and imminent budget cycle, and cyclic reporting in months, quarterly and annually, based on the evaluation methods set for the program; managing properties; and writing grant proposals, conducting research, and preparing legislation amendments. The program processed all necessary medical and work history documentation for its clients. As interim director, I advocated for Navajo occupational epidemiology and public health, environmental and community issues before representatives from Navajo Nation, U.S. Congress, state and local governments, research institutions, and other related parties. Public relations tasks included individual consultation, public presentations at conferences and through media, and testimonies before the Navajo Nation Council and its committees for supplemental funding. In order to assist the uranium workers, the program established a network of medical, scientific and legal professionals locally and nationwide to help promote compensation, conduct research, instigate and coordinate studies, and lobby public officials for amendments to RECA and other relevant laws. Two of four proposals that I was involved in developing were funded. One is in the amount of $200,000 for medical screening and epidemiology follow-up and the other was for $123,000 for legislation amendments. Other duties included serving on the Navajo Nation Institutional Human Health Research Review Board, Navajo Area Indian Health Service contract health plan work group, and Aneth health risk and public health assessment task force. The position was a 90-day temporary assignment. Another person was hired as a full-time permanent employee. Rosalyn Curtis, former Navajo Nation Division of Health diirector, was my supervisor, and can be contacted at 520-871-6350.

2/97-3/97 Environmental and Public Health Scientist Consultant, Community Health Services Program, Northern Navajo Medical Center, U.S. Indian Health Service, U.S. Public Health Service, Shiprock, Navajo Nation, N.M.

The consultation work has been periodic and the work varied from education, public health and environmental protection, Navajo lifestyle, cultural and language preservation, natural preservation, fund raising and legislation amendments with the tribe, state and U.S. Conducted the initial literature research and coordination for an environmental health assessment and environmental impacts from oil fields in the Navajo communities in southeastern Utah. Dr. Chris Percy, director of Community Health Services, was my supervisor and can be contacted at 505-368-6001.

11/95-12/96 Executive Director, Diné CARE (Citizens Against Ruining Our Environment).

Diné CARE is a not-for-profit organization whose mission was to assist Navajo communities that faced environmental, political and ethnic injustices. As director, I advocated for and promoted the communication of environmental and health issues facing Indigenous people, locally and internationally, through networking with communities and organizations with community emphases. My responsibilities included all administrative duties, policy development, personnel, proposal development, fund raising, and establishment of an Environmental and Resource Center. I worked with Diné College to establish a web site for the Diné CARE. I submitted all monthly, quarterly and annual reports to all the board members and a few associates. I developed proposals for funding environmental health research by forming partnerships with research institutes and universities. I secured funds for coalition building and organizational development with workshops in budget and monthly or quarterly activity reports for the board and foundations. I promoted environmentally friendly businesses, assisted in the initiation of environmental projects, developed operating guidelines and procedures, and responded to correspondences and agreements for Diné CARE. I encouraged networking and communication with the organizations, parties and individuals, from the local to international level. I promoted environmental education among the youth by developing proposals for youth projects and activities for incentives to enhance involvement. And I participated in the Impacts of Big Mines on Indigenous

People conference held in London, England, in May 1996. My position ended in December 1996; the organization has since closed its Shiprock office.

5/92-11/95 Injury Prevention and Control Specialist, Shiprock Service Unit, U.S. Indian Health Service, U.S. Public Health Service, Shiprock, N.M.

In this position, I provided technical assistance in community intervention projects regarding epidemiology, environmental modifications, enforcement and education; monitored projects for effectiveness as project justification, implementation, development and evaluation; provided awareness and training in the community about injury prevention and resources currently available; maintained injury data that was used to provide statistical, summary, evaluation and epidemiological reports on the injury prevention program; served as an injury prevention advocate in community, county, state and national committees; promoted injury prevention education and projects at the community level and before tribal, local and national agencies and organizations; worked with interdisciplinary team of professions in the southwestern part of the U.S. using different methods of injury prevention for all age groups; and monitored and coordinated community injury prevention projects; responded to needs of the community by researching potential human and financial resources based on community vision. I also developed and implemented successful community projects for prevention of domestic violence, suicide, motor vehicle crashes, elderly falls and abuse, child abuse, fire, burns and occupational hazards. Some of these projects included promotion of child car seat and seat belt use, prevention of violence, suicide and DUI, and education on home safety to prevent burns, drowning, and falls. Many of these projects involved forming community partnerships and encouraging local empowerment; others were contracted for implementation. I resigned from this position to become executive director of Diné CARE after I failed in several attempts to obtain a managerial position that had more responsibilities in and emphasis on environmental health issues as they related to the quality of public health. My supervisor was Mr. Len Courtois, Environmental Health Specialist, who can be contacted at 520-871-1318.

1/91-5/92 Science and Math Instructor, Navajo Community College, Tsaile, Navajo Nation, Ariz.

I taught Introduction to Chemistry, General Chemistry I and II, Microbiology, Introductory to Physical Science, Environmental Research, Arithmetic and Intermediate Algebra for four semesters. I developed a curriculum for an Associate of Science degree in Environment Science and an Associate of Applied Science in Hazardous and Solid Waste Management and Technology, and still still serve as a curriculum consultant. The environmental science curriculum was implemented later. I served as the faculty advisor to the American Indian Science and Engineering Society, and was a member of the library faculty committee, the GED program committee, the Diné Philosophy of Learning curriculum development committee, and the Diné Teacher Education. I worked with other universities and state and national agencies on student transfers, articulation, contracts and grants, partnerships and curriculum development. I resigned from this position after securing a position with the Indian Health Service, to which I owed at least two years of service obligation due to a scholarship agreement. I was a ful-time instructor from January 1991 through May 1992, and an adjunct instructor from January

1993 through May 94. I received faculty internships in July 1993 to Lawrence Livermore National Laboratory and in July 1996 to the University of Stuttgart in Stuttgart, Germany. Mr. Carlon Ami, NCC department chair and peer Instructor, was my supervisor and can be contacted at 520-724-6716.

7/91-8/91 Chemist, Lawrence Livermore National Laboratory, Livermore, Calif.

I researched uranium isotope isolation using bioassay sample techniques and methods. I conducted a literature review and research specific for certain facilities. The goal of this work was to implement similar type of research and methods for Navajo communities. I worked with an interdisciplinary team of individuals from the chemistry, environmental chemistry, environmental science, public health and employee health departments. The position was a summer faculty internship for one month.

1989-1990 College Supervised Teaching, Department of Environmental Health, Colorado State University, Fort Collins, Colo.

I taught 700-level classes in epidemiology and chemical epidemiology.

8/86-5/90 Tutor, International Program, Colorado State University, Fort Collins, Colo.

I taught Beginning Navajo for non-native speakers and tutored undergraduates in math and science.

5/88-9/88 Senior Commissioned Officer in the Student Training Extern Program (COSTEP), Navajo Area Indian Health Service (NAIHS), Window Rock, Ariz.

I received management and administrative training in program reviews, policy and procedure making, and regulations and code development, and consulted with the Navajo Nation Department of Health in developing policies for community and institutional health promotion and disease/injury prevention. I worked with the Institutional Sanitarian and helped develop the Sanitation and Safety Code for Day Care Centers on the Navajo Nation. I provided day care, early childhood care and school related educational materials, gave presentations and provided recommendations on food sanitation, vector/rodent control, water and waste water treatment facilities, solid waste disposal, hazardous waste, and injury prevention to provide a safe and healthy environment for the children and staff. I started working on the Nursing Home when the assignment ended. This was a four month assignment. Jim Spahr, the Institutional Sanitarian, was my supervisor. The NAIHS Office of Environmental Health number is 520-871-4811.

5/86-7/86 Junior COSTEP, Fort Defiance Service Unit, NAIHS, Fort Defiance, Ariz.

I advised public facilities and vendors on maintaining quality environmental health for the public and employees, and surveyed these facilities to monitor and enforce the environmental, food, health and safety codes. I worked with the District Sanitarian conducting sanitation and safety field inspections of public, school, recreational, retail and temporary food facilities. I provided educational materials, gave presentations and provided recommendations on food sanitation, vector/rodent control, water and waste water treatment facilities, solid waste disposal, hazardous waste, and injury prevention. This was a two month assignment. Ken Secord, District Sanitarian, was my supervisor. The NAIHS Office of Environmental Health number is 520-871-4811

8/84-5/86 Tutor, Learning Assistance Center, Northern Arizona University, Flagstaff, Ariz.

I tutored undergraduate math and science students. The Learning Assistance Center can be reached at 520-523-9011.

1984-1985 Research Assistant, Minority Biomedical Research Support, National Institutes of Health, Northern Arizona University, Flagstaff, Ariz.

I studied the effects of cobalt-60 irradiation on the -SH and the -SS groups in the membrane of mouse sperm.

1980-1983 Laboratory Technician at Various Clinical and Industrial Facilities in New Mexico, Arizona and Nevada

I was responsible for collection, analysis and reporting of human, water and environmental samples while working for various clinical, research and industrial laboratories in the Southwest. I engaged in these jobs for the experience and to support plans for further education. The laboratory facilities were located at a surface coal strip mine, a coal-fired electric powerplant, the Mobil Section 9 Pilot uranium in situ leach mine west of Crownpoint, N.M., and a streptococcal disease control facility. As a result of this work, I became interested in and knowledgeable about the environmental and public health impacts of mineral and energy development.

1978-1979 Laboratory Technician at two U.S. Public Health Service Indian Hospitals

Completed the clinical rotation through the Gallup Indian Medical Center and Phoenix Indian Medical Center. This PHS program has since been abolished.

Volunteer/Affiliations/Community Involvement

Four-year appointment to the Navajo Nation Human Health Research Review Board by the President of the Navajo Nation, present-2000; resigned in 1998 due to job transfer to CDC in Atlanta.

Navajo Nation Commission of Local Government Development (publication, legislative and traditional subcommittee member), 1997-2000; resigned in 1998 due to job transfer to CDC in Atlanta.

Elected as the Vice President of the Sanostee Chapter, Navajo Nation, 1996-2000; resigned in 1998 due to job transfer to CDC in Atlanta.

Volunteer Lobbyist for Sanostee Chapter, 1996-1998. For more than a year and a half, I served my home community, Sanostee Chapter, as a volunteer lobbyist while working full time at the positions listed above. I developed and submitted proposals for community infrastructure development, education, land use planning, and business/economic development, and worked with the Navajo Nation government, congressional offices, and state and other local governments to promote these initiatives. Mr. Eddie Mike, Sanostee Chapter president, is familiar with my work for the community and can be contacted at 505-723-2479.

Two-year appointment to the National Environmental Justice Advisory Council (NEJAC) by USEPA Administrator Carol Browner, May 1996-1998.

Named to Bojack Hall of Fame as the "Environmental Doctor of the Year," Flagstaff, Ariz., May 1996.

Scholarship recipient to Using Health Research to Insure Environmental Justice Conference, which was held to promote collaboration on environmental health issues among environmental organizations, grassroots groups, and various federal agencies, 1994-1995.

Recipient of New Mexico Department of Health Injury Prevention grant to sponsor an introductory to injury prevention and intervention course for the Community Health Representatives in Shiprock Service Unit, Shiprock Youth Center, Shiprock, N.M., 1993.

Navajo Community College. Faculty Lead Research in Environmental Chemistry from Coalition to Increase Minority Degrees from Arizona State University; Faculty Science Internship at Lawrence Livermore Laboratory; AISES Faculty Advisor; 1991-1992.

Colorado State University, Distinguished Minority Graduate Student, Martin Luther King Scholarship, NASA Academic Excellence Award, American Indian Science and Engineering Society; 1986-1990.

Consulted with the Inter-Tribal Council of Arizona, Inc., Laughlin, Nev., and Phoenix, Ariz. Exchanged information on pesticide toxicology and endangered species; 1990.

Northern Arizona University, Indian Health Service COSTEP Scholarship, IHS 437 grant, Minority Biomedical Research Support, National Institutes of Health grant, American Indian Honor Society; 1984-1986.

Community and Professional Organizations/Board Memberships

Member, American College of Epidemiologists, 1998-present.

Board Member, Navajo Office of Animal and Human Health (NOAH2), 1997-1999.

Navajo Nation Commission of Local Government Development, member of publication, legislative and traditional subcommittee, 1997-2000.

Vice President, Sanostee Chapter, Navajo Nation, 1996 - 2000.

Member, Navajo Nation Institutional Human Health Research Review Board, 1996-1998.

Navajo Teacher Education Program, 1995-1998.

Board Member, Diné Mining Action Center, 1996-1998.

Vice Chairperson, Shiprock New Campus Committee, Navajo Community College, 1994-1997.

San Juan County Partnership, member of personnel and fund raising committee, 1994-1995.

Member and Board Member, Diné Citizens Against Ruining our Environment, 1991-1994, 1994-1995.

Member, Minority Biomedical Research Support Advisory Board, NCC Shiprock Campus, 1991-1994.

President, Health Advisory Board for the Shiprock Agency Head Start Schools, 1992-1994.

Committee Member for GED Program at NCC, Tsaile Campus, 1991.

U.S. Public Health Service — National Environmental Health Association, Commissioned Officer/PHS (Inactive Reserved Sanitarian, Scientist Category, Serving on Shiprock Service Unit Safety, Domestic Violence Task Force, Injury Prevention, DWI Task Force, Wellness, Northwest New Mexico Fighting Back Initiatives, and Pedestrian Safety Committees); 1992-present.

Colorado State University — Graduate student council, Department representative, Environmental Health Student Association, AISES - Colorado State Chapter Secretary, Native American Student Association, International Companion, American Indian National Honor Society, and supplemental language programs); 1986-1990.

Specialized Skills

Data and Word Processing: Familiar with IBM and Apple computer software and hardware operations (Indian Health Service RPMS and QMAN, Windows 98, Microsoft desktop, WordPerfect Suite, Lotus 1-2-3, Quattro Pro, SAS, R:BASE, EPIINFO, graphics, Macintosh, VAX).

Interpersonal: Supervisory, administration, management, policy development, program priorities, goals and objectives, budgets, financial management, evaluation, personnel, contracting, and public communication and training.

Specialized Equipment: Operation of laboratory and water treatment analytical instruments and equipment, and interpretation of results.

Research:

- Literature researched in surgical procedures for bench marks and baseline in quality services and care, customer satisfaction, medical screening, and data collection, management and analysis for performance improvement; 1997-1998.

- Established a manageable uranium worker data base system within the Office of Navajo Uranium Workers to improve case management, conduct research, and prepare legislation amendments. (Health effects investigations from uranium mining and mill processing operations in the Southwest vary from the miners to the offspring of these workers.) Developed community education materials, and proposals for environmental health assessments, environmental testing and medical screening. 1997

- Community-based research and consultation on potential health and cultural effects from exposure to environmental hazards including radiation, forest clear cutting, air pollution, strip mining, oil and gas exploitation, imposed assimilation, and forced relocation. Developed community-based organization and university partnerships to address localized forest management, respiratory problems from air pollution, and cancer from radiation exposure. 1986-present.

- New Mexico Highway 64 Pedestrian Safety, New Mexico State-Wide Focal Group, 0-11 years old occupant restraint use projects. Each included coordination with the communities, State of New Mexico Department of Health, University of New Mexico's Department of Emergency Medicine, Safer New Mexico Now, and Shiprock Service Unit, Navajo Area Indian Health Service. 1992-1995.

- Produced *TIPPS* and *The Seat Belt and the Family* video tapes for community education. 1993-1994

- Faculty lead research on chemical residues in water, air, soil and the public's perception. Coalition to Increase Minority Degrees, Navajo Community College. 1991-1992.

- The Navajo Nation: Insecticide Application and Environmental Impacts. Study included federal environmental regulations, occupational hygiene, and pesticide toxicity and epidemiology. Department of Environmental Health, Colorado State University. 1990.

- Navajo Area Child Day Care Center Program Management Review 1988. Office of Environmental Health and Engineering/Navajo Area Indian Health Service/U.S. Public Health Service (OEHE/NAIHS/USPHS). 1988.

- 1987 Pilot Study of the Toxaphene Pesticide Residue in Soil, Surface and Subsurface Water Near Livestock Dipping Vats on the Navajo Nation. Supported by Navajo Area Bureau of Indian Affairs/Department of Interior. 1987.

- Effects of Co60 Irradiation on Male Mouse Sperm. Research was conducted with funds obtained for promoting minorities involvement in medical and scientific health research from the Minority Biomedical Research Support, National Institutes of Health/Department of Health and Human Service. 1984-1985.

Teaching experience

San Juan College -West — Introduction to Biology, BIO 121, for the San Juan College as an adjunct faculty Kirtland, NM. 1997-1998.

U.S. Public Health Service — Microsoft, Indian Health Service RPMS, EPIINFO statistics software package, Introductory to Injury Prevention, Taught plague and food handling courses, Applied Injury Prevention and Epidemiology courses. 1986 - 1998.

Navajo Community College — Fundamental and General Chemistry I & II, Microbiology, Arithmetic, Intermediate Algebra, Introduction to Physical Science and Environmental Chemistry Applied Undergraduate Research Tsaile, AZ and Shiprock, NM Campuses. 1991-1994.

Colorado State University — Supervised college teaching, Chemical Epidemiology; presented information on occupational safety in a business economics class at Navajo Community College; taught beginning Navajo Language to non-native speakers for three semesters through the International experimental and supplemental learning program; provided tutorial services for science and math courses, Student Learning Assistance. 1986-1990.

Northern Arizona University — Volunteered in teaching workshops as part of the tutoring services, Learning Assistance Center; provided tutorial services for the science and math courses, Student Learning Assistance. During semester breaks, I supervised college and high school students and community help projects. 1984-1986.

Conference Presentations

Presentations on Health and Environmental Issues Effecting Native Communities:

- Various public presentations as representative of the Sanostee Chapter.
- Uranium miners compensation, Southwest Indigenous Uranium Forum, 1997.
- Indigenous Environmental Health Issues, SW Network, Grand Canyon Trust Fund, Cortez, Colo., 1997.
- Uranium Amendments Public Forum, Kayenta, Ariz., 1997.
- Natural Resources Public Forum, Sanostee, N.M., 1997.
- KTNN Radio Environmental Forum, Window Rock, Ariz., 1996
- Navajo Nation Division of Health Hantavirus Conference, Farmington, N.M., 1996.
- Environmental Remediation with COIL, Stuttgart, Germany, 1996.
- Impact of Big Mines on Indigenous People, London, England, 1996.
- Environmental and Public Health Issues on the Navajo Nation, NAU, Flagstaff, 1996.
- Navajo High School Youth forum on the Future of Energy and Natural Resource on Navajo, 1996.
- Public commentary at NEJAC, Grand Canyon Visibility Study, Defense Theater Missile Testing, Colorado River Basin Stakeholders, nationwide Native and Environmental hearings, 1993-present.
- Community Based Environmental and Health Research, Indigenous Environmental Network, 1994-present.
- Public statement, National Environmental Justice Advisory Counsel meeting in Atlanta

NM Highway 64 Pedestrian Project. New Mexico Injury Prevention Themes, Dreams, and Time Machines Conference 1994 Albuquerque, NM.

NM Highway 64 Pedestrian Project and *The Effects of Operation Shut-off.* Using Health Research to Insure Environmental Justice 1994 Arlington, VA.

Environmental Health Today. Tuba City (Ariz.) School District, Navajo Heritage Program. 1991-1992.

American Indian Research Opportunities Symposium; Bozeman, MT; 1990.

Navajo Livestock Pest Control Workshop. Red Rock State Park. 1990 Gallup, NM.

Abandonment of Livestock Dipping Vats on the Navajo Nation. 1988 Window Rock, AZ.

Hazardous Waste on Tribal Lands; Toxic Waste in Minority Communities Symposium at the University of Colorado, Boulder, Colo., 1988.

Results from a *Pilot Analytical Study of Toxaphene Residuals in Soil, Surface and Subsurface Waters*; Annual Navajo Nation Pesticide Certification Workshop. UNM Gallup Branch. 1988 Gallup, NM.

Numerous presentations on Health and Environmental Problems facing the Navajo Nation. Navajo Environmental Protection Administration, 1986-1990.

Extracurricular Activities and Community Involvement

Dine' Mining Action Center (DMAC) and Dine CARE (Citizens Against Ruining our Environment). Protect the ecosystem, tradition, and culture of the Navajo Nation including the Chuska Mountains from commercial logging, Aneth surface and underground water from oil fields drainage, Dzilthnaodithhle mountain from illegal occupancy, eastern Navajo from Uranium leach wells and open pit mining and other environmental and cultural sensitive issues. Addressed the federal departments on the need for community and tribal collaboration in funding, education, restoration, funding, research (medical and scientific) and policy (legislative) development to insure environmental justice and equity. 1991-1998.

Navajo Code Talker Association (non-profit organization) activities. 1988-present.

Community Mobilization Effort underway with Eastern Shiprock Service Unit's "Sacred Journey to Save Lives" in effort to bring awareness to prevent DWI and other irresponsible drinking behavior. Journey from Farmington to Nageezi, N.M., 1994.

Liaison for Sanostee community and Fort Collins Nightwalker Enterprises. 1989-present.

Helped with Sanostee Chapter activities: Veteran Memorial Center dedication, Gym Committee's Youth and Leadership Recognition Days, 1988-present. Currently elected in as a chapter official.

Volunteered with the Fort Collins Nightwalker Enterprises winter clothing drive and distribution of clothes to Native American Nations, 1986-1989.

Colorado State University. Represented and provided presentations for Colorado college students. Minority student concerns. Governor's Interfaith Breakfast, National Conference of Christians and Jews. Importance of graduate school at the reception for CSU freshman minorities scholarships recipients. Graduate research on the environmental effects from pesticide application on the Navajo Nation. Welcome address for Mr. N. Scott Momaday, a Pulitzer Prize winning author, who was the key speaker of Native American Heritage Week. International programs companion. Graduate studies and research benefits for Indian Nations. Minority CSU Graduate Students, panelist on occasion.

References

(Available Upon Request)

Personal Interests

Swim, walk, read/write and computers are fun stuff to do with my seven-year-old son.

NATIONAL ENVIRONMENTAL JUSTICE ADVISORY COUNCIL

February 26, 1998

Ms. Carol Browner, Administrator
U. S. Environmental Protection Agency
401 M Street, SW
Washington, DC 20460

Dear Administrator Browner:

During the February, 1998 National Environmental Justice Advisory Council (NEJAC) meeting in Arlington, VA two resolutions developed by the Indigenous Peoples Subcommittee were passed by the Full NEJAC. The first resolution pertains to the potential impacts of a proposed new ski resort on Mount Shasta, California, and calls into question the Bureau of Land Management's and the Forest Service's efforts to conduct meaningful consultation with the Pit River Tribe, Shasta Nation and Resighini Rancheria. The second resolution regards the potential impacts of three proposed in situ uranium mines near the predominately Navajo communities of Crownpoint and Church Rock, New Mexico, and calls upon EPA with its underground injection control responsibilities to work with the Nuclear Regulatory Commission to ensure the communities have appropriate opportunity to meaningfully participate in the public decision making processes. The full text of these resolutions are attached for your review.

The NEJAC appreciates any assistance you can provide in addressing the concerns raised in these resolutions. Please forward these two resolutions to EPA Region 9, and a copy of the Uranium Insitu Leach Mines Resolution to the Office of Water. As the concerns are addressed by EPA, I ask that the response be coordinated through the Office of Environmental Justice, with a copy to Kathy Gorospe. Director of the American Indian Environmental Office. If I can be of any further help, please do not hesitate to call me at (610) 524-0404.

Sincerely,

Haywood Turrentine

Haywood Turrentine, Chairman
National Environmental Justice
Advisory Council

Attachment

NATIONAL ENVIRONMENTAL JUSTICE ADVISORY COUNCIL
INDIGENOUS PEOPLES SUBCOMMITTEE

URANIUM IN SITU LEACH MINES IN TWO NAVAJO COMMUNITIES

WHEREAS, the United States Environmental Protection Agency (EPA) is a federal agency which was created in 1970, with the direct purpose and responsibility to develop and implement strategies that protect public health and the environment; and

WHEREAS, the National Environmental Justice Advisory Council (NEJAC), established on September 3, 1993, is comprised of representatives of academia, business, industry, Federal, State, Tribal, local government, environmental organizations, community groups and non-governmental organizations, with the goal of providing advice to the EPA on matters related to environmental justice and racism for minority populations and low-income populations, and

WHEREAS, the Indigenous Peoples Subcommittee has been approached by indigenous community members regarding a proposed project and has brought it back to the full NEJAC for consideration and action, to with:

> Hydro Resources, Inc. (HRI) is proposing to construct and operate three uranium in situ leach (ISL) mines on sites in and within two miles of the Navajo community of Crownpoint, New Mexico (the "Crownpoint Lease" and "Unit 1" site respectively) and on a site in the Church Rock (N.M.) Chapter of the Navajo Nation inhabited and used by Navajos; and

WHEREAS, the proposed ISL, or solution mining is proposed to be conducted in a geologic formation that provides the sole source of drinking water for from 5,000 to 15,000 people, most of whom are Navajos who live in the town of Crownpoint and in several other Navajo communities located within 45 miles of Crownpoint; and

WHEREAS, it is reported to NEJAC that many Navajos routinely haul water from Crownpoint because public water supply systems and other sources of high-quality water for human and livestock consumption do not exist in most rural Navajo communities in northwestern New Mexico; and

WHEREAS, the Nuclear Regulatory Commission (NRC), in its Final Environmental Impact Statement (FEIS) has determined that the "unprecedented" close proximity of Crownpoint's five municipal water wells to solution mining operations at the Crownpoint Lease site (a maximum distance of less than 2,000 feet) necessitates the relocation of those wells because "the potential risk [of contamination from solution mining] is too great for groundwater to be degraded below EPA primary and secondary drinking water standards and the NRC 0.44 mg/L [milligram per liter] of uranium standard"; and

WHEREAS, the U.S. Environmental Protection Agency regulates underground injection associated with ISL mining pursuant to the federal Safe Drinking Water Act (SDWA) (42 U.S.C. nn 300f *et seq.*) and its implementing regulations (40 C.F.R. Parts 144, 146 and 147), including such mining on Indian lands of the Navajo Nation (40 C.F.R. n 147.3000(a)); and

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WHEREAS, the SDWA's Underground Injection Control (UIC) requirements prohibit endangerment of underground drinking water sources and do not authorize exemptions of aquifers that currently serve as sources of drinking water; and

WHEREAS, according to NRC's FEIS, NRC has determined that groundwater under and near the Crownpoint Lease site and Unit 1 site meet EPA's criteria for the definition of underground source of drinking water; and

WHEREAS, NEJAC is advised that, the opinion of the staff of the Ground Water Office of EPA, Region IX, is that aquifers lying within, and in the vicinity of, the solution mining zone at the Church Rock mine also constitute underground sources of drinking water; and

WHEREAS, the existing quality of water obtained by Crownpoint-area residents from town water wells is better than current EPA and Navajo Nation primary and secondary drinking water standards; and

WHEREAS, the NRC has proposed a license condition that would require HRI to relocate Crownpoint's water wells and associated water distribution system before ISL mining can occur at the Crownpoint Leases site, without benefit of a feasibility study to determine whether any other locations within the same aquifer or any other aquifers in the region can provide the same or better quantity and quality of drinking water now used by area residents with the equivalent accessability or better; and

WHEREAS, the NEJAC is advised that NRC acknowledges in its FEIS that the "entire area of impact constitutes an 'environmental justice population' " in that the vast majority of the population affected by the proposed uranium ISL mines is Navajo and has from 41 percent to 71 percent of the median household incomes of New Mexico residents and from 30 percent to 53 percent of the U.S. median household incomes; and

WHEREAS, the NEJAC is advised that, according to a petition filed with NRC by Eastern Navajo Dineh Against Uranium Mining (ENDAUM) in August, 1997, HRI's parent company, Uranium Resources, Inc. (URI), has a history of license violations at its South Texas uranium ISL mines, has never mined in Texas to the depths anticipated at the Unit 1 and Crownpoint Lease sites (400 feet to 700 feet in Texas versus 1,840 feet to 2,290 feet at Unit 1 and Crownpoint), and has mines in aquifers of considerably poorer quality than that documented at the Crownpoint, Unit 1 and Church Rock sites; and

WHEREAS, the NEJAC is further advised that the NRC's FEIS did not evaluate URI's Texas performance record; considered only the mining project's touted local job "benefits" and minimized the socioeconomic, environmental and cultural impacts; ignored or gave inconsistent statements about Navajo nation sovereignty and jurisdiction; and inhibited community participation by not widely distributing, first, a Draft Environmental Impact Statement (DEIS) issued in November, 1994, and second, the FEIS in March 1997, by charging $35.00 per copy for each FEIS for individuals, including community members, who had not commented in writing or orally on the DEIS, and by denying requests of ENDAUM and the Navajo Nation Environmental Protection Agency (NNEPA) that a public documents repository be established in the town of Crownpoint; and

WHEREAS, President Clinton's Executive Order on Environmental Justice provides that, "Each Federal agency shall conduct its programs, policies, and activities that substantially affect human health or the environment in a manner that ensures that such programs, policies, and activities do not have the effect of excluding persons (including populations) the benefits of, or subjecting persons (including populations) to discrimination under, such programs, policies, and activities, because of their race, color, or national origin"; and

WHEREAS, the NRC's own licensing panel, the Atomic Safety and Licensing Board, has determined that the provisions of Executive Order 12898 are "fully applicable to the Agency"; and

WHEREAS, the NEJAC is advised that the NRC staff on December 4, 1997, issued its Safety Evaluation Report (SER) which recommends the licensing of the proposed mines.

NOW THEREFORE BE IT RESOLVED by the NEJAC, on the basis of the foregoing reasons, that:

(1) NEJAC urges and recommends that EPA immediately, thoroughly, and carefully scrutinize all UIC permit applications and temporary aquifer exemption applications or actions for the proposed uranium in situ leach mines in and near the Navajo communities of Crownpoint and Church Rock, New Mexico and, pending further investigation and tribal and community participation, deny or revoke the same where there is a threat to underground sources of drinking water;

(2) NEJAC urges and recommends that the EPA Administrator, as Chair of the Inter Agency Workgroup on Environmental Justice, urge the Chair of NRC to ensure that all provisions of Executive Order 12898 are fully complied with and carried out in "the matter of Hydro Resources Inc.," NRC Docket No. 40-8968-ML;

(3) NEJAC urges and recommends that the EPA Administrator, as Chair of the Inter Agency Workgroup on Environmental Justice, urge the Chair of NRC to establish, fund and equip a local public documents repository for Docket No. 40-8968-ML in the town of Crownpoint, New Mexico, and to distribute, free of charge, copies of the DEIS, FEIS and SER to any person who requests them either orally or in writing; and

(4) NEJAC urges that the EPA Administrator, as Chair of the Inter Agency Workgroup on Environmental Justice, urge the Chair of NRC to ensure that to the maximum extent allowable by law, that the Atomic Safety and Licensing Board grant ENDAUM's and seven other groups of individuals petitions who challenge the permit, applications, motions or requests to intervene in the related licensing or permitting action, and to schedule and hold an evidentiary hearing on this critical issue in order to ensure that the "Environmental Justice" community has a meaningful and realistic opportunity to participate fully in the decision making processes.

NEW MEXICO ETHNICITY: Selected Demographics and Health Statistics*

Category	African Americans	American Indians	Hispanics	Whites	Other	New Mexico All Races
Socioeconomic Data:						
N.M. Pop. (est'd. 1993)	32,000	142,400	600,000	806,000	19,200	1,615,613
% of N.M. Pop. (1990)	2.0%	8.9%	37.5%	50.4%	1.2%	100.0%
% Pop. <24 yrs. old	47.2%	52.0%	46.6%	31.9%	43.3%	39.7%
Per capita income (1992)						$15,458
% Persons Below Poverty Level (1989)	27.8%	46.0%	27.8%	16.1%	40.7%	20.6%
General Health Status:						
Birth Rates Per 1,000 Live Births (1993)	24.1	27.5	23.2	10.5	25.0	17.2
% Births to Teenage Mothers (1993)	24.5	17.7	22.5	10.1	8.8	17.8
% of Live Births to Single Mothers (1993)	52.6%	68.6%	45.2%	22.4%	ND	41.4%
% of Live Births with Low Birth Wgt. (1993)	12.0%	6.5%	7.4%	7.2%	ND	7.3%
% Live Births w/ Congenital Anomalies						
('89-'93 aggregate)	1.50%	1.55%	1.17%	1.29%	1.26%	1.27%
('84-'88 aggregate)	1.21%	1.72%	1.12%	1.03%	0.99%	1.17%
% Live Births to Parents Reporting Low Level of Prenatal Care (1993)	13.1%	20.7%	13.9%	6.6%	8.1%	12.6%
Mortality:						
Life expectancy ('89-'91)						
Male (years)	70.5	68.7	72.1	73.7	ND	72.5
Female (years)	77.7	78.3	79.9	80.0	ND	79.7
Top 10 Leading Causes of Death ('91-'93 aggre.)						
%Diseases of the heart	25.8%	15.2%	23.1%	29.1%	ND	26.3%
% Malignant neoplasms	18.4%	11.9%	19.2%	24.1%	ND	21.7%
% Accidents	7.2%	18.9%	10.1%	4.7%	ND	7.3%
% Cerebrovascular dis.	4.2%	3.4%	5.1%	6.0%	ND	5.5%
%COPD	3.5%	1.2%	3.6%	6.7%	ND	5.4%
% Diabetes mellitus	2.8%	6.0%	5.0%	2.2%	ND	3.3%
% Influenza, pneumonia	2.8%	3.8%	3.5%	3.1%	ND	3.2%
% Suicide	2.2%	3.6%	2.7%	2.4%	ND	2.6%
% Chronic liver disease, cirrhosis	2.0%	4.0%	3.2%	1.2%	ND	2.0%
% Homicide	6.0%	3.0%	2.6%	0.7%	ND	1.5%
Infant mortality rate: '86-'93 mean annual (SD), per 1,000 births	15.0(3.1)	10.1(1.7)	7.9(0.8)	8.5(1.2)	5.2(2.2)	8.6(0.8)

*Data from 1993 New Mexico Selected Health Statistics Annual Report, N.M. Department of Health, Public Health Division, Bureau of Vital Records and Health Statistics, May 1995.

Boxed statistics indicate leading or largest number.

AMERICAN INDIANS IN NEW MEXICO
Selected Socioeconomic Data
(From: IHS, *Regional Differences in Indian Health 1994*)

CATEGORY	ALBQ. AREA	NAVAJO AREA	ALL IHS AREAS (AVERAGE)	ALL U.S. RACES
% high school grads, ≥25 yrs.	61.1%	54.8%	65.3%	75. 2%
% bachelor's degree, ≥25 yrs.	7.0%	5.2%	9.0%	20. 3%
% unemployment, males, ≥ 16 yrs.	20.0%	23.5%	16.2%	6. 5%
% unemployment, females, ≥ 16 yrs.	15.8%	18.6%	13.5%	6. 2%
median household income, 1989 (New Mexico, 1995)	$15,791	$13,984	$19,886	$30,056 $26,594
% of population below poverty level	42.1%	46.8%	31.6%	13. 1%

Comparison of Age-Adjusted Mortality Rates for Albuquerque and Navajo IHS Areas with Age-Adjusted Rates for All IHS Areas and All U.S. Races

(From: IHS, *Regional Differences in Indian Health 1994*)

CATEGORY	ALBQ. AREA	NAVAJO AREA	ALL IHS AREAS* (AVERAGE)	ALL U.S. RACES
Age-adjusted mortality rates, all causes, per 100,000 pop. ('89-'91)	540.5	620.8	585.2/713.9	520.2
Age-adjusted accident mortality rates, per 100,000 pop. ('89-'91)	84.2	**149.6**	86.0/116.9	37.0
Age-adjusted diabetes mortality rates, per 100,000 pop. ('89-'91)	37.3	25.7	29.7/38.8	11.7
Age-adjusted cancer mortality rates, per 100,000 pop. ('89-'91)	86.9	79.3	94.5/111.2	135.0

*The first number shown is the statistic for all 12 IHS Areas; the second number is for 9 IHS Areas, excluding three areas (California, Oklahoma and Portland) that are believed to have underreported Indian race on death certificates.

Boldface indicates statistic is greatest among IHS services areas.

DEPARTMENT OF HEALTH & HUMAN SERVICES

U.S. Public Health Service

Indian Health Service
Post Office Box 358
Crownpoint Healthcare Facility
Crownpoint, NM 87313-0358

Crownpoint Healthcare Facility
Safety Committee
Position Statement Regarding the In-Situ-Leach Uranium Mine Proposed by Hydro-Resources, Inc.

May 23, 1997

Background

The Crownpoint Healthcare Facility (CHF) is an Indian Health Service facility, servicing a population of approximately 20,000 people, located in Crownpoint, New Mexico on the Navajo Indian Reservation. The CHF Safety Committee is composed of representatives from each department in the hospital, as well as a representative from the IHS Office of Environmental Health. The Committee is chaired by the Administrative Officer, Ron Begay. Medical staff, nursing, pharmacy, dental, as well as each ancillary department are represented on this committee. The purpose of the Safety Committee is to address all safety issues for the facility, the patients, and the staff. Concern regarding the Hydro-Resources, Inc. (HRI) proposal to mine uranium in Crownpoint by the in-situ-leach (ISL) technique led to the following position statement.

Hydro-Resources, Inc (HRI) has applied for licensure through the Nuclear Regulatory Commission (NRC) to construct and operate an ISL uranium mine in Crownpoint. ISL uranium mining involves the injection of sodium bicarbonate and dissolved oxygen into the West Water Aquifer directly under Crownpoint. Uranium in the surrounding rock would oxidize and dissolve. The uranium-containing solution would be pumped out. The uranium would be removed in an above-ground processing plant. Uranium slurry would be dried to form yellow cake, which would then be transported to an out-of-state processing facility. HRI proposes to restore most of the extracted water to a potable state and return it to the aquifer. Other chemical waste products would require transport to licensed disposal facilities.

The NRC has reviewed this application, and released a Final Environmental Impact Statement (FEIS). The FEIS makes a recommendation to license this project. For several reasons, this committee remains in disagreement with that recommendation.

Discussion

First of all, the FEIS has been published and presented as a sufficient document to support the recommendation for licensure, yet environmental and health risks are not fully defined in the FEIS. A safety evaluation report, SER, is necessary for a recommendation to license a project. This SER has not yet been completed, and is not projected to be complete until August 1997. Recommendation for licensure is, therefore, premature as the necessary data to support this recommendation is incomplete to date. The SER should be considered by the NRC to be of prime importance in its recommendation for licensure, as it provides an analysis of the measure of potential hazards to human health and well-being in our community.

Even with the publication of the SER pending, there is still no guarantee that it will address the issues of concern with respect to the safety of our community. The initial Draft Environmental Impact Statement (DEIS), and the subsequent FEIS are severely lacking as documents in their attempt to support the NRC's recommendation for licensure. The DEIS was found to be such an inadequate document that a complete revision and marked expansion were required. The DEIS was presented to the community for public comment without easy access to the document, and without adequate interpretation for a community with a high percentage of non-English-literate people.

Public comment time periods were extended upon pleas from the community, but they were still short. Now the FEIS is presented without an opportunity for public comment.

In spite of the extensive revisions and expansion from its original form, the FEIS remains an inadequate document. Health statistics in the FEIS are incomplete, and grossly inadequate to use to accurately model the potential health risks associated with the proposed project. Note that specific data regarding rates of cancer, congenital defects, chronic lung disease, gastrointestinal disorders, and motor vehicle mortality and morbidity are not documented in the FEIS for Crownpoint. Releases of radon, yellow cake dust, uranium-containing lixiviant, processing chemicals, and waste products are all going to occur. Such substances will have the potential to affect specific cancer types and their rate of occurrence as well as rates of chronic lung disease, congenital defects, and gastrointestinal diseases. Increased truck traffic on local highways will present a potential increase in baseline rates of motor vehicle morbidity and mortality. Baseline data on motor vehicle morbidity and mortality specific to the Crownpoint area are absent from the FEIS. In order to model or estimate the future effect of these changes on the community, disease-specific data need to be collected and analyzed as a baseline. Such data exist and are readily available. Data for Crownpoint are available from the New Mexico Tumor Registry, which tracks all neoplasias state-wide, and in Window Rock, Arizona, at the Navajo Area IHS Headquarters, detailed Service-Unit specific and disease specific data are available. There is no excuse for the vague, incomplete information presented in the FEIS. The lack of baseline data analysis makes it impossible to predict or track the future effects of the project. The NRC has, therefore, failed to adequately provide data analysis necessary to declare that this is a safe project, or to measure the future impact of the project on the health of the community.

The FEIS is also lacking in revealing the proximity of the majority of our population to the ISL site, and the processing plant. Note that none of the maps in the FEIS include the specific location of the hospital, hospital housing, the high school, or housing areas east of State Highway 371. The majority of Crownpoint residents, and daytime students and employees who commute to Crownpoint, live or work within 2 miles of the processing plant. This fact is not stated or diagramed clearly in the FEIS.

The FEIS is inaccurate and misleading in the description of the emergency readiness of this community. The Crownpoint Volunteer Fire Department (VFD) has only twelve active volunteers at any one time. They do not "cover McKinley County", as noted in the FEIS on page 5.6. They have only one paid employee. For any one call, six or fewer fighters response. Yet they are required to cover an area of approximately 3400 square miles. In 1996, they answered 326 calls. At a recent major fire, there was significant delay in successful containment of the fire when several pumps were not working correctly. Assistance from the closest VFD came from Thoreau, 25 miles away.

The Crownpoint Police Department usually has no more than two officers on duty at any one time, covering an area similar in size to that of the VFD. Only one police officer is an Emergency Medical Technician (EMT). There are ten EMTs assigned to the Crownpoint Service Unit of the IHS. There are only two or three EMTs on duty at any one time. They have basic EMT skills only. There are no paramedics. Crownpoint Healthcare Facility is a small rural hospital with only 20 functional beds, not 36, as stated in the FEIS. There are only seven emergency room beds with only two doctors and one nurse available at night or weekends.

Of the above service organizations, only one firefighter has completed the 80-hour Hazardous Materials, "Haz-Mat" training which is required for certification as a "Haz-Mat' responder. A few firefighters have completed introductory courses. None of the EMTs or police officers have completed such training. Two hospital employees have completed introductory courses. The cost of a complete course is several thousand dollars per attendee. None of the service providers own "Haz-Mat" gear. One set of protective clothing and mask costs approximately $3,000. Also, the hospital currently lacks a decontamination room. Building one would require an addition to the hospital. HRI met with the hospital Administrative Officer, Ron Begay, but the HRI representative was quite vague about any details regarding how they would assist to alleviate the significant financial and human resource burden the proposed uranium mine would place on this community with regard to safety.

The services for air access are also lacking in Crownpoint. There is an airstrip, however it is not accessible in bad weather. Electric power for Crownpoint is provided by the Continental Divide Electric Cooperative in Grants, NM. Power outages are frequent due to our location at the end of the power line. The hospital frequently relies on backup generators a few times per month. The FEIS does not mention backup generators, nor any details regarding the actual lack of infrastructure in this small rural community.

Finally, a major concern of this committee is regarding our water supply. The FEIS fails to address the proposal by HRI to completely move the entire Crownpoint water system to an unidentified alternative source, and plug or decommission all existing wells in Crownpoint. This is of great concern for our hospital, as it is necessarily a huge consumer of local water. It is also of concern to all of us as residents of this community, and as health care providers.

Currently, a large portion of our patients and community members do not have running water. They haul water from wells in Crownpoint to surrounding areas. The number of people dependent on the Crownpoint water system far exceeds the estimated population of Crownpoint, approximately 3,000. Households without running water do appear to have higher rates of infectious disease. Infectious diseases also present in a much more aggressive fashion due to a dearth of clean water in a household for adequate sanitation, hand washing, or wound care. Dehydration and gastrointestinal illnesses are common in all ages, and unhealthy alternatives to water (eg. soda pop) are often chosen over the less palatable "hauled water". Contaminated water containers used to haul water also increase the transmission of infectious disease.

HRI proposes to render all of the existing wells in Crownpoint unusable for 20 years. The alternative water source and its system of transport remain undefined in the FEIS. How many more families would be forced to haul water? There is no description in the FEIS of location or size of the proposed alternative water source. There is no description of how the water will be transported to Crownpoint. Without knowing either source or mode of transport, it is impossible to determine whether the quality or the quantity of the water will be adequate. The FEIS contains no projections of future population size in Crownpoint. Water needs will inevitably rise over the 20 year period of the proposed mine's function. There is no description in the FEIS of pump systems to be used. The hospital is dependent on a consistent water pressure to function. It is impossible, without knowing what the alternative water supply is, to estimate the additional cost to this community in financial resources, human resources, and additional disease which seems likely to result from the change to a still undefined alternative water source.

Once the project is complete, we are left with an aquifer depleted of a huge amount of water, precious to the survival of this community. Assuming 99% of the water extracted by the ISL technique is returned to the aquifer in a potable form, the quantity of water used over 20 years that is not replaceable is approximately equivalent to 20 years worth of water at our current usage rate. This may not be in the best interest of this community, located in a desert climate with scarce water resources.

Aside from safety issues, there are many other aspects of this project which concern this committee's members — aesthetic and cultural effects, environmental justice issues, the lack of financial benefit to the community, the fears that a uranium mine creates in a community where radiation exposure has caused disease in the past. The psychological health of a population facing a potentially hazardous industry in close proximity to their community has already taken a toll. Our community members are already afraid of this project. Fear breeds distrust, stress, and illness. This type of impact would be difficult to measure, but it must be considered relevant. Nowhere in the FEIS is this aspect of health accounted for.

Recommendation

Considering all of the above, the Safety Committee for the Crownpoint Healthcare Facility strongly recommends against NRC licensure of HRI's proposed ISL uranium mine in Crownpoint. It is the responsibility of the NRC to ensure that this project will not jeopardize the safety, human or environmental health, or resources of this community. The FEIS fails to provide documentation sufficient to ensure a minimal negative impact on our community. The NRC demonstrates a lack of concern for our community by recommending licensure before an SER is available. It is crucial in evaluating a project of such tremendous potential impact on a community to apply data collection and analysis specific to the location of the project in order to give the community accurate predictions of risk to health and environment. The deficiencies in the infrastructure of our small community are not taken into account in the FEIS, nor is the additional burden of this project on what are currently stressed and insufficient resources. Finally, the FEIS does nothing to address the required use of an alternative water source by our community for 20 years.

In conclusion, the CHF Safety Committee does not support the licensure of HRI's ISL uranium mine in Crownpoint. As a committee responsible for safety and health in our hospital and community, we cannot support a project which poses such potential risk to those whom we are responsible to protect.

Enclosed is a list of signatures from our committee.

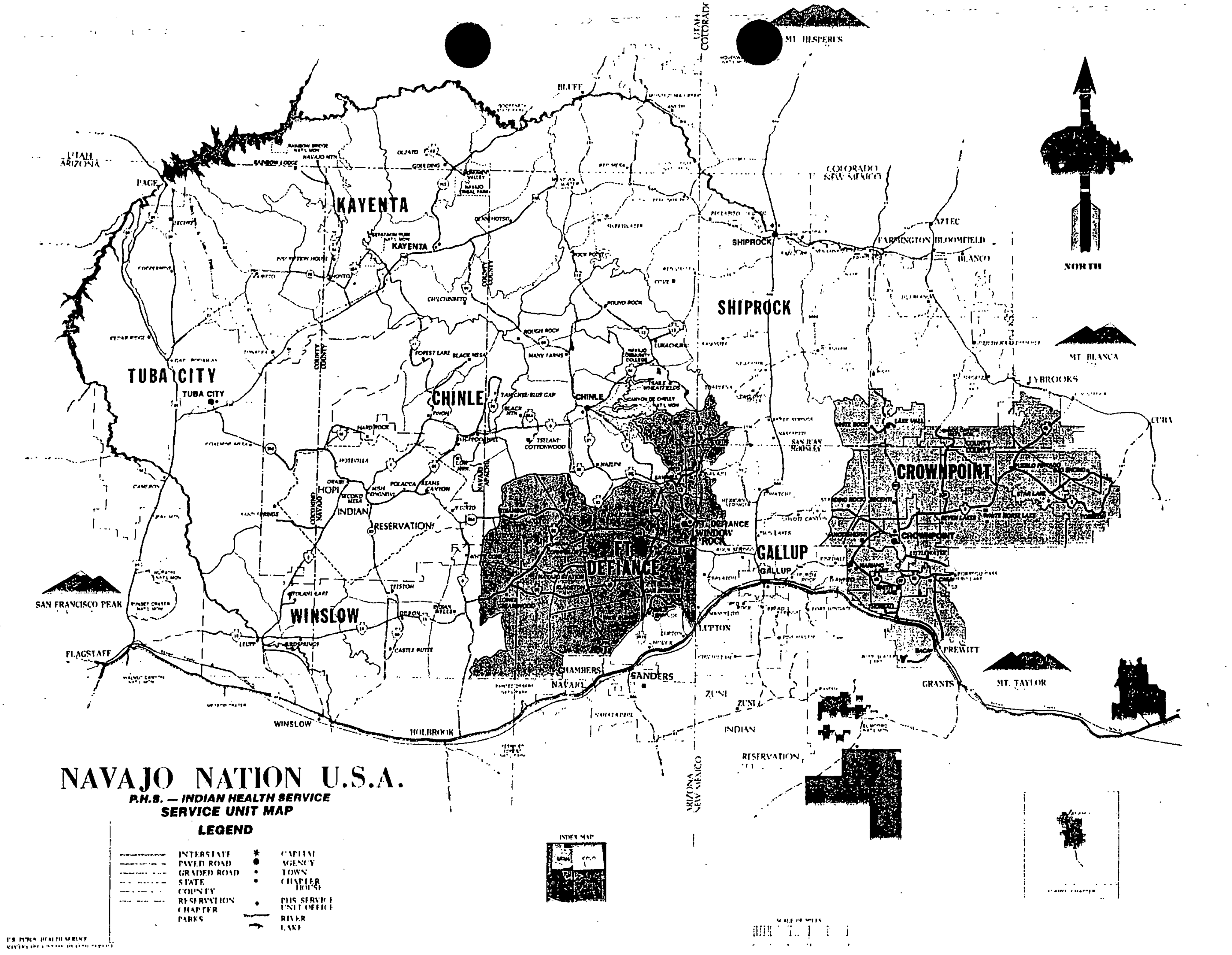
DEPARTMENT OF HEALTH & HUMAN SERVICES

U.S. Public Health Service

Indian Health Service
Post Office Box 358
Crownpoint Healthcare Facility
Crownpoint, NM 87313-0358

We, the undersigned, as member of the Crownpoint Healthcare Facility's Safety Committee agree with the preceding statement regarding the HRI and the proposed uranium mine in Crownpoint, New Mexico:

Anita Muneta	Anita Muneta, Chief Executive Officer
[illegible]	Ron C. Begay, Administrative Officer
E. Ann Hosmer M.D.	E. Ann Hosmer, MD, Medical Staff
Sherrie Mendoza	Sherrie Mendoza, RN, SCN-CSR, AICO
Leslie Kerr	Leslie Kerr, RN, SCN-ER
Gail E. Neises SCN	Gail E. Neises, RN, SCN-OPD
Pamela Gates RN, SCN	Pamela Gates, RN, SCN
Irene Marietta RN	Irene Marietta, RN, MPH
Charlene Valdo	Charlene Valdo, Supervisor, Med Records
[illegible]	Andrew Perry, Foreman, Hsekpg, MVO, Security
Marsh F[illegible]	Marsh Fairey, Bio-Med Engineer
Gwen Duran, Lab. Supvr	Gwen Duran, Laboratory Supervisor
[illegible]	Phil Pedro, Radiology Supervisor
Brian Lawler, P.T.	Brian Lawler, Senior Physical Therapist
[illegible] OD	Steve Glover, OD, Chief Optometry
Michael Cad[illegible]	Mike Cadieux, DDS, Dental
[illegible]	Rob Palladino, LTJG, Registered Pharmacist
H Becenti	Henry Becenti, Acting Facility Manager



NAVAJO NATION U.S.A.
P.H.S. — INDIAN HEALTH SERVICE
SERVICE UNIT MAP
LEGEND
INTERSTATE
PAVED ROAD
GRADED ROAD
STATE
COUNTY
RESERVATION
CHAPTER
PARKS
CAPITAL
AGENCY
TOWN
CHAPTER HOUSE
PHS SERVICE UNIT OFFICE
RIVER
LAKE
INDEX MAP
NORTH
MT. HESPERUS
MT. BLANCA
MT. TAYLOR
SAN FRANCISCO PEAK
UTAH
ARIZONA
UTAH
COLORADO
COLORADO
NEW MEXICO
ARIZONA
NEW MEXICO
KAYENTA
TUBA CITY
CHINLE
SHIPROCK
CROWNPOINT
GALLUP
FT. DEFIANCE
WINSLOW
PAGE
BLUFF
KAYENTA
TUBA CITY
CHINLE
SHIPROCK
FARMINGTON
BLOOMFIELD
AZTEC
BLANCO
LYBROOKS
CUBA
CROWNPOINT
GALLUP
PREWITT
GRANTS
WINDOW ROCK
FT. DEFIANCE
LUPTON
CHAMBERS
NAVAJO
SANDERS
ZUNI
ZUNI INDIAN RESERVATION
HOPI INDIAN RESERVATION
FLAGSTAFF
WINSLOW
HOLBROOK
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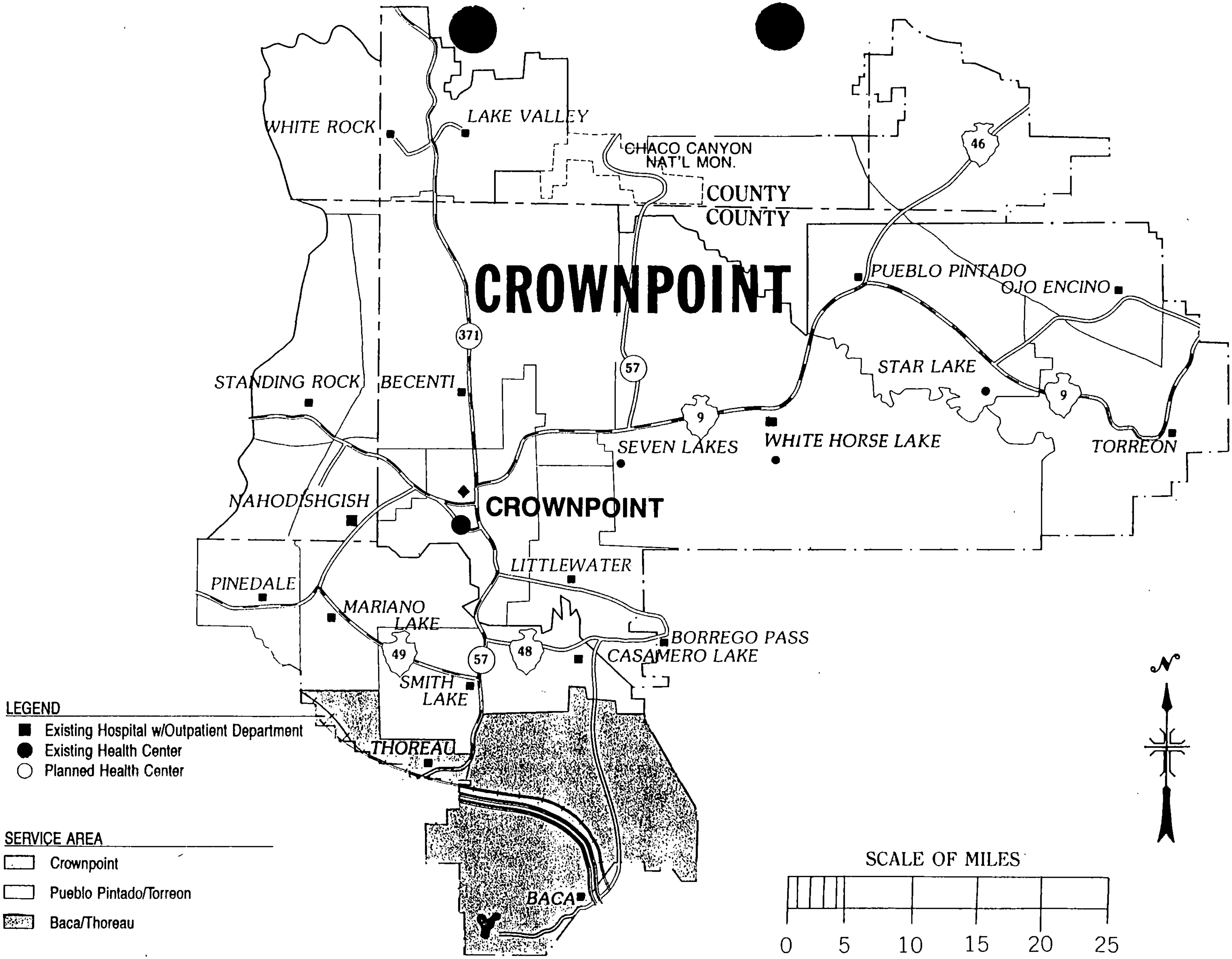
CROWNPOINT
WHITE ROCK
LAKE VALLEY
CHACO CANYON NAT'L MON.
COUNTY
COUNTY
PUEBLO PINTADO
OJO ENCINO
STAR LAKE
STANDING ROCK
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371
57
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SEVEN LAKES
WHITE HORSE LAKE
TORREON
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CROWNPOINT
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PINEDALE
MARIANO LAKE
BORREGO PASS
CASAMERO LAKE
49
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SMITH LAKE
THOREAU
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LEGEND
Existing Hospital w/Outpatient Department
Existing Health Center
Planned Health Center
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Pueblo Pintado/Torreon
Baca/Thoreau
SCALE OF MILES
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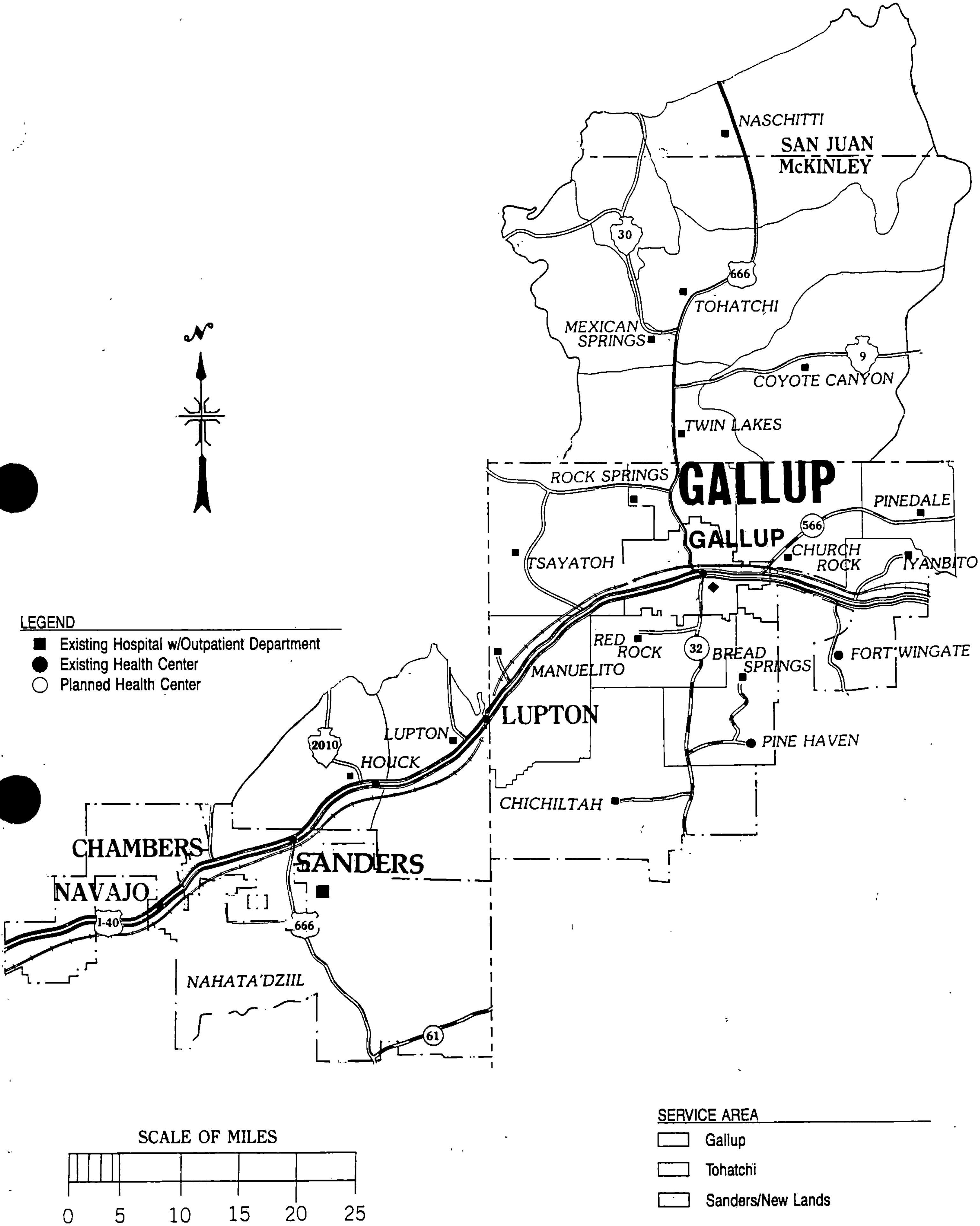
NASCHITTI
SAN JUAN
McKINLEY
30
666
TOHATCHI
MEXICAN SPRINGS
9
COYOTE CANYON
TWIN LAKES
ROCK SPRINGS
GALLUP
PINEDALE
566
GALLUP
CHURCH ROCK
IYANBITO
TSAYATOH
RED ROCK
32
BREAD SPRINGS
FORT WINGATE
MANUELITO
LUPTON
LUPTON
2010
HOUCK
PINE HAVEN
CHICHILTAH
CHAMBERS
SANDERS
NAVAJO
I-40
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NAHATA'DZIIL
61
LEGEND
Existing Hospital w/Outpatient Department
Existing Health Center
Planned Health Center
SCALE OF MILES
0
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15
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25
SERVICE AREA
Gallup
Tohatchi
Sanders/New Lands

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Navajo Area
Indian Health Service
P.O. Box 9020
Window Rock, Arizona 86515-9020

December 17, 1996

Chris Shuey, Director
Community Water, Waste and Toxics Program
Southwest Research and Information Center
P.O. Box 4524
Albuquerque, New Mexico 87106

Dear Chris:

Enclosed please find some of the information you had requested from us through your fax letter of December 5, 1996.
You can obtain additional information on cancer from the New Mexcio Tumor Registry.Also you might want to call or write to the Indian Health Service Office of Occupational Health and Safety Management, Mr. Richard Haskins, Director.
P.O. Box 9020, Window Rock, Arizona 86515 or call (520) 871-5851, 5852 to get more information on any other occupational exposures and/or waterborne contaminants.

Please find the Infant Death Rates by service units from 1972 to CY 1993. FY 1996, Selected Ambulatory Care Visits by clinical impressions for Crownpoint and Area Summary. Census Population for three years and the ten leading reasons for outpatient visits in all our service units. Enclosed also, Diabetes report by Martia Glass, Navajo Area IHS Diabetes Coordinator.

The report on non-malignant respiratory disease including COPD by service unit is "not available" at this time, and will be a time-consuming to obtain.

If I can be of any additional help, please let me know.

Sincerely,

Ruby A. Spencer

Ruby A. Spencer
Program Assistant
Office of Planning and Evaluation

enclosures

NAVAJO AREA INDIAN HEALTH SERVICE
SELECTED AMBULATORY CARE VISIT DIAGNOSES
FISCAL YEAR 1994-1996 (AREA/CROWNPOINT)

DRAFT

	FY 1996		FY 1995		FY 1994	
INFECTIOUS DISEASES)	Area Total	Crown-point	Area Total	Crown-point	Area Total	Crown-point
Bacillary Dysentery	537	15	1,348	33	417	17
Salmonellosis	21	0	30	0	28	2
G-enteritis Diarrhea	14,377	1,445	20,478	1,669	15,155	1,297
Food Poisoning	36	1	62	1	44	2
Infectious Hepatitis	236	15	1,260	37	2,151	140
Diabetes Mellitus	49,680	3,447	50,044	3,721	46,150	2,965
Congenital Anomalies	4,364	177	4,067	159	3,571	200

Source: Ambulatory Patient Care Report 1C Annuals.

Census Population	Area 96	Crown-point 96	Area 95	Crown-point 95	Area 94	Crown-point 94
	209,147	16,031	204,458	15,643	199,764	15,258

Regional *Differences* *in* Indian Health

Department of Health and Human Services
Donna E. Shalala, Secretary

Indian Health Service
Michael H. Trujillo, M.D., M.P.H., M.S., Director

Office of Public Health
Robert H. Harry, D.D.S., Acting Director

Division of Community and Environmental Health
Mary Beth Skupien, Ph.D., M.S., Director

Program Statistics Team
Anthony J. D'Angelo, Team Leader

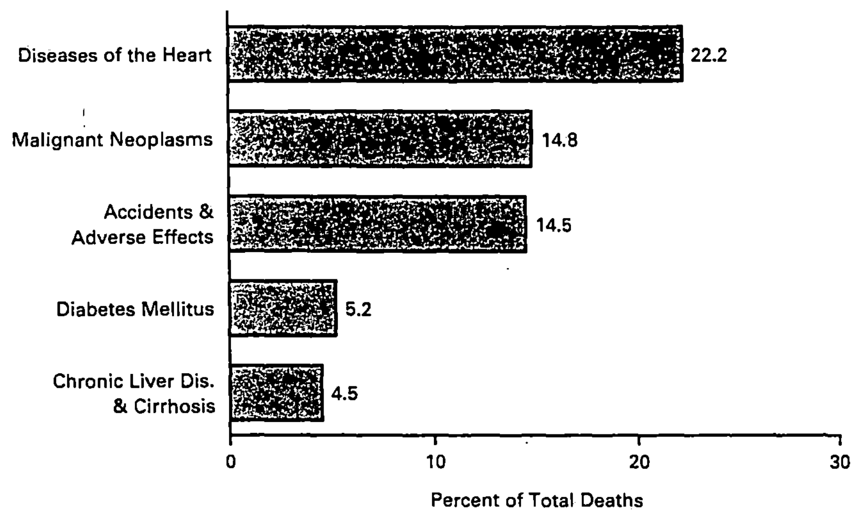
1997

In 1992-1994, 22.2 percent of all deaths in the IHS service area were caused by diseases of the heart. This was followed by malignant neoplasms at 14.8 percent.

Chart 4.3

Leading Causes of Death

All IHS Areas, Calendar Years 1992-1994

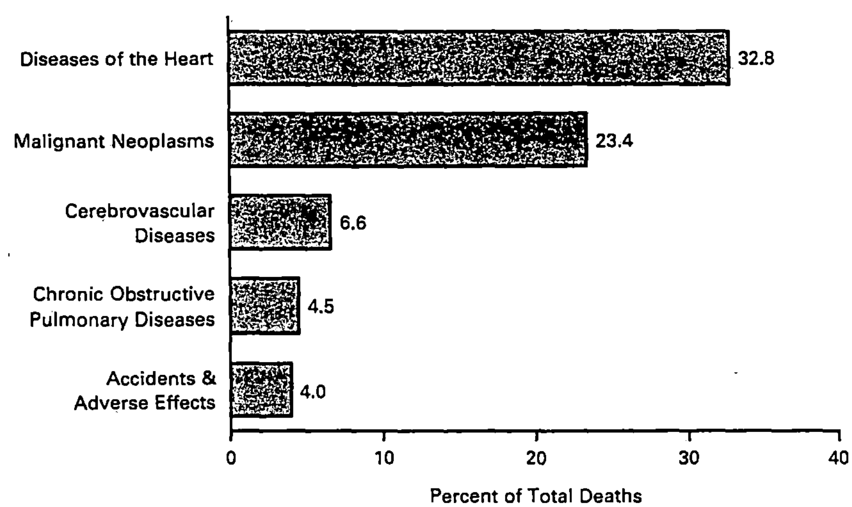


In 1993, 32.8 percent of all deaths in the U.S. were caused by diseases of the heart. This was followed by malignant neoplasms at 23.4 percent.

Chart 4.4

Leading Causes of Death

U.S. All Races, Calendar Years 1993

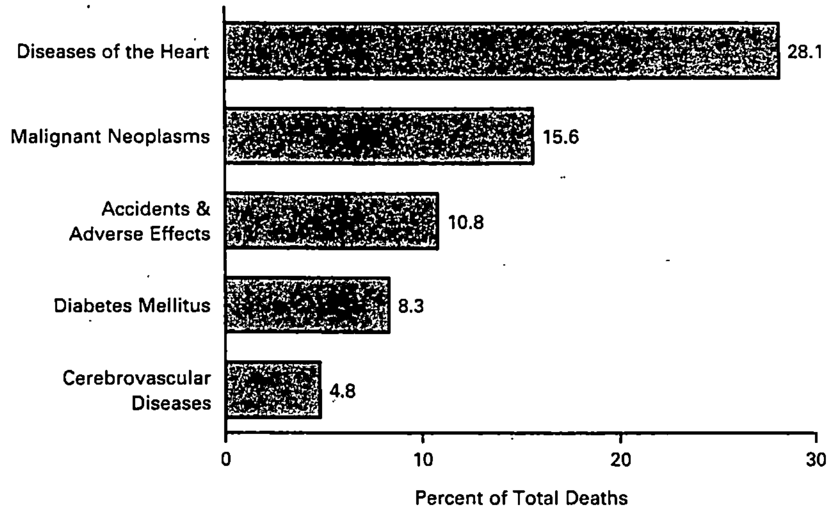


In 1992-1994, 28.1 percent of all deaths in the Nashville Area were caused by diseases of the heart. This was followed by malignant neoplasms at 15.6 percent.

Chart 4.11

Leading Causes of Death

Nashville Area, Calendar Years 1992-1994

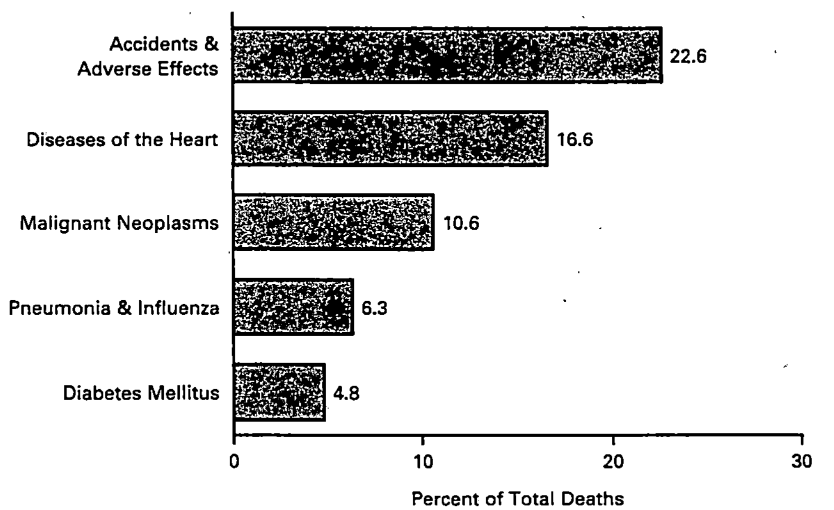


In 1992-1994, 22.6 percent of all deaths in the Navajo Area were caused by accidents and adverse effects. This was followed by diseases of the heart at 16.6 percent.

Chart 4.12

Leading Causes of Death

Navajo Area, Calendar Years 1992-1994

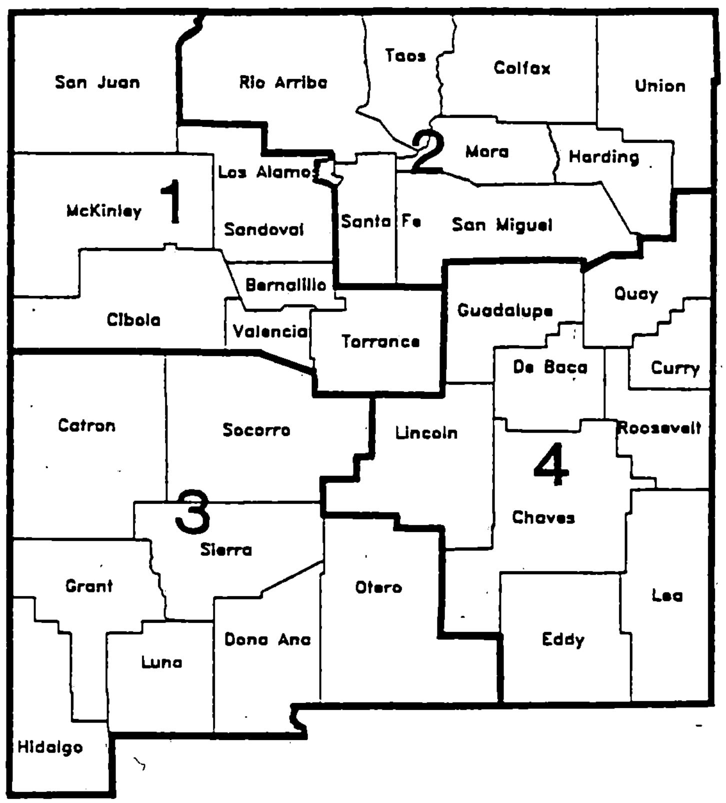


1996 NEW MEXICO SELECTED HEALTH STATISTICS

This report of New Mexico Health Statistics gives an overview of selected vital and health statistics for calendar year 1996. To portray the patterns of temporal change, data from earlier years have also been included. The primary sources of these data are the reportable certificates of birth and death, and the federal and state reporting systems.

Unless otherwise indicated, the tabulations of vital events are by place of residence. Thus, births and deaths of New Mexico residents that occurred in other states are included in the tabulations, while the vital events that occurred in New Mexico to non-residents are not included. Tabulations are based on 1996 birth and death certificates received in the vital records office through May 18, 1997. Extending the cut-off date so late into the following year allows for the inclusion of more than 99% of the vital events occurring in 1996 into the tabulations.

The following map depicts the alignment of New Mexico counties into four health service districts. The majority of county data presented in this report are grouped according to these districts.



Comments on the content and format of this report, or requests for additional data or analysis should be directed to:

New Mexico Vital Records and Health Statistics
Office of Information Management
Public Health Division
Department of Health
1105 St. Francis Dr.
P.O. Box 26110
Santa Fe, New Mexico 87502-6110

State of New Mexico DEPARTMENT OF HEALTH

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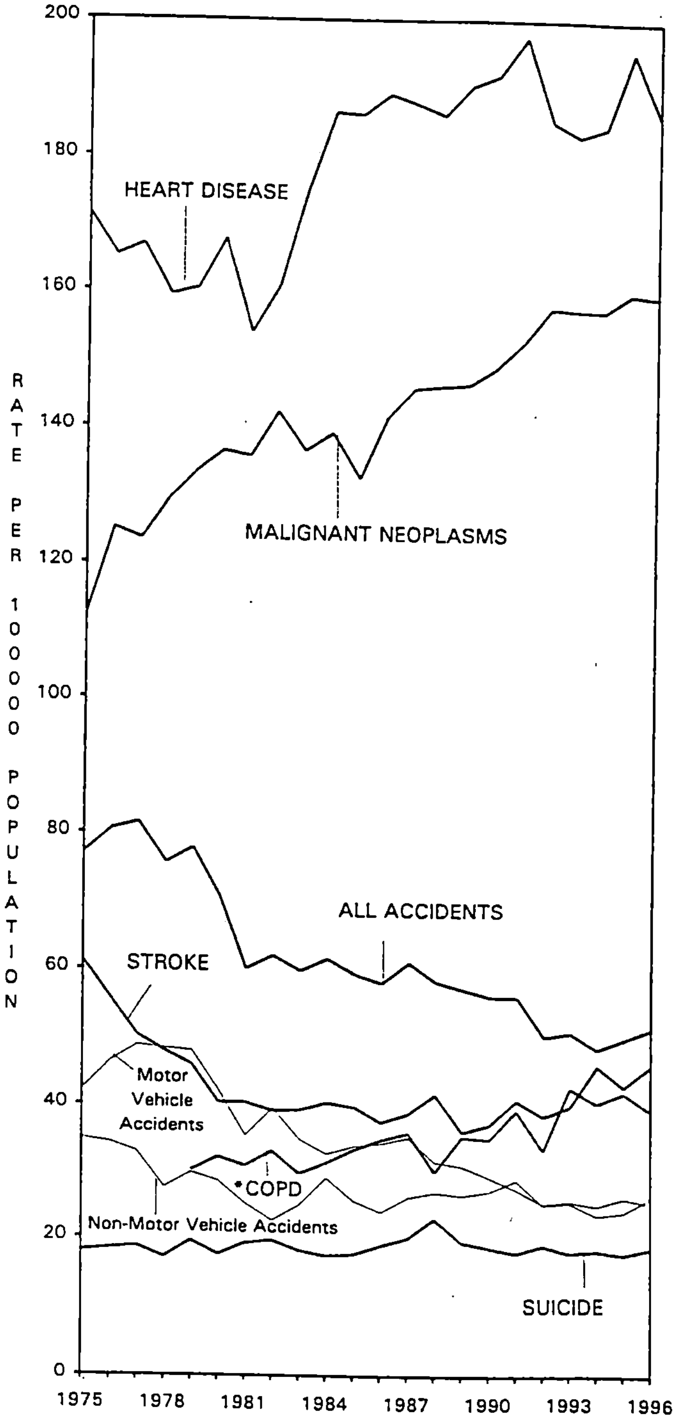
TABLE 3.7
NEW MEXICO RESIDENTS
CRUDE & AGE-ADJUSTED DEATH RATES BY NEW MEXICO ETHNIC / RACE
New Mexico Residents 1994-1996 Average
United States 1995

RATES PER 100,000 POPULATION	CRUDE DEATH RATE	N.M. ADJUSTED RATES TOTAL	MALE	FEMALE
UNITED STATES:				
All Causes	880.0	XXX	914.1	847.3
Heart Disease	280.7	XXX	282.7	278.8
Malignant Neoplasms	204.9	XXX	219.5	191.0
Cerebrovascular	60.1	XXX	48.0	71.7
COPD	39.2	XXX	42.0	36.4
Accidents	35.5	XXX	47.9	23.7
(% Motor Vehicle)	(46.5)	XXX	(47.5)	(44.5)
Influenza & Pneumonia	31.6	XXX	29.4	33.6
Diabetes Mellitus	22.6	XXX	20.4	24.6
HIV Infection (AIDS)	15.4	XXX	28.0	5.3
Suicide	11.9	XXX	19.8	4.4
Cirrhosis of Liver	9.6	XXX	12.9	6.5
Nephritis, Nephrotic Syndrome and Nephrosis	9.0	XXX	8.9	9.1
NEW MEXICO-ALL RACES:				
All Causes	733.8	831.8	867.7	797.6
Heart Disease	188.9	220.9	222.2	219.6
Malignant Neoplasms	159.0	176.3	187.2	166.0
Accidents	49.9	51.9	74.3	30.4
(% Motor Vehicle)		(50.8)	(49.0)	(55.1)
Cerebrovascular	45.0	53.9	41.5	65.8
COPD	40.5	46.1	47.0	45.3
Diabetes Mellitus	25.9	29.2	24.8	33.4
Influenza & Pneumonia	25.0	30.4	28.0	32.6
Suicide	18.2	18.7	31.0	6.9
Cirrhosis of Liver	14.8	15.6	21.5	10.0
Homicide	10.7	10.8	17.2	4.8
HIV Infection (AIDS)	7.8	8.1	15.6	1.0
NON-HISPANIC WHITE:				
All Causes	907.7	808.7	830.6	787.7
Heart Disease	260.2	230.3	230.3	230.3
Malignant Neoplasms	213.9	182.4	195.2	170.2
COPD	63.8	54.5	55.2	53.8
Cerebrovascular	58.3	52.7	39.6	65.1
Accidents	41.0	39.8	55.2	25.2
(% Motor Vehicle)		(46.1)	(46.6)	(44.9)
Influenza & Pneumonia	30.5	28.1	25.4	30.8
Suicide	21.4	19.9	31.6	8.7
Diabetes Mellitus	21.2	18.4	17.0	19.7
Atherosclerosis	10.7	9.9	7.7	11.9
Alzheimers Disease	9.6	8.7	6.1	11.3
Cirrhosis of Liver	9.5	8.2	10.7	5.7
HISPANIC WHITE:				
All Causes	574.0	850.3	907.6	795.6
Heart Disease	127.1	208.4	211.7	205.3
Malignant Neoplasms	111.7	169.5	179.4	160.2
Accidents	55.0	62.8	92.8	34.2
(% Motor Vehicle)		(48.8)	(45.5)	(58.2)
Cerebrovascular	34.3	57.4	45.0	69.2
Diabetes Mellitus	28.4	44.9	35.8	53.6
Cirrhosis of Liver	20.0	26.9	39.5	14.8
COPD	19.1	31.3	33.5	29.2
Influenza & Pneumonia	19.1	32.0	30.8	33.2
Homicide	15.3	15.1	25.0	5.7
Suicide	15.2	16.1	28.3	4.4
HIV infection (AIDS)	8.1	9.1	17.8	0.7
BLACK:				
All Causes	576.8	862.8	885.4	841.2
Heart Disease	156.2	252.1	255.1	249.1
Malignant Neoplasms	121.4	195.4	210.6	181.0
Homicide	38.6	34.6	57.1	13.2
Cerebrovascular	34.8	63.2	54.4	71.5
Accidents	30.1	29.6	45.7	14.0
(% Motor Vehicle)		(46.9)	(36.0)	(85.7)
COPD	19.8	32.0	31.3	32.8
Diabetes Mellitus	16.0	27.3	17.9	36.2
HIV Infection (AIDS)	14.1	14.0	24.6	4.0
Suicide	12.2	12.8	20.9	5.1
Influenza & Pneumonia	10.3	20.2	10.9	29.0
Atherosclerosis	7.5	14.3	5.6	22.7
INDIAN:				
All Causes	522.4	891.9	953.5	833.1
Accidents	86.4	99.8	146.5	55.2
(% Motor Vehicle)		(68.3)	(65.5)	(75.2)
Heart Disease	72.8	147.8	175.5	121.4
Malignant Neoplasms	71.9	138.3	136.7	139.8
Diabetes Mellitus	45.4	92.5	69.4	114.5
Cirrhosis of Liver	26.8	40.1	47.1	33.4
Influenza & Pneumonia	24.4	49.7	45.8	53.4
Cerebrovascular	21.4	43.8	43.0	44.5
Suicide	14.3	15.5	28.1	3.6
Alcoholism	14.0	19.6	27.7	11.8
Homicide	14.0	14.7	25.2	4.7
Congenital Anomalies	8.2	5.7	5.8	5.7

FIGURE 3.5
NEW MEXICO RESIDENT DEATHS
CRUDE DEATH RATES PER 100,000 POPULATION
SELECTED CAUSES 1975-1996



*C.O.P.D. - CHRONIC OBSTRUCTIVE PULMONARY DISEASE;reporting in this catagory began in 1979

TABLE 3.20
NEW MEXICO STANDARDIZED MORTALITY RATIOS BY RACE/ETHNIC BASED ON THREE YEAR RESIDENT MORTALITY 1994-1996 AGE AND SEX ADJUSTED

RACE/ETHNIC	ALL CAUSES	HEART DISEASE	MALIGNANT NEOPLASMS	ALL ACCIDENTS	MOTOR VEHICLE	ALL OTHER	STROKE	COPD	INFLUENZA & PNEUMONIA	SUICIDE	DIABETES MELLITUS	CIRRHOSIS OF LIVER	HOMICIDE	CERT. COND. IN PERINATAL PER.	CONGENITAL ANOMALIES	ATHERO-SCLEROSIS	ALCOHOLISM	HIV INFECTION
ALL PERSONS																		
OBSERVED DEATHS	37101	9551	8039	2524	1281	1243	2275	2046	1265	918	1309	748	541	241	253	366	246	393
EXPECTED DEATHS	39328	12214	9396	1712	821	891	2559	1755	1334	584	1013	455	440	285	239	261	100	800
SMR	94	78	86	147	156	140	89	117	95	157	129	164	123	85	106	140	246	49
% OF TOTAL DEATHS	100.0	25.7	21.7	6.8	3.5	3.4	6.1	5.5	3.4	2.5	3.5	2.0	1.5	0.6	0.7	1.0	0.7	1.1
NON-HISPANIC-WHITE																		
OBSERVED DEATHS	23069	6611	5436	1042	480	562	1481	1621	776	544	539	241	144	73	99	271	84	212
EXPECTED DEATHS	25289	8119	6138	941	427	514	1712	1169	883	322	667	285	216	88	96	176	61	438
SMR	91	81	89	111	112	109	87	139	88	169	81	85	67	83	103	154	138	48
% OF TOTAL DEATHS	100.0	28.7	23.6	4.5	2.1	2.4	6.4	7.0	3.4	2.4	2.3	1.0	0.6	0.3	0.4	1.2	0.4	0.9
HISPANIC-WHITE																		
OBSERVED DEATHS	10870	2407	2116	1042	508	534	649	361	361	288	538	379	289	137	109	75	95	153
EXPECTED DEATHS	11089	3262	2593	589	299	290	675	468	357	201	275	134	169	146	107	67	31	277
SMR	98	74	82	177	170	184	96	77	101	143	196	283	171	94	102	112	306	55
% OF TOTAL DEATHS	100.0	22.1	19.5	9.6	4.7	4.9	6.0	3.3	3.3	2.6	4.9	3.5	2.7	1.3	1.0	0.7	0.9	1.4
BLACK																		
OBSERVED DEATHS	613	166	129	32	15	17	37	21	11	13	17	3	41	7	6	8	1	15
EXPECTED DEATHS	593	173	135	34	17	17	36	24	19	12	14	7	10	8	6	4	2	17
SMR	103	96	96	94	88	100	103	88	58	108	121	43	410	88	100	200	50	88
% OF TOTAL DEATHS	100.0	27.1	21.0	5.2	2.4	2.8	6.0	3.4	1.8	2.1	2.8	0.5	6.7	1.1	1.0	1.3	0.2	2.4
INDIAN																		
OBSERVED DEATHS	2419	337	333	400	273	127	99	36	113	66	210	124	65	21	38	11	65	11
EXPECTED DEATHS	2178	617	487	134	70	64	129	87	70	44	52	26	40	39	27	13	6	60
SMR	111	55	68	299	390	198	77	41	161	150	404	477	163	54	141	85	1083	18
% OF TOTAL DEATHS	100.0	13.9	13.8	16.5	11.3	5.3	4.1	1.5	4.7	2.7	8.7	5.1	2.7	0.9	1.6	0.5	2.7	0.5

SMR not calculated for expected deaths equal to zero.

MCKINLEY COUNTY

MCKINLEY COUNTY POPULATION	1980 Census	1990 Census	1996 Estimate	Projected 2000
Total Population	56,449	60,686	67,754	72,172
% 19 and Younger	46.1%	42.1%	43.2%	43.3%
% 65 and Older	4.9%	6.4%	6.7%	7.0%
% White Non-Hispanic	20.3%	15.8%	XXXX	XXXX
% White Hispanic	12.5%	11.3%	XXXX	XXXX
% Black	0.6%	0.5%	XXXX	XXXX
% Indian	65.7%	71.8%	XXXX	XXXX
% Families Below Poverty	33.3%	38.0%	XXXX	XXXX
County % of State Population	4.3%	4.0%	4.0%	4.0%

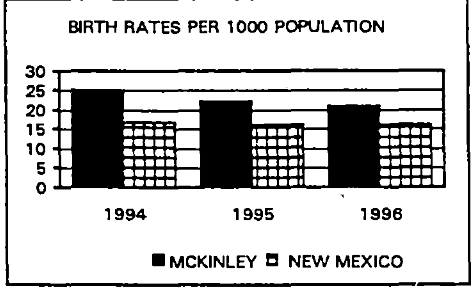
McKinley County ranks as the state's 6th most populous county and has a population density of 12.4 persons per square mile, accounting for 4.0% of the state's population.

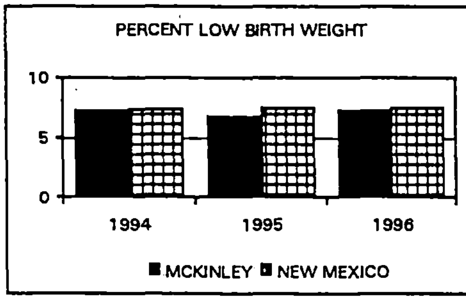
The county population is projected to reach 72,172 persons by the year 2000, with a relatively small percentage of the population being age 65 and older and a high percentage 19 and younger.

The county's birth rate of 21.0 births per 1,000 population is 32% higher than the state rate and accounts for 5% of New Mexico resident births.

The percentage of births to single mothers increased 4%, remaining 64% above the state level. The percentage of births to teens decreased slightly to a rate 0.5% higher than the state level. Low birth weight births increased 7% from the previous year remaining below the state levels.

MCKINLEY	YEAR 1994	1995	1996
LIVE BIRTHS	1644	1495	1421
WHITE			
NON-HISPANIC	117	92	98
HISPANIC	113	139	141
BLACK	13	8	13
INDIAN	1389	1240	1156
OTHER	12	16	13
COUNTY % OF TOTAL STATE BIRTHS	6.0%	5.6%	5.2%





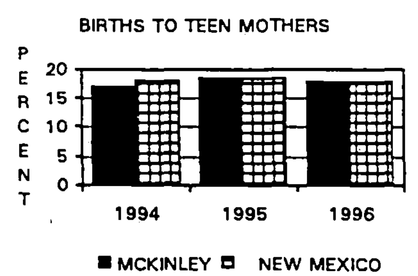
BIRTH DISTRIBUTION

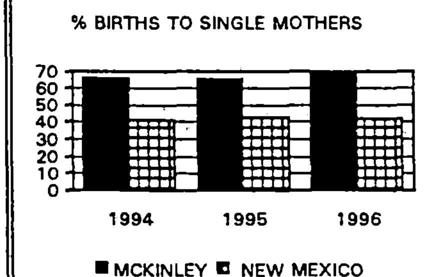
AGE OF MOTHER	MCKINLEY NO.	MCKINLEY %	NEW MEXICO %
ALL AGES	1421	100.0	100.0
<15	3	0.2	0.3
15-17	96	6.8	7.0
18-19	156	11.0	10.6
(15-19)	252	17.7	17.5
20-24	427	30.0	28.8
25-29	324	22.8	25.1
30-34	245	17.2	17.8
35-39	132	9.3	8.5
=>40	38	2.7	1.9

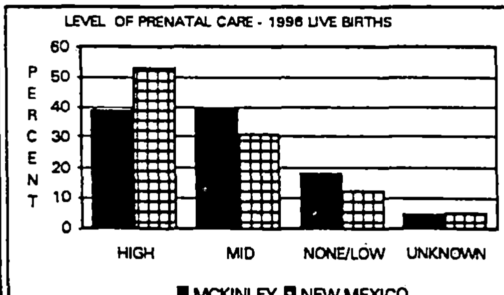
BIRTH RATES BY AGE GROUP

COUNTY	FERTILITY RATE (a)	10-14	15-19 TOTAL	15-17	18-19	20-24	25-29	30-34	35-39	40-49
MCKINLEY:										
1996	94.1	0.9	83.0	51.7	132.3	167.8	153.6	97.3	51.3	9.0
1995	96.9	0.6	89.0	61.4	130.6	168.1	154.1	106.0	53.2	8.2
1994	108.2	1.5	90.8	56.5	142.6	181.1	178.8	121.7	55.5	11.9
NEW MEXICO:										
1996	70.5	1.3	75.1	48.0	119.6	131.6	108.7	71.6	33.8	4.3

(a) Births Per 1,000 Women Ages 15-44







MCKINLEY COUNTY

The county crude death rate decreased to 6.0 deaths per 1,000 population, and accounts for 3.2% of all New Mexico resident deaths. Adjusted rates show higher than state levels of mortality for both males and females.

Heart disease, cancer and accidents are the leading causes of death, accounting for 50% of all deaths. Observed deaths are lower than expected for cancer and heart disease, but nearly three times higher than expected for accidents. Observed deaths are also higher than expected for diabetes, suicide, influenza/pneumonia, cirrhosis, homicide and alcoholism among others.

Postneonatal mortality is lower than statewide.

Nearly 88% of resident births occur within the county. Overall, the county experiences 3.5 births for every death.

MCKINLEY COUNTY DEATHS

			TOTAL	
YEAR	MALE	FEMALE	NUMBER	RATE
1996	229	175	404	6.0
1995	239	183	422	6.3
1994	222	162	384	5.9
1993	230	173	403	6.2
COUNTY % OF TOTAL (1996) STATE DEATHS	3.4%	3.0%	3.2%	

Crude Death Rate Per 1000 Population

AGE ADJUSTED DEATH RATES

1994-96 AVERAGE

MCKINLEY CO.	
MALE	1058.9
FEMALE	906.8
NEW MEXICO	
MALE	867.7
FEMALE	797.6

RATES PER 100,000 POPULATION

MCKINLEY COUNTY

PLACE OF RESIDENCE/1996	BIRTHS	DEATHS	BIRTHS PER 1 DEATH
Crownpoint-All	64	30	2.1
Gallup-Urban	423	128	3.3
Gallup-Rural	47	17	2.8
Rehoboth-All	11	3	3.7
Zuni-All	123	55	2.2
Thoreau-All	42	18	2.3
Tohatchi-All	35	11	3.2
Other & Unspecified	676	142	4.8
COUNTY TOTAL	1421	404	3.5
% OF COUNTY RESIDENT BIRTHS:			
Born in County	87.90%	XXXXX	XXXXX
Born in Other NM County	6.62%	XXXXX	XXXXX
Born Out of State	5.49%	XXXXX	XXXXX

MCKINLEY	INFANT DEATHS		NEONATAL		POSTNEONATAL	
COUNTY	NUMBER	RATE	NUMBER	RATE	NUMBER	RATE
1991	14	7.8	9	5.0	5	2.8
1992	25	13.7	10	5.5	15	8.2
1993	24	13.6	12	6.8	12	6.8
1994	21	12.8	10	6.1	11	6.7
1995	13	8.7	5	3.3	8	5.4
1996	7	4.9	6	4.2	1	0.7
NEW MEXICO						
1996	169	6.2	105	3.9	64	2.4

Rate Per 1000 Live Births

MCKINLEY COUNTY — THREE YEAR AGGREGATE 1994 - 1996

				% OF TOTAL DEATHS		YPLL RATE	
CAUSE	DEATHS OBSERVED	DEATHS EXPECTED	SMR	CO.	N.M.	CO.	N.M.
DISEASES OF THE HEART	235	299	79	19 4	25.7	7.7	7.5
MALIGNANT NEOPLASMS	211	237	89	17.4	21.7	11.8	12.1
ALL ACCIDENTS	158	59	268	13.0	6.8	30.8	18.3
- MOTOR VEHICLE ACCIDENTS	98	30	327	8.1	3.5	21.7	11.0
- ALL OTHER ACCIDENTS	60	29	207	5.0	3.4	9.2	7.2
CEREBROVASCULAR DISEASE	52	62	84	4 3	6.1	1.7	1.5
COPD	32	42	76	2.6	5.5	0.4	1.2
INFLUENZA AND PNEUMONIA	48	33	145	4.0	3.4	1.6	0.7
SUICIDE	24	20	120	2.0	2.5	4.8	6.5
DIABETES	89	25	356	7.3	3.5	3.4	1.8
LIVER DISEASE - CIRRHOSIS	43	13	331	3.5	2.0	5.7	2.9
HOMICIDE	21	17	124	1.7	1.5	4.8	4.8
CERTAIN PERINATAL COND	11	16	69	0.9	0.6	0.0	0.1
NEPHRITIS NEPHROTIC SYND	15	10	150	1.2	0.9	0.7	0.3
CONGENITAL ANOMALIES	19	12	158	1.6	0.7	1.1	0.9
ATHEROSCLEROSIS	3	6	50	0.2	1.0	0.0	0.1
ALCOHOLISM	25	3	833	2.1	0.7	3.6	1.2
SEPTICEMIA	14	9	156	1.2	0.7	1.3	0.3
HIV INFECTION - AIDS	5	27	19	0.4	1.1	0.7	2.9
ALL OTHER CAUSES	207	145	143	17.1	15.6	12.6	8.7
TOTAL FOR ALL CAUSES	1,212	1,034	117	100.0	100.0	92.8	71.7

The SMR (Standard Mortality Ratio) is the ratio of the observed deaths to the expected deaths times 100. The number of expected deaths is derived using the national mortality as a standard and are age/sex adjusted. YPLL (Years of Potential Life Lost) rate is per 1,000 population with deaths and population specific to ages 1-64.

% OF TOTAL DEATHS 1994-1996

AGE	MCKINLEY	N.M.
ALL	100.0	100.0
<1	3.4	1.5
1-4	1.3	0.4
5-14	1.2	0.6
15-24	4.3	2.5
25-34	6.8	3.4
35-44	7.5	5.2
45-54	9.2	6.6
55-64	14.0	10.4
65-74	17.4	20.1
75-84	19.1	27.0
85+	15.8	22.2

INFANT = <1 year, NEONATAL = <28 days, POSTNEONATAL = 28 days to <1 year.

TABLE A-9
NEW MEXICO RESIDENT DEATHS
NUMBER AND CRUDE DEATH RATE BY CAUSE
1996
(Rates Per 100,000 Population)

CAUSE OF DEATH	9TH REVISION ICDA	TOTAL		MALE		FEMALE	
		NUMBER	RATE	NUMBER	RATE	NUMBER	RATE
ALL CAUSES		12,458	727.0	6,709	796.4	5,747	659.8
TUBERCULOSIS (ALL FORMS)	010-018	8	0.5	4	0.5	4	0.5
SEPTICEMIA	038	88	5.1	39	4.6	49	5.6
HIV INFECTION (AIDS)	042-044	90	5.3	83	9.9	7	0.8
SYPHILIS AND ITS SEQUELAE	090-097	0	–	0	–	0	–
ALL OTHER INFECTIOUS AND PARASITIC DISEASES	001-008,020-037,039-041,045-088,098-139	51	3.0	26	3.1	25	2.9
MALIGNANT NEOPLASMS	140-208	2,735	159.6	1,429	169.6	1,306	149.9
Buccal Cavity and Pharynx	140-149	38	2.2	19	2.3	19	2.2
Digestive Organs and Peritoneum	150-159	663	38.7	365	43.3	298	34.2
Respiratory System	160-165	614	35.8	351	41.7	263	30.2
Breast	174,175	245	14.3	1	0.1	244	28.0
Genital Organs	179-187	363	21.2	223	26.5	140	16.1
Urinary Organs	188,189	113	6.6	73	8.7	40	4.6
Other and Unspecified Sites	170-173,190-199	395	23.1	229	27.2	166	19.1
Lymphatic and Hematopoietic Tissues	200-208	304	17.7	168	19.9	136	15.6
DIABETES MELLITUS	250	434	25.3	194	23.0	240	27.6
ALCOHOLISM	303	94	5.5	69	8.2	25	2.9
ALZHEIMER DISEASE	331.0	103	6.0	39	4.6	64	7.3
PARKINSON DISEASE	332	78	4.6	49	5.8	29	3.3
MAJOR CARDIOVASCULAR DISEASES	390-448	4,286	250.1	2,193	260.3	2,093	240.3
Diseases of the Heart	390-398,402,404-429	3,191	186.2	1,729	205.3	1,462	167.8
Active Rheumatic Fever	390-392	0	–	0	–	0	–
Chronic Rheumatic Fever	393-398	20	1.2	7	0.8	13	1.5
Hypertension with Heart Disease	402,404,405	110	6.4	56	6.6	54	6.2
Acute Myocardial Infarction	410	681	39.7	396	47.0	285	32.7
Other Ischemic Heart Diseases	411-414	851	49.7	470	55.8	381	43.7
Diseases of Pulmonary Circulation	415-417	74	4.3	32	3.8	42	4.8
Other Diseases of the Heart	420-429	1,455	84.9	768	91.2	687	78.9
Hypertension with or without Renal Disease	401,403	55	3.2	22	2.6	33	3.8
Cerebrovascular Disease	430-438	789	46.0	318	37.8	471	54.1
Atherosclerosis	440	118	6.9	46	5.5	72	8.3
Aortic Aneurysm	441	90	5.3	60	7.1	30	3.4
Other diseases of Arteries, Arterioles & Capillaries	442-448	43	2.5	18	2.1	25	2.9
PNEUMONIA	480-486	430	25.1	212	25.2	218	25.0
INFLUENZA	487	7	0.4	2	0.2	5	0.6
CHRONIC OBSTRUCTIVE PULMONARY DISEASES (COPD) AND ALLIED CONDITIONS	490-496	670	39.1	350	41.5	320	36.7
Bronchitis, Chronic and Unspecified	490-491	19	1.1	8	0.9	11	1.3
Emphysema	492	109	6.4	65	7.7	44	5.1
Asthma	493	34	2.0	11	1.3	23	2.6
Other COPD and Allied Conditions	494-496	508	29.6	266	31.6	242	27.8
PEPTIC ULCER	531-533	31	1.8	18	2.1	13	1.5
APPENDICITIS	540-543	3	0.2	1	0.1	2	0.2
HERNIA AND INTESTINAL OBSTRUCTION	550-553,560	43	2.5	16	1.9	27	3.1
CHRONIC LIVER DISEASE AND CIRRHOSIS	571	258	15.1	169	20.1	89	10.2
NEPHRITIS, NEPHROTIC SYNDROME, AND NEPHROSIS	580-589	114	6.7	58	6.9	56	6.4
COMPLICATIONS OF PREGNANCY, CHILDBIRTH, AND PUERPERIUM	630-676	3	0.2	0	–	3	0.3
CONGENITAL ANOMALIES	740-759	85	5.0	46	5.5	39	4.5
CERTAIN CONDITIONS ORIGINATING IN THE PERINATAL PERIOD	760-779	73	4.3	47	5.6	26	3.0
SYMPTOMS, SIGNS, AND ILL-DEFINED CONDITIONS	780-799	120	7.0	50	5.9	70	8.0
ALL OTHER DISEASES	Residual	1,232	71.9	558	66.2	674	77.4
ACCIDENTS AND ADVERSE EFFECTS	E800-E949	880	51.4	621	73.7	259	29.7
Motor Vehicle Accidents	E810-E825	432	25.2	294	34.9	138	15.8
All other Accidents and Adverse effects	E800-E807,E826-E949	448	26.1	327	38.8	121	13.9
SUICIDE	E950-E959	318	18.6	263	31.2	55	6.3
HOMICIDE AND LEGAL INTERVENTION	E960-E978	187	10.9	149	17.7	38	4.4
ALL OTHER EXTERNAL CAUSES	E980-E999	35	2.0	24	2.8	11	1.3

Gary E. Johnson
Governor

State of New Mexico
DEPARTMENT OF HEALTH

J. Alex Valdez
Secretary

Larry A. Martinez
Deputy Secretary

JACK CALLAGHAN
Deputy Secretary

WILLIAM H. WIESE, MD., MPH
Division Director

FAX COVER SHEET
SENT FROM FAX # (505) 827-1751

DATE: 1-26-99 PAGE 1 OF ~~3~~ 4

TIME: ______ AM/PM

****

SENT TO FAX # 505) 346-1459

NAME: Chris Shuey

SUBJECT: McKinley Death Stats

****

FROM: DON ORTEGA 827-2536

MESSAGE:

****

TO REPORT PROBLEMS WITH TRANSMISSION CALL (505) 827-0122.

****

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NEW MEXICO VITAL RECORDS & HEALTH STATISTICS
OFFICE OF INFORMATION MANAGEMENT
PUBLIC HEALTH DIVISION
1105 St. Francis Drive
Post Office Box 26110
Santa Fe, New Mexico 87502-6110
(505) 827-0121

HDFA305-18-04 TABLE 18.04 MCKINLEY COUNTY INDIAN 07/07/97 PAGE: 1

1994-96 SUMMARY OF DEATHS BY LEADING CAUSES, AGE, AND SEX
(BY PLACE OF RESIDENCE)

CAUSE OF DEATH	< 1		1 - 4		5 - 14		15 - 24		25 - 34		35 - 44		45 - 54		55 - 64		65 - 74		75 - 84		85 +		TOTAL FOR ALL AGES	
	MALE	FEM	MALE	FEM	MALE	FEM	MALE	FEM	MALE	FEM	MALE	FEM	MALE	FEM	MALE	FEM	MALE	FEM	MALE	FEM	MALE	FEM	MALE	FEM
030	0	0	0	0	0	0	0	0	2	0	0	1	0	3	2	0	0	0	2	0	0	2	6	6
140-150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
151	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	1	0	1	0	5	0
153	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	1	1	1	5
154	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	0	0	1	0	0	3	3
155	0	0	0	0	0	0	0	0	1	0	0	0	1	0	3	1	4	3	1	0	2	1	11	5
156-161	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	4	1	2	2	2	3	10
162-163	0	0	0	0	0	0	0	0	1	0	0	[illegible]	0	0	2	1	0	1	1	1	2	0	6	3
164-184	0	0	0	0	0	0	0	1	0	0	0	[illegible]	0	5	0	8	0	2	1	5	0	2	1	24
185	0	0	0	0	0	0	0	0	0	0	0	[illegible]	0	0	1	0	2	0	0	0	2	0	5	0
188	0	0	0	0	0	0	0	0	0	0	0	[illegible]	0	0	0	1	0	0	1	0	1	0	2	1
189-208	0	0	1	0	0	1	1	0	0	0	3	0	0	5	3	3	2	4	6	4	2	2	18	19
140-208	0	0	1	0	0	1	1	1	1	0	8	6	1	11	12	12	11	15	13	16	13	8	56	70
250	0	0	0	0	0	0	0	0	0	1	1	1	8	4	6	9	6	15	4	13	3	2	28	45
303	0	0	0	0	0	0	0	0	1	1	8	3	6	0	1	1	0	1	0	0	1	0	17	6
390-429*	0	0	0	0	0	1	1	0	2	1	4	0	6	3	19	6	20	18	15	14	15	11	79	46
430-438	0	0	0	0	0	0	0	0	1	0	0	2	2	1	0	0	4	5	3	1	3	4	13	13
440	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
480-487	2	0	1	0	0	0	0	0	0	0	2	1	2	0	2	1	2	5	4	3	6	6	21	16
490-493	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	2	2	3
494-496	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	2	3	1	5	4
571	0	0	0	0	0	0	1	0	2	3	4	5	2	3	2	6	1	1	1	1	0	1	13	20
580-589	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	3	0	0	2	2	1	5	6
740-759	2	11	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4	12
760-779	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4
810-825	1	1	3	3	0	2	18	4	20	4	9	2	7	0	5	1	0	2	1	1	0	0	64	22
826-969	1	0	1	0	3	1	4	1	8	0	3	1	6	1	4	3	3	0	1	0	2	3	30	12
800-969	2	1	4	3	3	3	22	7	28	4	14	3	13	1	9	6	8	2	2	1	2	3	102	34
950-959	0	0	0	0	1	0	2	0	9	0	4	0	1	0	0	0	0	0	0	0	0	0	17	0
960-978	1	0	1	1	0	0	4	0	2	2	4	0	0	0	0	0	0	0	0	0	0	0	12	3
OTHER	5	4	3	1	3	0	3	3	2	5	8	2	7	4	9	8	15	10	13	14	11	18	79	71
ALL CAUSES	16	20	11	5	7	5	55	12	51	17	52	24	44	30	62	51	67	45	58	69	50	61	459	359

* NOTE: 390-429 INCLUDES 390-398, 402, 404-429 ONLY

--> A053--

XDFA305-18-01 TABLE 18.01 MCKINLEY COUNTY ALL RACES/ETHNIC GROUPS 07/07/97 PAGE: 1

1994-96 SUMMARY OF DEATHS BY LEADING CAUSES, AGE, AND SEX

(BY PLACE OF RESIDENCE)

CAUSE OF DEATH	< 1		1 - 4		5 - 14		15 - 24		25 - 34		35 - 44		45 - 54		55 - 64		65 - 74		75 - 84		85 +		TOTAL FOR ALL AGES	
	MALE	FEM	MALE	FEM	MALE	FEM	MALE	FEM	MALE	FEM	MALE	FEM	MALE	FEM	MALE	FEM	MALE	FEM	MALE	FEM	MALE	FEM	MALE	FEM
038	0	0	0	0	0	0	0	0	2	0	0	1	0	3	2	0	1	0	3	0	0	2	8	6
140-150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3	0
151	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	1	1	0	1	1	6	2
153	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	1	1	3	6
154	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	1	0	1	1	0	0	5	3
155	0	0	0	0	0	0	0	0	0	0	0	1	1	0	4	2	5	3	2	1	2	1	14	8
156-161	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	2	1	4	2	3	2	2	6	13
162-163	0	0	0	0	0	0	0	0	1	0	0	0	2	0	5	2	3	5	3	1	2	2	16	10
174-175	0	0	0	0	0	0	0	1	0	0	0	6	0	12	1	4	0	7	1	7	0	5	2	42
185	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0	2	0	2	0	9	0
188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	3	1
189-208	0	0	1	0	2	1	1	0	0	0	4	0	1	5	6	8	3	7	8	6	3	3	29	30
140-208	0	0	1	0	2	1	1	1	1	1	4	7	5	18	22	21	20	28	26	23	14	15	96	115
250	0	0	0	0	0	0	0	0	0	1	1	1	4	4	7	12	9	10	6	18	4	4	51	55
303	0	0	0	0	0	0	0	0	1	1	8	3	7	0	2	1	0	1	0	0	1	0	19	6
390-429*	0	0	0	0	0	1	0	0	4	1	5	0	13	6	30	8	33	18	36	27	21	32	142	93
430-438	0	0	0	0	0	0	0	0	1	0	2	2	2	2	0	1	10	5	7	7	6	7	28	24
440	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	3	0
480-487	2	0	1	0	0	0	0	0	0	0	2	1	2	1	2	1	6	3	7	4	6	10	28	20
490-493	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	2	1	3	2	1	4	8	8
494-496	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	4	3	3	2	10	6
571	0	0	0	0	0	0	1	0	2	3	6	5	4	3	4	6	4	1	2	1	0	1	23	20
580-589	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	3	3	0	0	4	2	1	5	10
740-759	2	13	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	5	14
760-779	6	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	5
810-825	1	1	3	5	0	2	21	7	22	4	10	3	8	0	7	1	0	2	1	2	0	0	73	25
826-949	1	0	1	0	4	1	4	1	11	0	5	1	7	1	7	5	3	0	2	0	2	4	47	13
800-949	2	1	4	3	4	3	25	8	33	4	15	4	15	1	14	6	3	2	3	2	2	4	120	38
950-959	0	0	0	0	1	0	4	0	10	0	5	0	2	0	0	0	0	0	2	0	0	0	24	0
960-978	1	0	1	1	0	0	5	0	3	3	5	0	0	0	1	0	1	0	0	0	0	0	17	4
OTHER	5	4	3	1	3	0	3	3	4	6	9	2	10	7	16	9	26	12	23	18	17	31	119	93
ALL CAUSES	10	23	11	5	10	5	39	13	62	20	63	28	66	45	100	70	122	89	123	109	75	115	692	520

* NOTE: 390-429 INCLUDES 390-398, 402, 404-429 ONLY

TABLE 1.10
NEW MEXICO
RACE/ETHNIC DISTRIBUTION BY COUNTY
1990 CENSUS

HEALTH DISTRICTS	COUNTY	WHITE Non-Hispanic	WHITE Hispanic*	BLACK	AMERICAN INDIAN**	OTHER NON-WHITE
	NEW MEXICO	50.4%	37 5%	2.0%	8.9%	1.2%
	BERNALILLO	55.8	36.2	2.7	3.4	1.9
	CIBOLA	27 3	33.1	.8	38.5	4
	MCKINLEY	15.8	11.3	.5	71.8	6
1	SANDOVAL	51.2	25.7	1.5	19.7	.9
	SAN JUAN	50.0	12.5	.5	36.7	.3
	TORRANCE	60.5	37 6	.4	1.2	.3
	VALENCIA	45.7	49.7	1.1	2.9	6
	COLFAX	50.8	47 5	.3	.7	.6
	HARDING	52.4	46.7	.2	.5	2
	LOS ALAMOS	85 4	10.9	.5	.7	2.5
	MORA	14 4	84.7	–	.5	3
2	RIO ARRIBA	12.7	71.4	4	15.2	3
	SAN MIGUEL	18.2	79.2	.7	.9	1 1
	SANTA FE	47 0	48.7	6	2.9	8
	TAOS	27.7	54.4	.3	6.8	9
	UNION	65.9	33.6	–	.3	.1
	CATRON	70.5	28.3	.3	.8	.1
	DONA ANA	40.7	56.0	1.6	7	.9
	GRANT	47 8	50.6	.5	.8	.3
3	HIDALGO	49.0	49.9	.2	.3	6
	LUNA	50.3	47 3	1.4	.6	.4
	OTERO	64.1	22.9	5.3	5.7	2.0
	SIERRA	74 8	23.8	.4	.8	.2
	SOCORRO	40.4	47.2	.8	10.1	1.5
	CHAVES	60.1	36.4	2.1	.6	.8
	CURRY	67.1	23.1	6.9	.7	2.2
	DE BACA	65.7	32.1	.1	1.9	.2
	EDDY	62.2	34 9	1.7	.5	6
4	GUADALUPE	14 4	84.0	.3	.5	8
	LEA	64.7	29.5	4.7	.6	.4
	LINCOLN	70.3	27.8	.5	1.1	.3
	QUAY	60.0	36.9	1.4	1.0	.6
	ROOSEVELT	70.1	27.0	1.3	.8	.8

Percentage distribution from 1990 census counts:

* Includes Hispanics not classified as races Black, Indian, or Asian/Pacific Islander

** (Native American) includes Eskimo or Aleut.

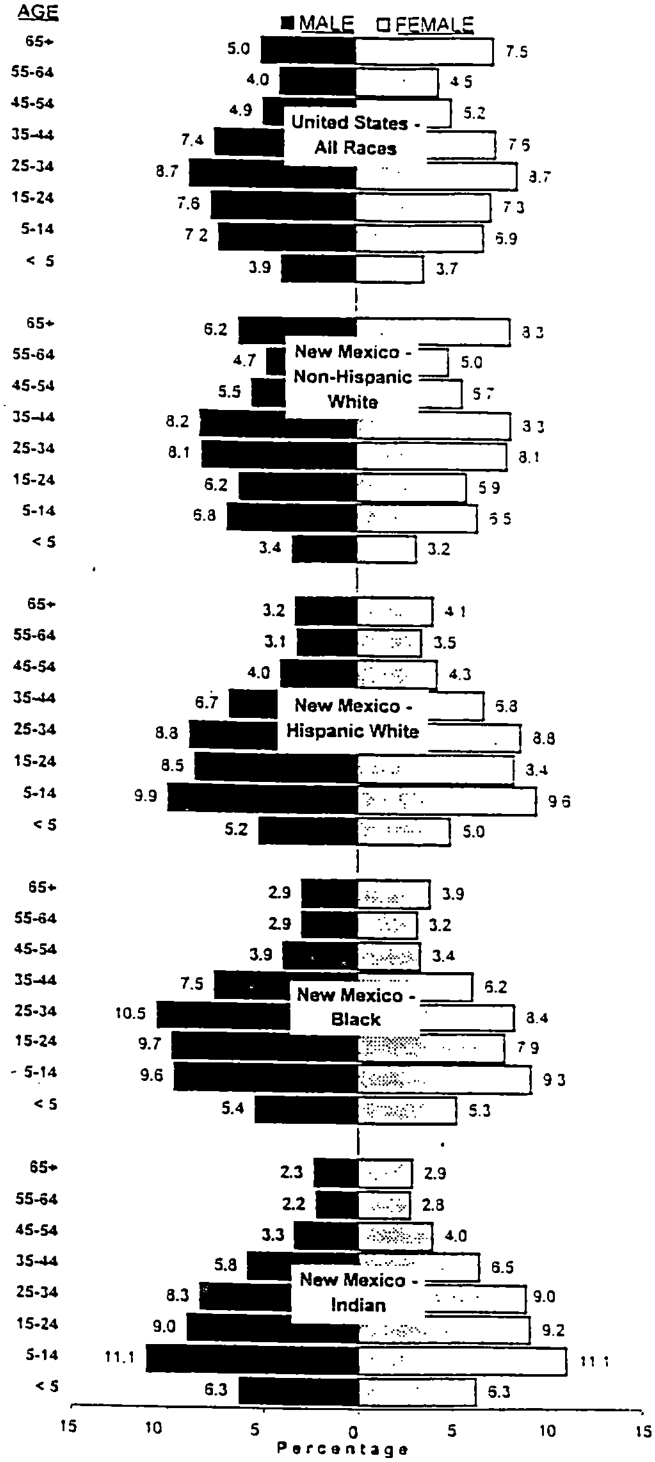
TABLE 1.11
NEW MEXICO
1990 RACE/ETHNIC POPULATIONS
Percentage Distribution by Age Group

AGE	ALL RACES	WHITE NON-HISPANIC	WHITE HISPANIC	BLACK	INDIAN	OTHER
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
< 5	8.5	6.5	10.1	10.7	12.6	9.1
5-14	16.6	13.3	19.6	19.0	22.2	17.6
15-24	14.6	12.1	16.9	17.5	18.2	16.6
25-34	16.9	16.2	17.6	19.0	17.2	21.3
35-44	15.0	16.5	13.6	13.7	12.3	17.8
45-54	9.7	11.2	8.3	7.3	7.3	8.4
55-64	8.0	9.7	6.6	6.0	4.9	5.8
65 +	10.7	14.4	7.3	6.8	5.3	3.4

Percentage distribution by age group for various race/ethnic groups based upon 1990 Census adjusted counts (age, sex, race).

In the population pyramids, Figure 1.12, the shift toward a younger age among New Mexico Hispanic, Black and Indian is graphically evident.

FIGURE 1.12
POPULATION DISTRIBUTION BY AGE
NEW MEXICO 1990 CENSUS
UNITED STATES 1990 CENSUS



At its 1996 level of 1,713,407 people, New Mexico, the fifth largest state in land area, ranks 36th among the states in total population and is the sixth lowest in population density.

INCOME

In 1996 New Mexico ranks forty-eight among the states in per capita income. New Mexico's 1996 per capita personal income figure of $18,770 was 23% lower than the national figure of $24,231 (Table 1.12).

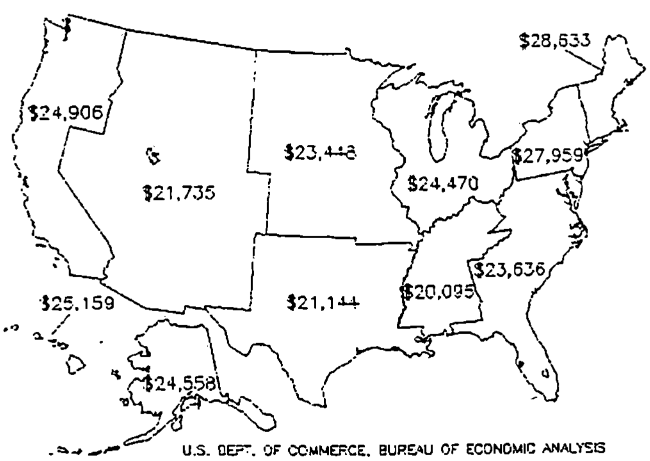
TABLE 1.12
PER CAPITA PERSONAL INCOME
NEW MEXICO AND UNITED STATES
1992- 1996

YEAR	UNITED STATES	NEW MEXICO INCOME	NEW MEXICO RANK
1996	$24231	$18770	48
1995	$23196	$18158	47
1994	$22045	$17079	48
1993	$21223	$16485	46
1992	$20582	$15693	48

SOURCE: U.S. Dept. of Commerce. Revised.

Figure 1.13 gives a general idea of the variation of per capita personal income throughout the nation by division based on 1996 data. Connecticut ranked highest among the states with a per capita income of $33.189 followed by New Jersey. Massachusetts, New York. and rounding off the top five - Delaware. The East South Central was lowest of any region; Mississippi was the lowest among the states, with a per capita personal income of $17,471, a level which New Mexico exceeded by 7%.

FIGURE 1.13
PER CAPITA INCOME 1996
BY DIVISION



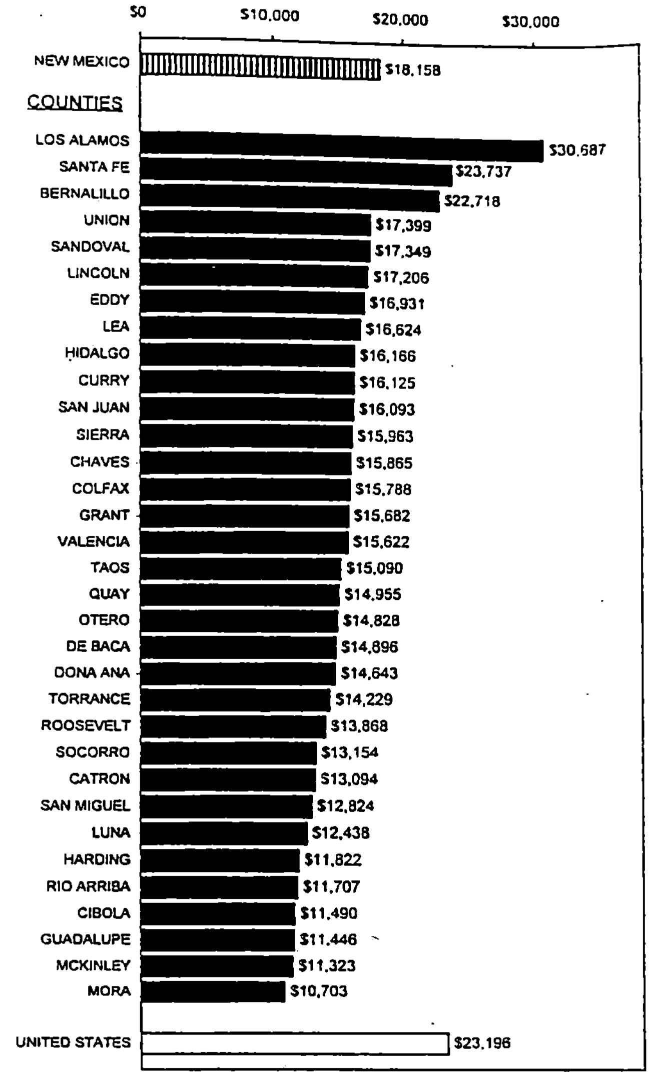
U.S. DEPT. OF COMMERCE. BUREAU OF ECONOMIC ANALYSIS

1995 data shows only two of New Mexico's counties exceeded the national figure for per capita personal income (Figure 1.14). Twenty-nine of the State's 33 counties registered a per capita personal income figure which was less than 75% of the national figure, and for four counties the figure was less than half that of the nation as a whole for that year.

Los Alamos County had the highest per capita income in the State, which was 32% higher than nationally. 69% higher than the State figure, and 29% higher than second ranking Santa Fe and 35% higher than third ranking Bernalillo. the State's most populous county.

According to the 1990 Census. 20.6% of the people in New Mexico are at or below poverty level compared to the national figure of 13.1%. The percentage of persons in New Mexico at or below the poverty level is 57% greater than nationally (Table 1.13).

FIGURE 1.14
PER CAPITA PERSONAL INCOME
NEW MEXICO 1995
RANKING BY COUNTY



SOURCE: U.S. DEPT. OF COMMERCE

TABLE 1.13
PERCENTAGE OF PERSONS AT OR BELOW POVERTY LEVEL
BY ETHNIC/RACE
NEW MEXICO AND UNITED STATES
1980 AND 1990 CENSUS

ETHNIC/RACE	UNITED STATES 1989	UNITED STATES 1979	NEW MEXICO 1989	NEW MEXICO 1979
TOTAL POPULATION	13.1%	12.5%	20.6%	17.4%
WHITE	10.7	9.4	16.1	13.3
Spanish Origin	28.1	23.8	27.8	23.2
All Other	NA	NA	40.7	37.5
Black	31.9	30.2	27.8	29.3
Indian	NA	NA	46.0	40.2
Asian & Pacific Islander	NA	13.9	17.2	23.7

UNITED STATES DEPARTMENT OF THE INTERIOR

URANIUM DEVELOPMENT IN THE SAN JUAN BASIN REGION

A REPORT ON ENVIRONMENTAL ISSUES

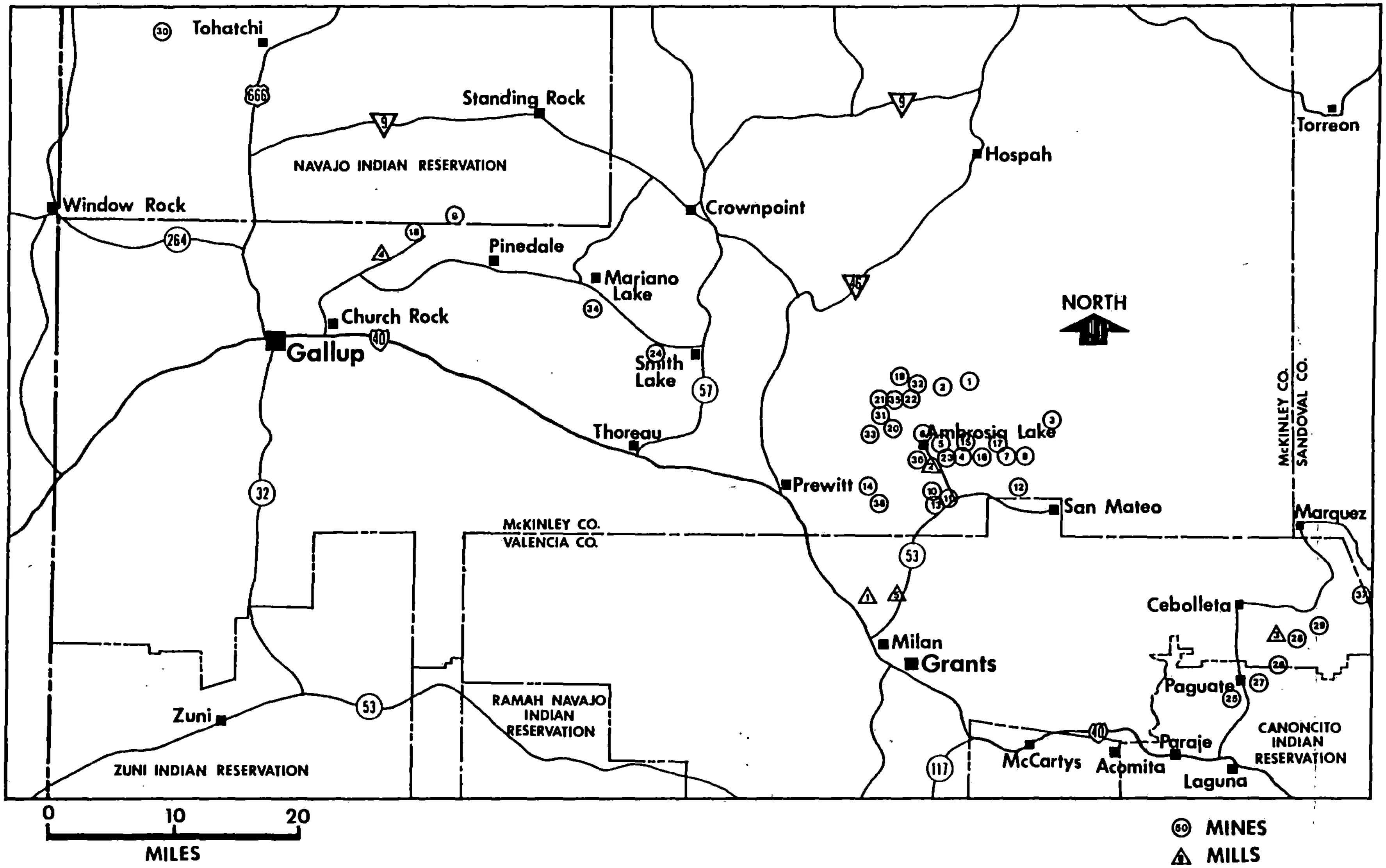
Final Edition

Prepared by

San Juan Basin Regional Uranium Study
Office of Trust Responsibilities
Bureau of Indian Affairs, Lead Agency
Albuquerque, New Mexico

Fall 1980

Map I-5



EXISTING MILLS & MINES

Table I-1
(KEY TO MAP I-5)
Existing Uranium Mines
(Compiled April 1979)

	Company	Mine Name
1.	Kerr-McGee	Sec. 17
2.	Kerr-McGee	Sec. 19
3.	Kerr-McGee	Sec. 24
4.	Kerr-McGee	Sec. 33
5.	Kerr-McGee	Sec. 30
6.	Kerr-McGee	Sec. 30W
7.	Kerr-McGee	Sec. 35
8.	Kerr-McGee	Sec. 36
9.	Kerr-McGee	Church Rock #1
10.	Ranchers	Hope Mine
11.	MM Mining Company	Flea Doris Extension
12.	Ranchers	Johnny M & Johnny M South End
13.	Reserve Oil	Poison Canyon
14.	Todilto Exploration	Haystack
15.	United Nuclear	Ann Lee
16.	United Nuclear	Sandstone
17.	United Nuclear	Sec. 27
18.	United Nuclear	Church Rock IV
19.	United Nuclear Homestake	Sec. 25
20.	United Nuclear Homestake	Sec. 23
21.	United Nuclear Homestake	Sec. 15
22.	United Nuclear Homestake	Sec. 13
23.	United Nuclear Homestake	Sec. 29 & 32
24.	Western Nuclear	Ruby #1
25.	Anaconda (Arco)	P-7/10
26.	Anaconda (Arco)	Jackpile-Paguate
27.	Anaconda (Arco)	PW-2/3
28.	Sohio Petroleum	JJ #1
29.	United Nuclear	St. Anthony Open Pit
30.	Ray Williams	Enos Johnson
31.	Kerr-McGee	Sec. 22
32.	Cobb	Sec. 12
33.	Cobb	West Ranch
34.	Gulf	Mariano Lake
35.	Cobb	Sec. 14
36.	Koppen	Spencer Shaft
37.	Kerr-McGee	Rio Puerco (Operations Postponed)
38.	Todilto Exploration	Piedre Triste

Existing Mills

	Company	Mill Name
1.	Anaconda	Bluewater
2.	Kerr-McGee	Ambrosia Lake
3.	Sohio Petroleum	L-Bar
4.	United Nuclear	Sec. 2
5.	United Nuclear Homestake	

Table IX-4

1977 Uranium Industry Employment in New Mexico

	Exploration	Mining	Milling
Geologists & Engineers	223		
Drilling Services	418		
Logging Services	85		
Aerial Services	3		
Others (such as surveyors and draftsmen	260		
Underground Miners		1,902	
Underground Support		1,608	
Open Pit Miners		352	
Open Pit Support		306	
Technical		380	71
Other		263	161
Supervisory		453	121
Mill Operations			362
Maintenance			306
Totals	989	5,264	1,021

Source: New Mexico Energy and Minerals Dept., 1979.

great many people who are $8 and $10 miners. In other words, they can draw about $8 or $10 an hour by working a reasonable amount, reasonably smart and reasonably hard. This puts them anywhere from $4 to $5 ahead of their [non-miner] peers. If they start making $20 to $25 an hour they get so far ahead of their peers they lose their peer group." (Ibid) The other said:

"A lot of the new companies coming into this area are not above trying to pirate some of your qualified people out from under you and I can't blame them. [New companies] will find a lot more stable diesel mechanics if they hire somebody from us that has been here for, say, 20 years..." (Ibid).

Thus labor shortages, rather than union unrest, have been problems facing the industry prior to the recent downward trend. Possibly the greatest problems facing the miner in the workplace are the threat of accidents and health risks. Health risks were discussed in Chapter IV. Accidents are discussed briefly here.

Occupational Safety: In 1974 mining was found second only to fire fighting among the most dangerous occupations in the United States. Seventy-one miners lost their lives for every 10,000 miners employed (3.8 per million man hours worked), in spite of a stringent mine safety program enforced by MESA.

Annual Resources Report

Energy and Minerals Department

Bruce King
Governor of New Mexico
Charles Turpen
Secretary of Energy and Minerals

Santa Fe 1982

TABLE 73—URANIUM ORE AND CONCENTRATE PRODUCTION IN THE UNITED STATES AND NEW MEXICO. Data on domestic production provided by the U.S. Department of Energy. Detailed data on New Mexico production provided by the New Mexico Energy and Minerals Department. Percent recovered from "other" includes mine-water, in situ and heap leach recovery (data from U.S. Department of Energy, personal communication, June 1982; New Mexico Energy and Minerals Department).

State	Ore processed: Million tons	Ore processed: Contained U_3O_8 (tons)	Tons U_3O_8 recovered: Concentrate from ore	Tons U_3O_8 recovered: other	Tons U_3O_8 recovered: total	% of Total U.S. production
New Mexico	5.4	6,510	6,055	155	6,210	32
Wyoming	4.9	4,380	4,175	180	4,355	23
Arizona, Colorado, Florida, Texas, Louisiana, Utah, Washington	4.2	5,800	5,430	3,245	8,675	45
Total	14.5	16,690	15,660	3,580	19,240	100

Gross tons ore: Mined	Gross tons ore: Processed from stockpiles	Gross tons ore: Milled	Average ore grade (% U_3O_8)	Number of reporting mines
3,102,600	2,367,580	5,470,180	0.124	38

Tons U_3O_8 (Yellowcake): Contained in ore	Recovered from ore	Average % recovery	Recovered from other	Total recovery	Number of operating mills
6,780	6,180	91.2	150	6,330	5

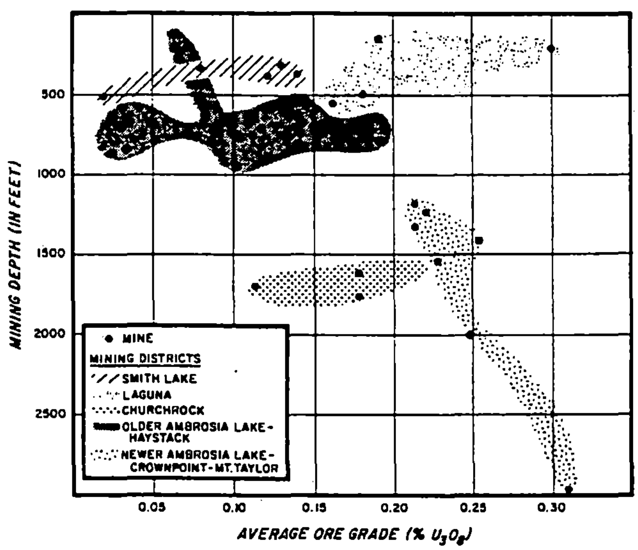


FIGURE 30—MINE DEPTH AND ORE GRADE DISTRIBUTION OF 1981 U_3O_8 PRODUCTION IN NEW MEXICO BY MINING DISTRICT (data from New Mexico Energy and Minerals Department).

these mines, 38 mines reported production during 1981 with 13 companies in operation. Table 74 lists all of the mines which reported production in 1981. Of the 38 mines reporting production, 11 had ceased production by the end of the year. As of July 1982, only 11 of the remaining 27 mines were reported to be in operation. In addition, 7 mines were on standby maintenance status as of mid-year 1982, with no production operations reported. The Jackpile-Paguate mine, the world's largest open pit uranium mine, ceased operations in March of 1982.

The number of operators actively engaged in uranium production by mid-year 1982 include Kerr-McGee, Homestake, Gulf Minerals, Nufuels (Mobil), and Ray Williams Mining Company, with a total of only eleven mines. Tables 75 through 78 furnish details concerning mines closed and mines still in production.

TABLE 74—NEW MEXICO URANIUM MINES REPORTING PRODUCTION IN 1981. Single asterisk = production supplemented by mine-water recovery; double asterisk = in situ-leach pilot operation; triple asterisk = production from mine-water recovery only (data from New Mexico Energy and Minerals Department).

COMPANY	MINE	COUNTY	DEPTH (ft.)	HOST ROCK
Anaconda	Jackpile-Paguate	Cibola	160	Brushy Basin
	NJ-45	Cibola	200	Brushy Basin
	P-10	Cibola	500	Brushy Basin
	P-13	Cibola	150	Brushy Basin
Cobb	Section 12	McKinley	666	Westwater
	Section 14	McKinley	350	Westwater
	West Ranch	McKinley	350	Brushy Basin
Gulf	Mariano Lake*	McKinley	510	Brushy Basin
	Mount Taylor	Cibola	3100	Westwater
Homestake	Section 13	McKinley	550	Westwater
	Section 15	McKinley	419	Westwater
	Section 23*	McKinley	651-783	Westwater
	Section 25*	McKinley	642-801	Westwater
	Section 32*	McKinley	596-607	Westwater
Kerr-McGee	Church Rock No. 1	McKinley	1637-1766	Westwater
	Church Rock No. 1 East	McKinley	1546	Westwater
	Section 17*	McKinley	877-1033	Westwater
	Section 19*	McKinley	640- 705	Westwater
	Section 24*	McKinley	690- 750	Westwater
	Section 30*	McKinley	656	Westwater
	Section 30 West*	McKinley	701- 740	Westwater
	Section 33*	McKinley	753	Westwater
	Section 35*	McKinley	1186-1336	Westwater
	Section 36	McKinley	1418	Westwater
Nufuels (Mobil)	Crownpoint South**	McKinley	2000	Westwater
Ranchers	Hope	McKinley	950	Todilto
	Johnny M	McKinley	1247	Westwater
Ray Williams	Enos Johnson	San Juan	Portal Entry	Recapture
SOHIO-Western	JJ No. 1	Cibola	550	Brushy Basin
Spider Rock Mining	Spider Rock	McKinley	700	Westwater
Todilto	Haystack U.G.	McKinley	130	Todilto
United Nuclear	Ann Lee***	McKinley	650	Westwater
	Sandstone***	McKinley	900	Westwater
	NE Church Rock*	McKinley	1700	Westwater
	Old Church Rock	McKinley	645	Westwater
Western Nuclear	Ruby No. 1	McKinley	360	Brushy Basin
	Ruby No. 2	McKinley	360	Brushy Basin
	Ruby No. 3	McKinley	320	Brushy Basin

Of New Mexico's total reported production, 80 percent came from underground mining; 18 percent from open-pit; and 2 percent from mine water, in-situ, and heap leach recovery.

Shallow deposits of uranium at depths less than 600 feet contributed approximately 700 tons of U_3O_8 or nearly 11 percent to total 1981 state production. Most deposits within this depth range, however, are nearly depleted of minable ore reserves. The majority of production is, therefore, derived from ore mined below this level. For example, 25 percent or approximately 1,600 tons of recovered uranium was mined in the 600- to 800-feet depth range and 34 percent or more than 2,100 tons from the 1,000- to 1,800-feet depth range. A significant but smaller quantity of uranium is being reported from deposits at depths in excess of 2,000 feet where in situ leach recovery may be a significant contributor to New Mexico uranium production in the future. Figure 32 shows the number of deposits reporting production during 1981 by depth and ore grade.

Further details of New Mexico production are shown in table 73 and figure 33. A substantial quantity of all ore processed in 1981 was derived from stockpiled material rather than from ore mined in the state. This is due primarily to excessively high mine production costs, declining producible reserves, and the need to fulfill existing supply contracts in lieu of mine closures. In fact, of the total 5.5 million tons of ore that were milled, over 40 percent (2.4 million tons) was derived from stockpiles.

TABLE 75—1981 PRODUCTIVE URANIUM MINES CLOSED IN NEW MEXICO AS OF DECEMBER 31, 1981 (data from New Mexico Energy and Minerals Department).

Company	Mine	County
Cobb	West Ranch	McKinley
Homestake	Section 13	McKinley
	Section 15	McKinley
	Section 32	McKinley
Kerr-McGee	Section 17	McKinley
	Section 24	McKinley
	Section 33	McKinley
Ranchers	Hope	McKinley
Sohio-Western	JJ No.1	Cibola
Spider Rock	Spider Rock	McKinley
Todilto	Haystack Underground	McKinley

TABLE 76—PRODUCTIVE URANIUM MINES CLOSED IN NEW MEXICO SINCE JANUARY 1, 1982 (data from New Mexico Energy and Minerals Department).

Company	Mine	County
Anaconda	Jackpile-Paguate	Cibola
	NJ 45	Cibola
	P-13	Cibola
	P-10	Cibola
Cobb	Section 12	McKinley
	Section 14	McKinley
Gulf	Mariano Lake	McKinley
Homestake	Section 25	McKinley
Ranchers	Johnny M	McKinley
United Nuclear	Ann Lee	McKinley
	NE Church Rock	McKinley
	Saint Anthony (Open Pit)	Cibola
	Saint Anthony (Underground)	Cibola
	Old Church Rock	McKinley
Western Nuclear	Ruby 1	McKinley
	Ruby 3	McKinley
	Ruby 2	McKinley

Milling

Table 79 lists licensed uranium mills in New Mexico in 1981. Total rated capacity for constructed mills amounted to 20,000 tons of ore per day; however, only 34 percent of this capacity is currently being utilized. Total rated capacity for licensed mills is the same as for 1980, 26,200 tons per day. Table 80 lists recent New Mexico mill shutdowns, which involve approximately 59 percent of the rated capacity of all the uranium mills which have been recently shutdown in the United States. Table 81 lists the utilization of mill capacity of New Mexico mills as of June 1982.

TABLE 77—PRODUCTIVE URANIUM MINES STILL IN PRODUCTION IN NEW MEXICO AS OF JULY 16, 1982. Crownpoint South Pilot mine is an in situ-leach pilot operation (data from New Mexico Energy and Minerals Department).

Company	Mine	Section	County
Gulf	Mount Taylor	24,	Cibola
Homestake	Section 23	23,	McKinley
Kerr-McGee	Church Rock 1	35,	McKinley
	Church Rock 1 East	36,	McKinley
	Section 19	19,	McKinley
	Section 30	30,	McKinley
	Section 30 West	30,	McKinley
	Section 35	35,	McKinley
	Section 36	36,	McKinley
Nufuels	Crownpoint South Pilot	9,	McKinley
Ray Williams	Enos Johnson	9	San Juan

TABLE 78—COMPARISON OF URANIUM PROPERTIES AND OPERATORS IN NEW MEXICO, 1978 TO MID-1982 (data from New Mexico Energy and Minerals Department).

Date	No. of properties in production	No. of operators
1978	39	15
1979	40	11
1980	45	15
1981	38	13
Mid-1982	11	5

These two tables clearly indicate that New Mexico has experienced a disproportionately higher share since June 1981 of total domestic mill shutdowns and cutbacks.

In addition to the five operating uranium mills, two additional mills, the Bokum mill and the Gulf mill, are licensed to operate but are not yet constructed. The Sohio-Reserve mill at Seboyeta near Laguna was shut down in June 1981. Anaconda processed the last shipment of ore at its Bluewater mill in March 1982, and United Nuclear ceased its milling operations at Church Rock in June 1982. As of mid-year 1982, only two New Mexico mills were in operation, Kerr-McGee and Homestake, and these mills are on reduced schedules.

Average mill recovery during 1981 in New Mexico was 91.2 percent of U_3O_8 contained in milled ores. The bulk of New Mexico uranium ores can be milled through the acid extraction process with only a small quantity that must be treated by the carbonate leach method.

Mining and Milling Costs

According to DOE calculations for mining and milling costs in New Mexico, underground mine operating costs average $71.30 per ton of ore or $28.52 per pound of U_3O_8 (assuming each ton of ore mined contains 2.5 pounds of U_3O_8). Total mining costs, including royalties, taxes, and other costs, average $100.10 per ton of ore or $40.04 per pound of U_3O_8. Milling costs average $5.30 per pound of recovered U_3O_8 and in-situ recovery costs are approximately

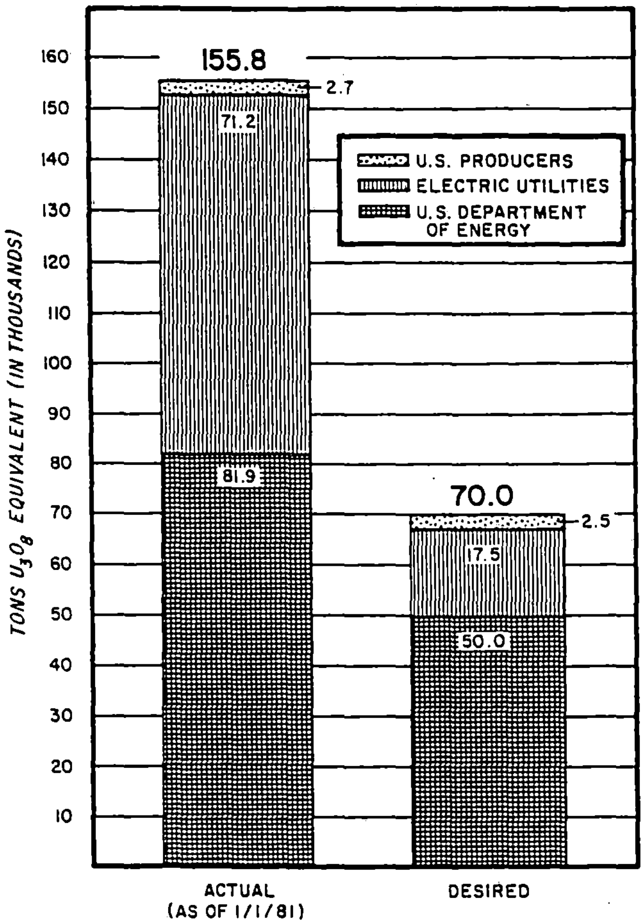


FIGURE 37—U_3O_8 ACTUAL AND DESIRED INVENTORIES HELD BY DOMESTIC PRODUCERS, ELECTRIC UTILITIES, AND U.S. DEPARTMENT OF ENERGY AS OF JANUARY 1, 1981 (data from Nuclear Exchange Corporation, Monthly Report on the Uranium Market, December 1981).

beginning in 1984, foreign suppliers could conceivably capture about half of the domestic market by the 1990s.

Employment

Uranium industry employment in New Mexico continued to decline during 1981 from earlier years as exploration and development virtually ceased and mining and milling responded to the depressed domestic uranium market. Massive layoffs at mines and mills occurred throughout the early months of 1982 and entire exploration staffs were relocated to areas outside of New Mexico.

Although the sharpest employment declines are in mining, all categories of employment show decreases. Figure 38 compares employment in New Mexico uranium mining, milling, and exploration/development from 1974 through 1981. A complete breakdown in all categories is not available for the years 1971 through 1974. As this figure indicates, however, mining and milling employment is at pre-1976 levels, and exploration and development employment is estimated to be at the lowest level since before 1974.

Table 85 shows employment in all reported categories and gives comparisons to U.S. totals. New Mexico uranium mining employment of 3,398 represents about 38 percent of total domestic uranium mining employment (9,009). Total state milling employment (821) is approximately 35 percent of total U.S. uranium milling employment (2,367). Roughly one-third of the 1981 U.S. total of 13,676 employees involved in the uranium industry were employed in New Mexico.

Revenues

Uranium production continues to be a significant source of severance and resource excise tax revenues for the state of New Mexico. Because the uranium mining and milling industry is experiencing a recessionary cycle, however, rev-

TABLE 84—U_3O_8 SUPPLY/DEMAND BALANCE IN THE UNITED STATES IN THOUSANDS OF TONS, 1982–1990. Beginning inventories are Nuclear Exchange Corporation estimates. Relative inventories for each year equal the number of years' forward consumption that could be supplied by that year's beginning inventory (data from Nuclear Exchange Corporation).

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Production less	14.0	10.6	9.5	8.8	8.9	8.9	8.85	8.15	7.45
Consumption plus	10.65	14.1	14.25	15.7	18.0	17.8	18.55	19.1	18.85
Net Imports/(Exports) equals	0.1	0.4	1.05	(0.15)	0.65	0.25	0.5	0.55	0.55
Supply Surplus/(Deficit) plus	3.45	(3.1)	(3.7)	(7.05)	(8.45)	(8.65)	(9.2)	(10.4)	(10.85)
Beginning Inventory equals	81.15	84.6	81.5	77.8	70.75	62.3	53.65	44.45	34.05
Ending Inventory	84.6	81.5	77.8	70.75	62.3	53.65	44.45	34.05	23.2
Relative Inventory	5.5	5.3	4.8	4.4	3.9	3.4	2.8	2.4	1.8

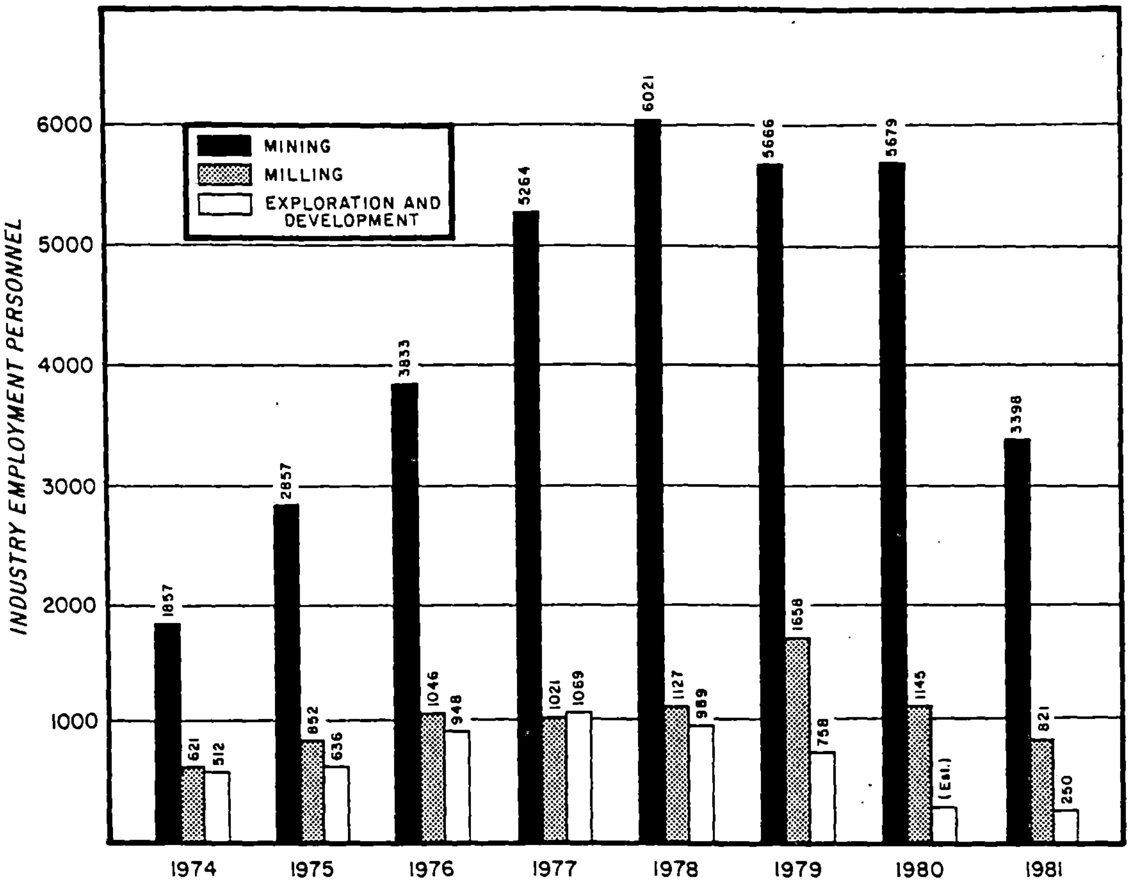


FIGURE 38—EMPLOYMENT TRENDS IN URANIUM MINING, MILLING, AND EXPLORATION IN NEW MEXICO, 1974–1981 (data from U.S. Department of Energy., 1976–1980; U.S. Department of Energy, personal communication, June 1982).

TABLE 85—EMPLOYMENT IN URANIUM MINING, MILLING, AND EXPLORATION AND DEVELOPMENT IN NEW MEXICO COMPARED WITH THE NATION. Employment data withheld for in situ and by-product activities in New Mexico (data from U.S. Department of Energy, personal communication, June 1982).

	Person-years NM	Person-years US
Mining		
Miners	1,349	(NA)
Underground service and support	1,029	(NA)
In-situ and by-product	-	1,536
Technical (engineers, geologists, etc.)	287	(NA)
Supervisory	414	(NA)
Other (clerical, administrative, etc.)	319	(NA)
Total New Mexico	3,398	
Total U.S.		9,009
Milling		
Operation	334	(NA)
Maintenance	209	(NA)
Technical	82	(NA)
Supervisory	137	(NA)
Other	59	(NA)
Total New Mexico	821	
Total U.S.		2,367
Exploration/Development (Estimated)		
All Categories (including geologists, drillers, surveyors, engineers, technical and administrative support, clerical, supervisory)	250	
Total U.S.		2,300
Total New Mexico Uranium Industry	4,469	
Total U.S. Uranium Industry		13,676

enues to the state in 1981 decreased by $5.6 million in comparison to 1980 revenues. In addition, due to the state of the industry in 1981, legislation was enacted during the 35th session of the New Mexico State Legislature to temporarily reduce the taxable value of severed uranium from 100 percent to 60 percent of the sales price per pound of U_3O_8 through June 30, 1984. Figure 39 compares severance and resource excise tax revenues from 1975 through 1981.

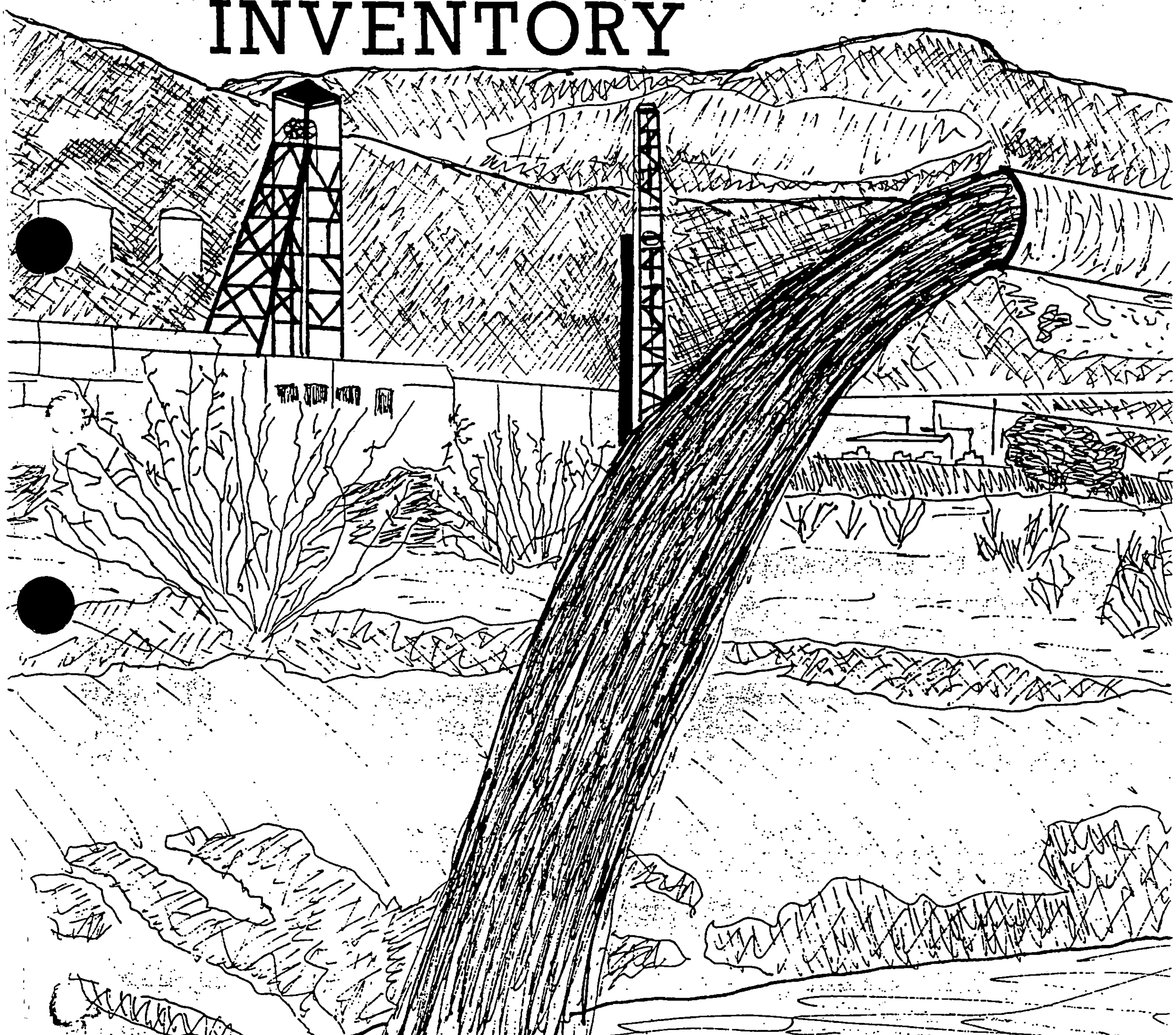
Table 86 shows detailed severance, resource excise, and conservation tax collections in New Mexico between 1976 and 1981.

Projections

Scenario Development

To determine the future outlook for uranium development in New Mexico, the Uranium Supply Model of the New Mexico Energy Management Information System was utilized. This model provides an economic evaluation of uranium mine development and production. To perform this function, the model initially estimates the start-up and subsequent operating costs for a new mine based on mine size, ore grade, and depth characteristics of a given deposit. These mining costs, which are adjusted to reflect a specified rate of return (8 percent) and the applicable severance tax rate, are used to calculate a minimum selling price. This minimum price required to profitably develop a given deposit then relates to potentially recoverable quantities of uranium within the model, yielding a supply schedule. From the

NEW MEXICO URANIUM INVENTORY



Compiled by Wm. Paul Robinson

Southwest Research and Information Center

P.O. Box 4524 Albuquerque, New Mexico 87106

MINE: Churchrock I mine[1]

COMPANY: Kerr-McGee

LOCATION: T17N; R16W; Sec. 35 McKinley County

GE: On line 1975

DEPTH: 1851'[8]

CAPACITY:

WORKERS: 243[5] - 280[8]

RECEIVING WATERS: Rio Puerco of the west to Little Colorado

DISCHARGE RATE: 2.16 MGD = 2404 Af/yr.[3] 4.6MGD[17]

WATER AND AIR QUALITY DATA: Water Discharge monitoring from EPA, 1975[2]

	Ave. Flow MGD	Gross Alpha pCi/1			Ra226 pCi/1			Total U mg/1			TSS mg/1		
		MX	MN	$\bar{x}$	MX	MN	$\bar{x}$	MX	MN	$\bar{x}$	MX	MN	$\bar{x}$
ischarge Potable Water	2.18	240	210	230 120	8.7	6.8	7.9 6.5	0.97	0.72	0.81	58	38	47

CONT'D	Se mg/1			V mg/1		
	MX	MN	$\bar{x}$	MX	MN	$\bar{x}$
'ischarge rotable Water	0.01	0.01	0.01	0.9	0.7	0.8

Effluent limitations for NPDES permit now in adjudication

	Daily Ave.	Daily Max.
TSS mg/1	20 mg/1	30 mg/1
otal U mg/1	N/A	2 mg/1
otal Ra226 pCi/1	N/A	3.3 pCi/1

HISTORY AND DOCUMENTS:

- NPDES permit application received by EPA 7/14/74.
- Assigned NPDES number: NM 0020524, to be effective 1/28/75.
- Adjudicatory hearing requested 1/10/75.
- Adjudicatory hearing granted 8/23/75.

NEW MEXICO URANIUM INVENTORY 3 UN-NC OPEN

MINE: Northeast Churchrock Mine

COMPANY: United Nuclear

LOCATION: T17N; R16W; Sec. 35

AGE: On line 1975

DEPTH: 1800'[8]

CAPACITY:

WORKERS: 375[5] - 549[8]

RECEIVING WATERS: Unnamed arroyo tributary to Rio Puerco of the West

DISCHARGE RATE: 2.016 MGD

WATER AND AIR QUALITY DATA: For 2/26/75-3/6/77 EPA Survey[2]

	Ave. Flow MGD	Gross Alpha pCi/l MX	MN	$\bar{x}$	Ra 226 pCi/l MX	MN	$\bar{x}$	U mg/l MX	MN	$\bar{x}$	TSS mg/l MX	MN	$\bar{x}$
Mine Discharge	2.06	870	730	810	27.3	19.8	23.3	7.6	6.5	7.2	71	33	50
Mine Potable Water Supply				620			12.6						
Mine Mobile Home Water Supply				1110			39.7						

CONT'D

	Se mg/l MX	MN	$\bar{x}$	Va mg/l MX	MN	$\bar{x}$
Mine Discharge	0.06	<0.01	0.04	0.5	0.4	0.4
Mine Potable Water Supply			0.06			
Mine Mobile Home Water Supply			0.06			

NPDES Limitation in Permit for 7/1/77-1/27/80

	Daily Ave.	Daily Max.
TSS-mg/l	20	30
Total U-mg/l	N/A	2
Dissolved Radium226-pCi/l	N/A	3.3

No Standard for Se, Mo, Va

VENTILATION SHAFTS: 3[17]

AIR DISCHARGE(cfm): 465,000

HISTORY AND DOCUMENTS:

-NPDES application received by EPA-6/21/74
-Permit issued- Number NM 0020401
-Effective Date-1/28/75-Only effective NPDES permit for a uranium operation in New Mexico

Southwest Research and Information Center
P.O. Box 4524 Albuquerque, New Mexico 87106

NEW MEXICO URANIUM INVENTORY-REFERENCE LIST

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3-Charles Nylander, Assessment of the Adequacy of Selected Legal Controls on the Quality of Effluent Discharged from Uranium Point Sources in the Grants Mineral Belt, New Mexico, Water Resources Management Program, Univeristy of Wisconsin, Madison, Wisconsin, 1977. Mr. Nylander is on the Water Quality staff of the New Mexico Environmental Improvement Agency.

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6-US Department of Interior, Status Report-Uranium Development on Federal and Indian Lands, Northwest New Mexico, Department of Interior, Southwest Region, Albuquerque, NM, September, 1976

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8-Governor's Energy Impact Task Force, Managing the Boom in Northwest New Mexico, Energy Resources Board, Santa Fe, NM, September, 1977

9-Phillips Petroleum Corp., "Discharge Plan for Section 31 Shaft Excavation," November 15, 1977, in NMEIA Water Quality Division Files.

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12-J.W. Schomisch, "Cleanup of Uranium Tailings Could Cost $125 Million," Gallup Independent, Gallup, NM, January 4, 1978

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17-T. Buhl, Progress Report to the Legislature: Uranium Mine and Mill Tailings Study, Radiation Protection Section, Environmental Improvement Agency, Santa Fe, NM, December 1, 1977

Mortality among Navajo Uranium Miners

ABSTRACT

Objectives. To update mortality risks for Navajo uranium miners, a retrospective cohort mortality study was conducted of 757 Navajos from the cohort of Colorado Plateau uranium miners.

Methods. Vital status was followed from 1960 to 1990. Standardized mortality ratios were estimated, with combined New Mexico and Arizona non-White mortality rates used for comparison. Cox regression models were used to evaluate exposure-response relationships.

Results. Elevated standardized mortality ratios were found for lung cancer (3.3), tuberculosis (2.6), and pneumoconioses and other respiratory diseases (2.6). Lowered ratios were found for heart disease (0.6), circulatory disease (0.4), and liver cirrhosis (0.5). The estimated relative risk for a 5-year duration of exposure vs none was 3.7 for lung cancer, 2.1 for pneumoconioses and other respiratory diseases, and 2.0 for tuberculosis. The relative risk for lung cancer was 6.9 for the midrange of cumulative exposure to radon progeny compared with the least exposed.

Conclusions. Findings were consistent with those from previous studies. Twenty-three years after their last exposure to radon progeny, these light-smoking Navajo miners continue to face excess mortality risks from lung cancer and pneumoconioses and other respiratory diseases. (*Am J Public Health.* 1995;85:535–540)

Robert J. Roscoe, MS, James A. Deddens, PhD, Alberto Salvan, MD, PhD, and Teresa M. Schnorr, PhD

Introduction

Radon progeny, both in the workplace and in the household, are a continuing cause for concern because of the well-established association between exposure to radon progeny and lung cancer.[1–7] In addition to lung cancer, associations have been suggested between exposure to radon progeny and other cancers, including leukemia, non-Hodgkins lymphoma, malignant melanoma, and kidney cancer, in studies of uranium and other hard rock miners in Canada, Sweden, Czechoslovakia, and the United States.[8–11] In the United States, excess mortality risks for lung cancer, pneumoconioses and other respiratory diseases, tuberculosis, and chronic nephritis have been reported for the heavy-smoking White uranium miners of the Colorado Plateau study group.[12–16] Studies among various populations of Navajo uranium miners in the United States have demonstrated excess mortality from lung cancer.[17–19] The most recent report on the Navajo uranium miners in the Colorado Plateau study group, published in 1976, indicated significant excess mortality from lung cancer and a trend toward excess mortality from tuberculosis, nonmalignant respiratory disease, and unintentional injuries.[13] To provide updated information on lung cancer and other mortality risks for these light-smoking Navajo men exposed to radon progeny, we have now updated and reanalyzed the cohort mortality data on the Navajo uranium miners from the Colorado Plateau study group.

Methods

The cohort of Navajos was selected from the Colorado Plateau study group of 4126 White and non-White men who mined uranium on the Colorado Plateau.[12] To be included in the group, miners must have been examined in the US Public Health Service medical surveys conducted between 1950 and 1960 and must have worked at least 1 month underground in a uranium mine by January 1, 1964. Although the uranium miners' pre-1954 participation rates in the medical surveys were low, approximately 90% of the miners in the areas visited by the Public Health Service participated in the 1957 and 1960 surveys.[12] Occupational, medical, and smoking information was obtained during the surveys and was updated during subsequent annual censuses of the miners conducted by the Public Health Service through the early 1970s.

The working level months of exposure to radon progeny were determined by multiplying the working months (1 working month consists of 170 hours) spent underground by the working level of the particular mine at that time. One working level is equal to any combination of radon progeny in 1 L of air that results in the ultimate release of 1.3×10^5 MeV of potential alpha energy. Lundin et al [12] have described the four methods used to estimate the working levels of radon progeny in a given mine in a given year,

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and Hornung and Meinhardt[15] have evaluated the magnitude of error. In our life table analysis, exposures to radon progeny were separated into four categories having approximately the same number of expected deaths. The lowest exposure category (less than 120 working level months) was chosen to coincide with exposures that would be allowable under the current limit of 4 working level months per year[7] over a 30-year career; our other three categories were 120 to 400, 400 to 1000, and 1000 or more working level months.

Vital status was ascertained from January 1, 1960, through December 31, 1990, through the records of the Social Security Administration, Internal Revenue Service, National Death Index, Health Care Financing Administration, and Indian Health Service. Those whose vital status was unknown were considered lost to follow-up on the date last observed. Death certificates were obtained and coded by a qualified nosologist into the appropriate revision of the *International Classification of Diseases* (ICD); the rules in effect at the time of death were used in coding. Deceased individuals for whom no certificate was located were assumed dead on the date specified by the reporting agency with the cause of death unknown.

Life Table Analysis

A modified life table analysis system[20,21] was used in analyzing the cohort. Time since first exposure and duration of exposure were calculated from the first date of employment underground in a uranium mine. Because we used state mortality rates, initiated in 1960, as our comparison, person-years at risk of dying were also calculated from 1960. The expected number of deaths was computed by multiplying cause- and time-specific mortality rates for non-Whites in New Mexico and Arizona by the corresponding person-years distribution in the study population. Standardized mortality ratios represented the ratio of observed to expected deaths. The combined New Mexico and Arizona rates for mortality among non-White men (all except Whites and Hispanics) were chosen as the comparison rates because Navajos, Zunis, and other American Indians composed a relatively large percentage of the non-White population.[22,23]

Direct standardization of rates, used to calculate the standardized rate ratios for lung cancer in Table 3, provided for internal comparisons between the higher exposure categories (i.e., 120 to 400, 400 to 1000, and > 1000 working level months) and the lowest exposure category (< 120 working level months). Our procedure for direct standardization calculated weighted rates for each of the four exposure categories; the age, race, sex, and calendar time stratum-specific sums of person-years across all exposure categories for the entire cohort were used as weights. The 95% confidence interval (CI) for the standardized rate ratio was calculated on the basis of a Taylor series approximation of the variance.[21]

In calculating standardized mortality and standardized rate ratios by exposure categories in Table 3, we lagged exposure to radon progeny by 5 years under the assumption that 5 years was a reasonable estimate of a minimum induction period necessary before exposure could cause disease.[21]

Cox Regression Analysis

To account for simultaneous risk factors for disease mortality and to address problems associated with the choice of a possibly inadequate external comparison group encountered in the life table analyses, we performed a Cox regression analysis[24,25] of the entire Navajo cohort. The disease-specific age at death was the censored outcome variable. All comparisons were thus age adjusted. The analyses were also stratified on categories of year of birth (1883 to 1909, 1910 to 1916, 1917 to 1923, 1924 to 1943). The time-dependent regressors considered for inclusion in the models were cumulative exposure, log cumulative exposure, duration of exposure, log duration, exposure rate, log exposure rate, log cumulative pack-months of smoking (all lagged 5 years), time since first exposure, time since last exposure, and smoking status (yes/no), together with possible two-way interactions. Log cumulative exposure was taken to be the logarithm of cumulative exposure to radon progeny plus a background of 0.4 working level months per year of age.[15] Duration of exposure was taken to be the number of months of underground uranium mining. This variable included all mining exposures and included but was not limited to radon progeny. Exposure rate was taken to be the ratio of cumulative exposure to radon progeny divided by months spent in underground mining. Log cumulative pack-months was the logarithm of cumulative pack-months of smoking plus a background of .005 packs per day.[15] We considered log-linear models in the logarithm of cumulative dose (these models are sometimes called "power" function models), as follows:

$$h(t, \text{dose}) = h_0(t)e^{\beta \log(\text{dose} + \text{background})},$$

where $h(t, \text{dose})$ and $h_0(t)$ are the hazard and baseline hazard functions, respectively. We also considered the linear excess relative risk function

$$h(t, \text{dose}) = h_0(t)(1 + \beta \text{ dose}/100).$$

Plots of log cumulative hazards were used to check the proportional hazards assumption within categories of year of birth. The EPICURE[26] software package was used to perform all Cox regression analyses.

Results

Of the 779 non-Whites in the Colorado Plateau study group, 3 were Black and 1 was Asian; the remaining 775 were Navajos, including Hopi, Laguna, and Comanche. Although we included Blacks, Asian Americans, and other Native Americans in our cohort, just as they were included in the non-White state mortality rates that we used for comparison, we have called our study group a Navajo cohort because the vast majority were Navajos. Twenty-two Navajo miners were excluded because they did not meet the cohort eligibility criteria. The characteristics of the remaining cohort of 757 Navajo miners are given in Table 1.

We reviewed all of the records on smoking from the periodic surveys between 1950 and 1973 for the Navajo miners. All records reviewed were available at the time of previous smoking classifications.[12,13] We reviewed the records to correct all smoking classifications without knowledge of disease status. This reclassification caused a small difference between the smoking data in this report and previous reports on the Navajo miners.[12,13] The revised smoking classifications are reported in Table 1. All Navajo miners reporting that they smoked pipes or cigars also smoked cigarettes. The 38 Navajos who chewed tobacco or used snuff with no other use of tobacco were categorized as never having smoked.

Cohort Mortality

The 303 deaths observed are listed by their underlying causes in Table 2, along with the expected numbers of deaths and standardized mortality ratios. Heart, circulatory, and digestive diseases (specifically cirrhosis standardized mortality ratio = 0.5, 95% CI = 0.2, 0.7) were found

TABLE 1—Navajo Uranium Miners Cohort, 1960 through 1990

	Sample
Vital status, no. (%)	
Alive	452 (59.7)
Deceased	303 (40.0)
Death certificate	295 (97)
No certificate	8 (3)
Unknown[a]	2 (0.3)
Total[b]	757 (100)
Smoking characteristics, no. (%)	
Never smoked[c]	446 (58.9)
Ex-smokers	106 (14.0)
<1 pack/day (light)	174 (23.0)
1 pack/day (moderate)	18 (2.4)
>1 pack/day (heavy)	3 (0.4)
Missing information	10 (1.3)
Total	757 (100)
Other characteristics, mean (SD)	
Year of birth	1923 (10.7)
Year first employed	1953 (4.2)
Age employed, y	29 (9.7)
Duration employed, y	8.3 (5.6)
Months of underground uranium mining	64 (49.8)
Exposure from uranium mining, working level months[d]	755 (847)
Exposure rate, working level months/month[d]	14.2 (26.1)
Exposure from other mining, working level months[e]	unknown
Age at end of study, y[f]	64 (8.4)
Years since first employment	31.7 (9.0)
Years since last employment	23.4 (9.6)

[a]Persons with unknown vital status had person-years accumulated until last date observed.
[b]The number of person-years was 19 185.
[c]Includes tobacco chewers and users of snuff.
[d]Median exposure = 403 working level months; median exposure rate = 9 working level months per month.
[e]Some Navajo uranium mines had other mining exposure, but the working level months data were not collected by Public Health Service investigators.
[f]For persons alive or of unknown status on December 31, 1990.

TABLE 2—Mortality in Navajo Uranium Miners vs Non-Whites in New Mexico and Arizona: 1960 through 1990

Cause of Death	ICD-9[a] Code(s)	No. of Observed Deaths	No. of Expected Deaths	Standardized Mortality Ratio	Exact 95% Confidence Interval
Cancers					
All cancers	140–208	56	42.2	1.3	1.0, 1.7
Stomach	151	7	4.2	1.7	0.7, 3.4
Intestine	152–153	2	2.5	0.8	0.1, 2.9
Rectum	154	1	1.0	1.0	0.02, 5.6
Liver	155–156	2	2.7	0.7	0.1, 2.4
Pancreas	157	1	2.3	0.4	0.01, 2.4
Lung	162	34	10.2	3.3	2.3, 4.6
Prostate	185	1	4.5	0.2	0.01, 1.2
Kidney	189.0–189.2	1	1.2	0.8	0.02, 4.7
Bladder	188, 189.3–189.9	1	0.7	1.5	0.04, 8.2
Unspecified	194–199	3	4.5	0.7	0.1, 2.0
Lymphatic/hematopoietic	200–208	3	3.7	0.8	0.2, 2.4
Nonmalignant diseases					
Tuberculosis	001–018	12	4.6	2.6	1.4, 4.6
Diabetes mellitus	250	6	8.3	0.7	0.3, 1.6
Alcoholism	303	4	9.6	0.4	0.1, 1.1
Nervous system	320–389	6	4.6	1.3	0.5, 2.8
Heart	390–429	39	65.3	0.6	0.4, 0.8
Circulatory system	415–417, 430–459	8	21.8	0.4	0.2, 0.7
All respiratory	460–519	34	24.8	1.4	1.0, 1.9
Pneumoconioses and other respiratory diseases	470–478, 494–519	20	7.7	2.6	1.6, 4.0
Digestive	520–579	12	26.3	0.5	0.2, 0.8
Genitourinary	580–629	6	8.0	0.8	0.3, 1.6
Musculoskeletal	711–739	2	0.6	3.3	0.4, 11.9
Ill defined	780–793, 795	28	19.1	1.5	1.0, 2.1
Unintentional injuries	E800–E949	57	57.9	1.0	0.7, 1.3
Suicide	E950–E959	8	4.9	1.6	0.7, 3.2
Homicide	E960–E978	6	12.4	0.5	0.2, 1.0
Other causes	Residual	13	10.6	1.2	0.6, 2.1
All causes	All	303[b]	325.5[c]	0.9	0.8, 1.0

Note. ICD-9 = *International Classification of Diseases*, 9th edition.
[a]Some ICD-9 codes in broad ranges were excluded and fall under "Other causes."
[b]Includes 6 deaths with missing death certificates.
[c]Includes 4.5 expected deaths for diseases not included in this table.

to involve lowered standardized mortality ratios. Kidney cancer (Table 2), leukemia (standardized mortality ratio = 0.0, 95% CI = 0.0, 2.8), non-Hodgkins lymphoma (standardized mortality ratio = 0.6, 95% CI = 0.01, 3.3), and melanoma (standardized mortality ratio = 0.0, 95% CI = 0.0, 18.4), suspected of being associated with exposure to radon progeny,[8–11] were not found to be in excess. Other diseases associated with uranium mining, including chronic nephritis and renal sclerosis[14] (standardized mortality ratio = 0.9, 95% CI = 0.2, 2.5) and unintentional injuries[13,14] (Table 2), also were not found to be in excess. Lung cancer, pneumoconioses and other respiratory diseases, and tuberculosis, however, were found to be in excess (Table 2); further analyses focus on these three diseases.

For the 34 Navajos who died from lung cancer (Table 2), (1) the mean age at death was 53 years (range = 33 to 81 years), (2) the mean time since first exposure to radon progeny was 26.7 years (range = 12.5 to 44.7 years), and (3) the mean exposure to radon progeny was 1517 working level months (median = 1284 working level months), (range = 30 to 3896). Cigarette smoking status for the 34 Navajos who died from lung cancer was about the same as that reported for the entire cohort of Navajo miners (Table 1). Mortality risk ratios for lung cancer are reported in Table 3 by

TABLE 3—Lung Cancer Mortality Risk Ratios for Navajo Uranium Miners, by Cumulative Exposure to Radon Progeny, 5-Year Exposure Lag, 1960 through 1990

	Exposure to Radon Progeny from Uranium Mining, Working Level Months				
	<120	120–400	400–1000	>1000	Total
Observed/expected deaths[a]	1/2.20	2/2.78	10/2.36	21/2.85	34/10.19
Standardized mortality ratio	0.4	0.7	4.2	7.4	3.3
95% CI	0.01, 2.5	0.1, 2.6	2.0, 7.8	4.6, 11.3	2.3, 4.6
Standardized rate ratio	1.0	1.4	8.3	24.1	8.4
95% CI	...	0.1, 16.0	1.1, 65.2	3.0, >100	1.2, 61.8
Cox estimate[b]	1.0	2.9	6.9	18.9	...
95% CI	...	1.4, 4.8	2.3, 13.0	4.9, 37.7	...
No. of person-years	4438	5269	4349	4336	18 392[c]
Median working level months[d] (no. who did not progress)	48 (148)	232 (228)	624 (175)	1810 (206)	403

[a]Observed deaths/expected deaths, Arizona and New Mexico non-Whites.
[b]Cox linear excess relative risk estimates as compared with the exposure category of less than 120 working level months.
[c]Five-year exposure lag contained 793 person-years, no observed deaths, and 0.05 expected deaths, placed in the unexposed category.
[d]Median exposure from uranium mining for miners who did not progress to a higher category of exposure.

cumulative exposure to radon progeny. No deaths from lung cancer were observed among Navajos within 10 years of their first exposure to radon progeny.

Cox Regression Analyses

Lung cancer. For lung cancer, we considered both log-linear relative risk models and linear excess relative risk Cox regression models. The log-linear relative risk model using duration of exposure yielded the best fit. Increased duration of exposure was strongly related to increased risk of lung cancer mortality ($\hat{\beta} = 0.2611$, SE = 0.0383, $P < .0001$). The estimated relative risk for a 5-year duration of exposure vs nonexposure was 3.7 (95% CI = 2.5, 5.4). When duration of exposure was included in the log-linear model, no other variables added significantly to the model fit. Increased log cumulative exposure to radon progeny was also strongly related to increased mortality from lung cancer in the log-linear model ($\hat{\beta} = 0.9838$, SE = 0.1902, $P < .0001$). With log cumulative exposure to radon progeny in the log-linear model, time since last exposure and exposure rate, when considered separately, added significantly to the model fit. For linear excess relative risk models, cumulative exposure to radon progeny was the best predictor variable, while time since last exposure added significantly to the model fit.

In order to use the Cox regression results to obtain estimates of relative risk comparable to the standardized rate ratios included in Table 3, we estimated the risk of each category relative to the same internal comparison group (exposure of less than 120 working level months) using the median exposure levels in the categories. For example, the linear excess relative risk model ($\hat{\beta} = 1.986$) revealed that the estimated relative risk for the 400 to 1000 working level month category vs the less than 120 category was 6.9 (95% CI = 2.3, 13.0) (Table 3). A likelihood-based approach was used to obtain the confidence interval because of the unreliable standard errors in the linear excess relative risk model.

In the log-linear model including log cumulative exposure and time since last exposure, log cumulative exposure was positively related to mortality ($\hat{\beta} = 0.9271$, SE = 0.1992, $P = .0001$), while time since last exposure was negatively related to mortality ($\hat{\beta} = -0.0984$, SE = 0.0384, $P = .008$) ($\hat{}$ over β indicates a model estimate). The estimated relative risk for 400 working level months relative to no exposure was 9.0 (95% CI = 4.6, 41.7). The estimated relative risk at 10 years since last exposure vs 0 years was 0.37 (95% CI = 0.18, 0.79). In the log-linear model including log cumulative exposure, rate of exposure to radon progeny was negatively related to mortality ($\hat{\beta} = -0.0671$, SE = 0.0269, $P = .001$). The estimated relative risk due to an increase in the rate of 10 working levels was 0.51 (95% CI = 0.30, 0.87). No other variables contributed significantly to model fit when log cumulative exposure to radon progeny was included in the log-linear model. This was particularly true of all smoking variables and of all two-way interaction terms.

Pneumoconioses and tuberculosis. Increased mortality due to pneumoconioses and other respiratory diseases ($P = .001$) and to tuberculosis ($P = .01$) was also significantly related to duration of exposure in the log-linear relative risk and linear excess risk Cox regression analyses. For the log-linear model, the coefficients of duration of exposure were .1519 (SE = .0441) for pneumoconioses and other respiratory diseases and .1426 (SE = .0658) for tuberculosis. Hence, the estimated relative risks for a 5-year duration of employment in underground uranium mining vs no such employment were 2.1 (95% CI = 1.4, 3.3) for pneumoconioses and other respiratory diseases and 2.0 (95% CI = 1.1, 3.9) for tuberculosis. No other variables contributed significantly to the model fit for these causes.

Mortality over calendar time. The standardized mortality ratio analysis showed that the lung cancer rate increased over time from 2.4 (95% CI = 0.6, 6.5) in the 1960s to 3.6 (95% CI = 2.2, 5.5) in the 1980s. The rate of pneumoconioses and other respiratory diseases increased as well, from 1.5 (95% CI = 0.1, 7.2) in the 1960s to 2.9 (95% CI = 1.4, 4.5) in the 1980s. When the effects of duration of exposure and cumulative exposure to radon progeny over calendar time were controlled in the Cox analysis, the results indicated that exposure was the primary factor in the observed risk trend.

Discussion

Recent analyses of lung cancer among the Colorado Plateau study group have focused on the White miners.[1,2,5,14-16] This is the first analysis since 1976 of mortality among the Navajo uranium miners in the Colorado Plateau study group. In this analysis, we extended vital status follow-up (17 years) through 1990, assessed risk by cumulative exposure to radon progeny and by duration of exposure to underground uranium mining, reviewed smoking status, and provided rate ratios using both an external and an internal comparison group. We found (1) elevated standardized mortality ratios for lung cancer (3.3, 95% CI = 2.3, 4.6), pneumoconioses and other respiratory diseases (2.6, 95% CI = 1.6, 4.0), and tuberculosis

(2.6, 95% CI = 1.4, 4.6); (2) trends of increasing risk with increasing duration of exposure to uranium mining and with increasing cumulative exposure to radon progeny for lung cancer, pneumoconioses and other respiratory diseases, and tuberculosis; and (3) a relative risk of 6.9 (95% CI = 2.3, 13.0) for lung cancer among those exposed to the midrange of 400 to 1000 working level months.

Prior to our study, the most recent investigation of the Navajo uranium miners in the Colorado Plateau study group had been conducted by Archer et al.[13] with mortality follow-up through 1973. When we extended that follow-up by 17 years and used the same external comparison population for our standardized mortality ratio estimates, we found that overall mortality risk patterns had not changed. For mortality from all causes, lung cancer, nonmalignant respiratory disease, tuberculosis, and unintentional injuries, our standardized mortality ratio findings were similar to Archer's. Our analysis revealed that standardized mortality ratios for lung cancer and pneumoconioses and other respiratory diseases appeared to continue to increase over time and remained elevated over the period 1980 to 1990. It seems clear that both lung cancer and pneumoconioses and other respiratory diseases continue to be elevated among this cohort of very-light-smoking Navajos an average of 23 years since their last exposure to radon progeny. However, the results of the Cox analysis indicated that exposure was the primary factor in the observed risk trend.

For lung cancer, our standardized mortality ratio of 3.3 (95% CI = 2.3, 4.6) was lower than the ratio of 4.2 (95% CI = 2.1, 7.6) estimated for Navajos by Archer et al.[13] and the ratio of 4.8 (95% CI = 4.2, 5.6) estimated for White uranium miners by Waxweiler et al.[14] Using Cox regression, we estimated a relative risk of 6.9 (95% CI = 2.3, 13.0) for those exposed to the midrange of 400 to 1000 working level months in comparison with those exposed to less than 120 working level months; using an internal comparison in our life table analysis, we estimated a standardized rate ratio of 8.4 (95% CI = 1.2, 61.8) for the same comparison (Table 3). Our estimates of lung cancer risk using internal comparisons are probably better indications of the true risk ratio.

Comparison of the Cox regression analysis of lung cancer in the present Navajo study with the previous Cox regression analysis of the White uranium miners[15] revealed that increased exposure to radon progeny was strongly associated with increased risk of death due to lung cancer in both studies. The power function model was used in both studies, and similar coefficients were obtained for White and Navajo miners. In the Navajo study, duration of exposure was a better predictor than logged cumulative exposure to radon progeny (possibly as a result of measurement error in exposure). In the study of the White miners, cumulative exposure was a better predictor of lung cancer than duration of exposure (R. W. Hornung, J. A. Deddens, and R. J. Roscoe, written communication, 1993). In the Navajo study, the log-linear model in log cumulative exposure and the linear model in cumulative exposure both fit the data equally well (both had the same deviances), yielding estimated relative risks of 13.8 and 9.0 for 400 working level months relative to no exposure, respectively. Log cumulative pack-months of cigarette smoking was strongly associated with increased risk of death due to lung cancer in the White miners study but not in the present Navajo study, possibly because the Navajos smoked considerably less than their White counterparts. Of the Navajos, 58.9% had never smoked (Table 1), in comparison with about 18% of the White miners; moreover, among the Navajo miners categorized as light smokers, many were very light smokers (about 75% smoked five or fewer cigarettes per day). In both the Navajo and White studies, exposure rate and time since last exposure showed a negative association with risk of death due to lung cancer.

For all nonmalignant respiratory disease, our standardized mortality ratio of 1.4 (95% CI = 1.0, 1.9) was similar to the ratio of 1.3 (95% CI = 0.5, 1.8) for Navajos estimated by Archer et al.[13] and lower than the ratio of 3.2 (95% CI = 2.6, 3.9) for White uranium miners estimated by Waxweiler et al.[14] Differences in smoking habits are probably the explanation for the difference in standardized mortality ratios for Navajos and Whites. The excess mortality in our cohort was mainly due to pneumoconioses and other chronic respiratory diseases. Silica and other mining exposures, rather than radon progeny, are the likely explanations for the increased risk.

Our estimate of tuberculosis mortality (standardized mortality ratio = 2.6, 95% CI = 1.4, 4.6) was similar to the mortality ratio for Navajos estimated by Archer et al.[13] (2.2, 95% CI = 0.9, 4.3) and lower than that for White uranium miners estimated by Waxweiler et al.[14] (4.1, 95% CI = 2.2, 6.9). Silicosis and silicotuberculosis were mentioned on 4 of the 12 death certificates, indicating that silica, rather than radon progeny, is the likely explanation for the increased risk.

Associations have been suggested between exposure to radon progeny and other cancers, including leukemia, non-Hodgkins lymphoma, malignant melanoma, and kidney cancer.[8-11] We did not observe elevated mortality from these cancers. This result is consistent with the findings of Darby et al.[27]

An important factor that could affect the standardized mortality ratios in our life table analysis is the choice of mortality rates to be used for comparison. The mortality pattern for male American Indians in the Southwest is quite different from that of US White or non-White men. While rates of death due to tuberculosis, injuries, alcoholism, and diabetes are higher among American Indians, rates of death from ischemic heart disease, cancer (particularly lung cancer), and respiratory disease are lower.[28,29] The deficits in heart and lung disease are thought to be due, in large part, to a low prevalence of cigarette smoking among American Indians.[28] We chose the non-White mortality rates for New Mexico and Arizona as the comparison because no national mortality rates for American Indians were available and because the non-White population in these two states included a relatively high percentage of American Indians. However, because the non-White comparison rates include other races that have mortality patterns different from that of the Navajo, some standardized mortality ratios in this study may have been biased. Potentially compounding any bias were the changing percentages of American Indians among the non-Whites in the two states over the period of the study. To address this problem, we performed Cox regression analyses to provide for internal comparisons.

In conclusion, we found excess mortality for lung cancer, pneumoconioses and other respiratory diseases, and tuberculosis for Navajo uranium miners. Increasing duration of exposure to underground uranium mining was associated with increased mortality risk for all three diseases. Increasing cumulative exposure to radon progeny, decreasing exposure rate, and decreasing time since last exposure to radon progeny were associated with increased mortality risk for lung cancer. The pattern of risk ratios among the light-smoking Navajo uranium miners was consistent with the risk ratios found in the previous analyses of Navajo and heavy-smoking White uranium miners. The most important long-term mortality risks for the Navajo uranium miners continue to be lung cancer and pneumoconioses and other nonmalignant respiratory diseases. □

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Ethnic Differences in the Prevalence of Nonmalignant Respiratory Disease among Uranium Miners

ABSTRACT

Objectives. This study (1) investigates the relationship of nonmalignant respiratory disease to underground uranium mining and to cigarette smoking in Native American, Hispanic, and non-Hispanic White miners in the Southwest and (2) evaluates the criteria for compensation of ethnic minorities.

Methods. Risk for mining-related lung disease was analyzed by stratified analysis, multiple linear regression, and logistic regression with data on 1359 miners.

Results. Uranium mining is more strongly associated with obstructive lung disease and radiographic pnuemoconiosis in Native Americans than in Hispanics and non-Hispanic Whites. Obstructive lung disease in Hispanic and non-Hispanic White miners is mostly related to cigarette smoking. Current compensation criteria excluded 24% of Native Americans who, by ethnic-specific standards, had restrictive lung disease and 4.8% who had obstructive lung disease. Native Americans have the highest prevalence of radiographic pneumoconiosis, but are less likely to meet spirometry criteria for compensation.

Conclusions. Native American miners have more nonmalignant respiratory disease from underground uranium mining, and less disease from smoking, than the other groups, but are less likely to receive compensation for mining-related disease. (*Am J Public Health.* 1997;87:833–838)

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Introduction

In addition to its well-known association with lung cancer, uranium mining is associated with an increased risk of nonmalignant respiratory diseases.[1] The atmosphere of uranium mines may contain high concentrations of silica dust, radon, and diesel fumes; in addition, non-Hispanic White miners are known to have high rates of tobacco use.[1] Studies of uranium miners in the Colorado Plateau have found excess mortality from pneumoconiosis and other respiratory diseases in non-Hispanic White and Native American miners.[2,3] These studies have suggested differences in the rates of nonmalignant respiratory disease among non-Hispanic White and Native American uranium miners, although the relative contribution of cigarette smoking and mining exposure in each group has not been addressed.

Uranium mines in New Mexico and the Colorado Plateau were responsible for the majority of the US uranium production during the Cold War.[4] Many of the earliest mines in this area, known as "dog holes," were infamous for their lack of ventilation and poor working conditions. Non-Hispanic Whites, Hispanics, and Native Americans from the region were recruited to work in the mines, which were often located on Native American reservations.[5(pp183–202)] It has been alleged that uranium mining is an example of "environmental (in)justice," wherein certain racial and economically disadvantaged groups incur an undue burden of illness from hazardous exposures.[5(pp183–202),6–8]

In 1990, the Congress of the United States passed the Radiation Exposure Compensation Act (RECA) to atone for illness sustained by these miners in an industry considered vital to the national defense.[9] RECA specifies that to receive compensation for a nonmalignant respiratory disease, a miner must have the following: (1) a forced expiratory volume in 1 second (FEV_1) or forced vital capacity (FVC) less than 75% of what is predicted by the Knudsen 1983 formula,[10] (2) a chest radiograph demonstrating at least a 1/0 profusion score by the International Labor Organization rating system, and (3) proof of 200 working-level months of underground mining exposure if a nonsmoker, or 500 working-level months if a smoker. Although it is accepted practice to use ethnic-specific prediction equations whenever they are available,[11] RECA uses the Knudsen formula, based on non-Hispanic White nonminers, as the standard for all miners.

Since 1989, the New Mexico Miners' Outreach Program has offered free screening for mining-related diseases to active and retired miners in the southwestern United States. This paper describes the results from this program and addresses the following questions: (1) Have Native American miners incurred a higher prevalence of nonmalignant respiratory disease associated with underground uranium mining than non-Hispanic White or Hispanic miners? (2) How does the use of

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impairment criteria based solely on spirometric prediction equations for non-Hispanic Whites affect Native American and Hispanic miners?

Methods

The New Mexico Miners' Outreach Program is conducted by Miners' Colfax Medical Center in Raton, NM, in collaboration with pulmonary physicians from the University of New Mexico Health Sciences Center. The program is designed to detect mining-related diseases in persons who have worked in mines of any type. Any self-identified current or former miner is eligible for free health screening. Participants are examined at the Miners' Colfax Medical Center or in a mobile clinic that periodically visits mining communities in New Mexico and south central Colorado.

Miners are recruited through mining unions, physician referrals, and notices in newspapers and on radio. The health screening is composed of a standardized medical questionnaire administered by a trained interviewer, a posterior-anterior chest radiograph interpreted by a certified "B" reader who is not aware of the clinical history, and spirometry performed according to American Thoracic Society guidelines by a certified respiratory therapist.[11] From the inauguration of the clinic on December 5, 1989, through May 18, 1995, a total of 2964 miners were screened, 1809 of whom report having worked in a uranium mine. Fifty miners who were missing chest-radiograph or pulmonary function data were excluded; 253 miners who worked less than 3 years in uranium mining were excluded, because this is the minimum time needed to accumulate the working-level months of radon exposure required by the RECA. Of the 1506 remaining, 23 females; 17 persons reporting an ethnic background other than non-Hispanic White, Hispanic, or Native American; and 107 persons who were missing data on total years of uranium mining, pack-years of smoking, or physiometric data were excluded. The remaining 1359 persons were included in our analysis.

Definitions of obstructive and restrictive lung disease and pneumoconiosis are based on the RECA criteria. Obstruction is defined as an FEV_1 less than 75% of what is predicted by the Knudsen formula,[10] with an FEV_1/FVC ratio below 70%. Restriction is defined as an FVC less than 75% of what is predicted by the Knudsen formula,[10] with an FEV_1/FVC ratio above 70%. Radiographic pneumoconiosis is defined as a profusion of 1/0 or greater as read by a certified "B" reader using the International Labor Organization classification system. Pack-years were calculated by dividing the average number of cigarettes the miner used per day over his lifetime by 20, and then multiplying by the total number of years he smoked.

Multivariate models for obstructive lung disease, radiographic pneumoconiosis, and FEV_1 were developed by ethnic group to look for evidence of effect modification on the basis of ethnicity. Analysis of factors associated with restrictive disease was limited by the small number of miners meeting the restrictive disease definition. Univariate analysis was used to identify important factors to be included in the models. Uranium miners who worked exclusively underground had a higher risk of obstructive lung disease and radiographic pneumoconiosis than those with any above-ground experience, so above-ground uranium mining was included in the nonunderground uranium-mining category. Stepwise regression was used to arrive at the most parsimonious models, with covariates eliminated if they were nonsignificant ($P > .05$). Underground uranium mining was retained in all models as the exposure of interest. Pack-years of cigarette smoking and mining other than underground uranium mining were also retained in all models as important confounders.

All data were stored and processed using SAS applications programming.[12] Demographic data were analyzed by one-way analysis of variance using the SAS GLM procedure, with differences between groups tested with the use of a Scheffé test for the difference between means at a .05 significance level. Differences in the proportions of spirometric and radiographic abnormalities among ethnic groups were tested with exact procedures.[13] Multiple linear regression and logistic regression models were calculated with the GLM and LOGISTIC procedures in SAS. Differences in the coefficient estimates between ethnic groups were tested using the Student's t test for the difference between independent means, with a P value of .05 or less designated as significant.

To find the effect of using compensation criteria based on non-Hispanic Whites for Hispanic and Native American miners, spirometric prediction equations based on Hispanic adult men from New Mexico and Native American adult men from Utah were selected as the reference standards for these two groups.[14,15] The number of Hispanic and Native American uranium miners in our survey disqualified for compensation by the RECA was calculated through a comparison of (1) the number with FEV_1 or FVC less than 75% of what is predicted by the Knudsen equation with (2) the number with less than 75% as predicted by the appropriate ethnic-specific equation.

Results

Of the 1359 miners in this study, the majority were Native American (63.4%). The Native American group was significantly older than the Hispanic and non-Hispanic White groups (Table 1). The non-Hispanic White group was significantly taller and heavier than the other two groups; however, there was no significant difference in the body mass index among the three groups.

The proportions of miners who were smokers, exsmokers, or nonsmokers varied dramatically among the three ethnic groups. Of Native American miners in the study, 72.9% reported never smoking cigarettes, compared with 22.2% of non-Hispanic Whites and 34.6% of Hispanics. Of the miners who were current or previous cigarette smokers, the mean pack-years of cigarette use also varied significantly among the three ethnic groups. Native Americans who had ever used cigarettes smoked an average of only 6.4 cigarettes per day, while non-Hispanic White and Hispanic smokers averaged 20.5 and 14.3 cigarettes per day, respectively.

Mining experience also varied significantly among the three ethnic groups (Table 1). Native Americans in our survey were more likely to have worked only in underground uranium mining, as opposed to working above ground at an underground mine or at a surface or "open-pit mine. The Native Americans in our survey were also more likely to have engaged only in uranium mining, while non-Hispanic Whites and Hispanics often worked in several different types of mines. Metal mining was the most common other type of mining engaged in by the non-Hispanic Whites and Hispanics in our survey; in New Mexico, this includes underground molybdenum and open-pit copper mining. Coal mining was the most common other type of mining engaged in by the Native Americans in our survey; in New Mexico, coal mining is usually open-pit mining.

The prevalence of spirometric and radiographic abnormalities by ethnic group was tabulated with the RECA definitions (Table 1). The non-Hispanic Whites had a significantly higher proportion with obstructive lung disease ($P < .001$), while the Native Americans had a higher proportion with restrictive lung disease ($P < .05$). The non-Hispanic White and the Native American groups did not differ in the prevalence of radiographic pneumoconiosis despite the significantly lower average lifetime mining exposure of Native Americans.

Risk factors for obstructive lung disease in our study were, overall, underground uranium mining, other types of mining, cigarette smoking, and advanced age (Table 2). Height, weight, and working exclusively above ground did not significantly affect risk for obstructive lung disease. The adjusted odds ratio for underground uranium mining exposure is greater in the Native American group than in the others, and significantly higher than for the Hispanic group. Although mining experience in other mines was also associated with an increased risk of obstructive lung disease in the overall model, the adjusted odds ratios for the individual groups were highly variable and not significantly different. Cigarette smoking was also significant only in the overall model. The adjusted odds ratios for age were lower in the Native American group than the other groups. This age effect could be due to residual confounding from smoking, because of inaccuracies in estimation of pack-years and because of the positive correlation in non-Hispanic White and Hispanic miners between pack-years and age.

TABLE 1—Demographic, Spirometric, and Mining Data by Ethnicity: New Mexico and South Central Colorado Uranium Miners, 1989 through 1995

	Non-Hispanic White (n = 162)	Hispanic (n = 335)	Native American (n = 862)
Demographic data			
% of total (n = 1359)	11.9	24.7	63.4
Mean age, y[a] (SD)	57.3 (11.8)	54.0 (10.6)	60.1 (10.6)
Mean height, cm[b] (SD)	174.4 (7.3)	168.8 (6.4)	169.3 (5.7)
Mean weight, kg[b] (SD)	85.9 (17.1)	79.6 (12.8)	79.2 (14.1)
Smoking			
Never, no. (%)	36 (22.2)	116 (34.6)	628 (72.9)
Exsmoker, no. (%)	85 (52.5)	125 (37.3)	193 (22.4)
Pack-years[a] (SD)	31.0 (30.0)	16.9 (18.1)	6.8 (13.2)
Smoker, no. (%)	41 (25.3)	94 (28.1)	41 (4.8)
Pack-years[a] (SD)	36.1 (33.3)	19.1 (14.6)	4.5 (6.3)
Mining experience			
Underground uranium only, no.[a] (%)	101 (62.4)	199 (59.4)	727 (84.3)
Above-ground uranium only, no.[c] (%)	15 (9.3)	25 (7.5)	32 (3.7)
Underground and above-ground uranium, no.[c] (%)	46 (28.4)	111 (33.1)	103 (12.0)
Mean years underground uranium mining[c] (SD)	13.0 (8.0)	13.8 (8.4)	9.9 (6.7)
Mean years other mining[a] (SD)	7.5 (9.5)	3.6 (6.7)	1.5 (4.9)
Miners meeting RECA criteria			
Obstructive disease, no.[b] (%)	27 (16.7)	22 (6.0)	37 (4.3)
Restrictive disease, no.[c] (%)	1 (0.6)	2 (0.6)	16 (1.9)
Radiographic pneumoconiosis, no.[d] (%)	21 (13.0)	24 (7.2)	122 (14.2)

Note. RECA = Radiation Exposure Compensation Act.
[a]Difference between all groups significant ($P < .05$).
[b]Difference between non-Hispanic Whites and other groups significant ($P < .05$).
[c]Difference between Native American and other groups significant ($P < .05$).
[d]Difference between Hispanic and other groups significant ($P < .05$).

Underground uranium mining was associated with a statistically significant reduction in FEV_1 only in the Native American group (Table 3). The FEV_1 decreased by an estimated 8.0 mL for each year the average Native American worked in an underground uranium mine, yielding a mean decrease of 79.2 mL for the group, or a decrease of 160 mL after 20 years in uranium mining. The estimates for uranium mining in the non-Hispanic White and Hispanic groups were less than for Native Americans, but not statistically different. The mean decrease in FEV_1 associated with uranium mining was 62.4 mL and 33.1 mL in non-Hispanic Whites and Hispanics, respectively. The decrease in FEV_1 associated with working in other types of mines was also significant only in the Native American miners; however, the estimates in this category were very unstable. The decrease in FEV_1 associated with each pack-year of cigarette smoking was similar for the three groups. However, because of the differences in smoking behavior among the three groups, the net effect of smoking on each group is very different. For those persons in each group who reported ever smoking cigarettes, the smoking-related decrease in FEV_1 averaged 161, 67, and 27 mL for non-Hispanic White, Hispanic, and Native American miners, respectively. Note that these figures apply only to miners who have ever smoked, and 72.9% of the Native American miners never smoked. In summary, underground uranium mining was related to a significant decrease in FEV_1, and the degree of reduction in FEV_1 associated with 1 year of uranium mining is similar to that seen with 1 pack-year of cigarette smoking. Because of the differences in smoking behavior among the three groups, most of the decrease in FEV_1 in the Hispanic and non-Hispanic White groups is attributable to cigarettes, while most of the decrease in FEV_1 in the Native American group is attributable to uranium mining.

Multiple logistic regression was used to analyze factors associated with pneumoconiosis on chest x-ray (Table 4). Underground uranium mining was a statistically significant factor only in the Native American and Hispanic models, although the adjusted odds ratios among the three groups were not significantly different. Experience in other types of mines and smoking were not associated with radiographic pneumoconiosis in any group. The adjusted odds ratio estimates for age were greater in the Hispanic and non-Hispanic White groups.

We next examined the effect of using compensation criteria based on spiromet-

TABLE 2—Multiple Logistic Regression Results Providing the Important Risk Factors for Obstructive Lung Disease by Ethnic Group: New Mexico and South Central Colorado Uranium Miners, 1989 through 1995

	Non-Hispanic White OR (CI) (n = 162)	Hispanic OR (CI) (n = 335)	Native American OR (CI) (n = 862)	All, OR (CI) (n = 1359)
Underground uranium mining for 10-year intervals	1.114 (0.643, 1.930)	0.839 (0.491, 1.431)	**1.561 (1.027, 2.372)**	**1.347 (1.030, 1.763)**
Other mining for 10-year intervals	1.186 (0.759, 1.852)	0.777 (0.432, 1.399)	1.166 (0.700, 1.941)	**1.139 (1.096, 1.751)**
Smoking for 10 pack-years	1.097 (0.973, 1.236)	1.085 (0.843, 1.397)	1.236 (0.898, 1.699)	**1.188 (1.081, 1.305)**
Age, y	1.041 (0.994, 1.091)	**1.090 (1.038, 1.144)**	1.009 (0.976, 1.042)	**1.028 (1.006, 1.051)**

Note. OR = odds ratio; CI = confidence interval. Values expressed as adjusted odds ratios and Wald 95% confidence intervals. Model: logit(P[have obstructive lung disease]) = $\alpha + \beta_1$ (underground uranium mining) + β_2 (other mining) + β_3 (smoking) + β_4 (age) + ϵ.

TABLE 3—Multiple Linear Regression for FEV_1 by Ethnic Group: New Mexico and South Central Colorado Uranium Miners, 1989 through 1995[a]

	Non-Hispanic White (n = 162)	Hispanic (n = 335)	Native American (n = 862)	All (n = 1359)
Intercept, L[b]	−0.6194 (P = .69)	−1.4085 (P = .15)	−1.1927 (P = .05)	−0.8658 (P = .07)
Age, y[b]	−0.0373 (P < .01)	−0.0309 (P < .01)	−0.0331 (P < .01)	**−0.0343 (P < .01)**
Height, cm[b]	0.0351 (P < .01)	0.0382 (P < .01)	0.0374 (P < .01)	**0.0358 (P < .01)**
Underground uranium mining for 10 years[b]	−0.0520 (P = .52)	−0.0240 (P = .58)	**−0.0800 (P < .01)**	−0.0429 (P = .05)
Other mining for 10 years[b]	0.0057 (P = .93)	−0.0429 (P = .35)	**−0.0789 (P = .02)**	−0.0349 (P = .10)
Smoking for 10 pack-years[b]	−0.0493 (P = .01)	−0.0377 (P = .07)	−0.0425 (P = .12)	**−0.0397 (P < .01)**

Note. FEV_1 = forced expiratory volume in 1 second. Values expressed as parameter estimates in liters and P values for H_0: $\beta_\lambda = 0$.
[a]Model: $FEV_1 = \beta_0 + \beta_1$ (age) + β_2 (Height) + β_3 (underground uranium mining years) + β_4 (other mining) + β_5 (smoking) + ϵ. H_0: $\beta_\lambda = 0$.
[b]Difference in parameter estimates among ethnic groups not significant.

TABLE 4—Multiple Logistic Regression Results Providing the Important Risk Factors for Radiographic Pneumoconiosis by Ethnic Group: New Mexico and South Central Colorado Uranium Miners, 1989 through 1995[a]

	Non-Hispanic White OR (CI) (n = 162)	Hispanic OR (CI) (n = 335)	Native American OR (CI) (n = 862)	All, OR (CI) (n = 1359)
Underground uranium mining for 10 years	1.856 (0.940, 3.665)	**1.942 (1.104, 3.417)**	**2.591 (1.984, 3.384)**	**2.124 (1.724, 2.616)**
Other mining for 10 years	1.160 (0.680, 1.977)	1.114 (0.636, 1.952)	1.146 (0.819, 1.604)	1.139 (0.921, 1.407)
Smoking for 10 pack-years	0.963 (0.814, 1.140)	1.172 (0.892, 1.540)	0.796 (0.523, 1.213)	0.917 (0.811, 1.038)
Age, y[b]	**1.173 (1.085, 1.268)**	**1.141 (1.076, 1.211)**	**1.061 (1.038, 1.084)**	**1.087 (1.067, 1.108)**

Note. OR = odds ratio; CI = confidence interval. Values expressed as adjusted odds ratios and Wald 95% confidence intervals.
[a]Model: logit(P[have abnormal chest x-ray]) = $\alpha + \beta_1$ (underground uranium mining) + β_2 (other mining) + β_3 (smoking) + β_4 (age) + ϵ.
[b]Difference between estimates for Native Americans and others are significant (P < .05).

ric criteria derived from non-Hispanic Whites for Native Americans and Hispanics. The number of members of each ethnic group in our survey who met the compensation criteria by the RECA formula were compared with the number of miners who were less than 75% predicted in FEV_1 and FVC with the use of prediction equations derived from populations similar to those of our Native American and Hispanic miners. Little difference was found in the Hispanic group with the use of a Hispanic-specific equation for either FVC or FEV_1 criteria.[14] Two Hispanic miners with obstructive lung disease were excluded by the RECA formula (22 miners versus 20), and there was no difference in the number of Hispanic miners with restrictive lung disease. No miner with obstructive or restrictive lung disease by the RECA formula was excluded by the Hispanic-specific equation. For the Native American group, the discrepancy between the RECA formula and the ethnic-specific equation was greater.[15] Our survey shows that 24% of Native Americans with restrictive lung disease by the Native American–specific equation were excluded by the RECA formula (21 miners vs 16). One Native American with obstructive disease was also excluded by the RECA formula (38 miners vs 37). No

Native American with obstructive or restrictive lung disease by the RECA formula is excluded by the ethnic-specific equations.

As another index of the relative fairness of the act, we also tabulated, by ethnic group, the number of miners with radiographic evidence of pneumoconiosis who had spirometric values that qualified them for compensation by the RECA criteria. As Table 1 shows, 122 Native Americans, 21 non-Hispanic Whites, and 24 Hispanics had abnormal x-rays consistent with pneumoconiosis. Of the Native Americans, 10.6% (13) met the criteria for obstructive disease, compared with 33.3% (7) of the non-Hispanic Whites, and 8.3% (2) of the Hispanics. Of the Native Americans, 1.6% (2) met the criteria for restrictive lung disease, compared with 8.3% (2) Hispanics, and no non-Hispanic Whites. In summary, although Native American miners had the highest prevalence of radiographic pneumoconiosis, they were less likely than the other groups to meet the RECA compensation criteria.

Discussion

Our survey found underground uranium mining to be associated with an increased risk of obstructive lung disease, decreased FEV_1, and increased risk of radiographically evident pneumoconiosis, with the degree of impairment per year spent in uranium mining greater in Native American than in Hispanic or non-Hispanic White miners. Cigarette smoking accounted for most of the obstructive lung disease in the non-Hispanic White and Hispanic uranium miners, but not in the Native Americans. In our survey population, the current RECA compensation criteria based on non-Hispanic Whites excluded 24% of Native Americans who, according to ethnic-specific standards, had restrictive lung disease and 4.8% of Native Americans who had obstructive lung disease. The current RECA spirometric criteria also exclude from compensation more Native American miners who have radiographic evidence of pneumoconiosis than Hispanic or non-Hispanic White miners.

Our study is subject to several limitations. The measures of exposure to mining and cigarettes depend entirely on self-report, although the mean uranium mining years and the prevalence and intensity of cigarette use by ethnicity are similar to findings of previous studies of Colorado Plateau and Grants mineral belt miners.[2,3,16] Also, the smaller numbers of Hispanics and non-Hispanic Whites in our survey reduce the power to detect an effect from uranium mining in the multiple linear regression and logistic regression models in these groups. Nevertheless, when the non-Hispanic White and Hispanic groups are combined, the estimates of effect for underground uranium mining are still much lower than for Native Americans, and not statistically significant.

Cross-sectional surveys are particularly susceptible to selection bias, which may have caused some of the differences among the ethnic groups. Obviously, we are able to examine only miners who have not already died with mining-related disease. Native American miners in our survey are mostly from the northwestern part of New Mexico, where the majority of the mines operating in the 1940s and 1950s are located. In the rush to produce uranium for nuclear weapons in the early part of the Cold War, safety in the early mines was neglected, and miners were exposed to high concentrations of radon and silica dust.[4,5(pp183–202)] Native Americans also tended to be subjected to greater underground exposures because they were less likely to work in supervisory positions.[4,6] The majority of non-Hispanic White and Hispanic miners in our survey live in the Grants Mineral Belt area, where most of the newer mines operating in the 1960s and 1970s are located, and were likely to have been exposed to much lower concentrations of silica dust and radon during their mining experience than the Native American miners. On the other hand, far fewer of the Native Americans exposed themselves to the confounding effects of cigarette smoking and nonuranium mining. Had we been able to recruit non-Hispanic Whites or Hispanic miners who worked in the same conditions and used cigarettes at the same rate as Native Americans, there is no reason to suspect the prevalence of lung disease would be any different among the three groups. Nevertheless, of the miners who were still living and participated in our survey, nonmalignant respiratory disease is much more closely related to uranium mining in Native Americans than in non-Hispanic Whites or Hispanics, and current compensation programs must reflect the burden of disease on miners alive today.

Previous studies of uranium miners in the Colorado Plateau and New Mexico suggested an association between obstructive ventilatory defects and uranium mining, but were unable to analyze the contribution of smoking or differences between ethnic groups. An early study of the Colorado Plateau miners found reductions in FEV_1 and FEV_1/FVC ratio associated with years of uranium mining and smoking; however, the methods of spirometric testing would be unacceptable by today's standards; the effect of silica dust exposure was dismissed; and Native Americans were specifically excluded.[17] Trapp et al. intensively studied 34 former uranium miners and concluded that silicosis was an important component of their lung disease, but were unable to measure the relative contributions of silica dust and radon.[18] A survey of mostly Hispanic and non-Hispanic White miners of the Grants Uranium Belt in New Mexico found a small decrease in the percentage of predicted FEV_1 and maximum midexpiratory flow attributable to uranium mining by multiple linear regression.[16] FEV_1 was predicted to decrease by 0.46% of predicted rates for each year of uranium mining, while current smoking decreased the FEV_1 by 7.75%. However, when multiple linear regression analysis was performed on the spirometric parameters without expressing them as a percentage of predicted value, the significance of uranium mining was lost, suggesting that there may have been errors in the prediction equations. Non-Hispanic White and Hispanic miners could not be analyzed separately, owing to the small number of miners surveyed.

Silica dust and radon gas are the two main exposures thought to result in nonmalignant respiratory disease in uranium mining; however, it is difficult to assess the relative contributions of each. Uranium in the Colorado Plateau and the Grants mineral belt in New Mexico is found in quartz sandstone, and uranium miners in these areas have been found to have a high prevalence of radiographic silicosis.[2,16,18,19] The Colorado Plateau studies have found an association between working-level months of radon exposure and increased mortality from nonmalignant respiratory disease, but have neglected the effect of silica dust.[23] Animal studies have found that rats and dogs exposed to high concentrations of radon develop interstitial fibrosis and emphysema,[20] and studies in which Syrian hamsters and beagle dogs were exposed to radon and uranium ore dust found increased rates and severity of interstitial lung disease compared with animals exposed to radon alone.[21,22] Because of the variation in radon concentrations in the uranium mines and the relatively poor records of radon and silica exposures for each miner, it is unlikely that we will be able to estimate the relative contributions of radon and silica dust to nonmalignant respiratory disease in our miners.

We have demonstrated that the current compensation program is unfair to Native American uranium miners; however, designing a fair system will be problematic. No fully adequate reference standards are available for persons of advanced age in any ethnic group. Evidence also suggests that a "healthy-worker effect" is present in most mining populations, which produces a bias against the miners if standards based on the general population are used for comparison.[23] The contribution of cigarette smoking to uranium-mining-induced malignant and nonmalignant lung disease is substantial, but is not understood well enough to make individual assessments about the relative importance. Until the relationship between uranium mining and respiratory disease is better understood, it would probably be more equitable to establish criteria for respiratory disease on arterial blood gas measurements or exercise tests.

Another problem with the RECA standards is the requirement of a chest radiograph with profusion of 1/0 or greater. We have identified 119 Native Americans in our survey who have spirometric abnormalities below the RECA standard, but whose chest x-rays do not meet the criteria. Autopsy studies have shown that a large proportion of miners with a moderate to severe degree of silicosis cannot be diagnosed by routine chest x-rays.[24] Several studies have also shown that the physiologic abnormalities associated with silica dust exposure are not substantially different in persons with and without mild radiographic abnormalities.[18,25] High-resolution computerized tomography may be able to detect evidence of mining-related disease not found on routine chest x-rays, but relatively few controlled studies have been reported.[26] More research in this area is needed.

In conclusion, our study suggests that (1) Native American uranium miners in our survey have sustained a disproportionate burden of respiratory disease from uranium mining, and (2) current compensation programs are biased against Native Americans. Further research is needed on the interactive effects of radon, silica dust, and smoking, as well as a review of criteria for compensation for mining-related lung disease among uranium miners. ☐

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PERCEIVED OCCUPATIONAL AND ENVIRONMENTAL EXPOSURES
A Case Study of Former Uranium Millworkers

GARY E. MADSEN *is an associate professor of sociology at Utah State University at Logan. His main research interests focus on occupational and environmental sociology. His current research interests include the study of psychosocial effects of working in hazardous conditions.*

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ABSTRACT: Former uranium millworkers (83 American Indians and 87 non-Indians) who were employed at several mills in the Southwest prior to the Mine Safety and Health Act (MSHA) were interviewed. They were asked questions about their perceptions of working conditions, their health, and their families' living environments. Almost 90% identified a work environment in which they noted uranium concentrate (yellowcake) and/or ore dust on their clothing. Most respondents also brought their work clothing home to be washed. Half the respondents attributed health problems to the millwork, with the Indians more than twice as likely as the non-Indians to do so. Psychosocial stress experienced by many millworkers and their families is discussed.

Recent contributions to the disaster literature will be important for scientists, administrators and practitioners as they deal

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with *different* types of disasters. Substantial emphasis has been placed on conceptually differentiating between natural and technological disasters and on understanding the psychosocial stress of documented and undocumented disaster victims (Baum, 1988; Baum, Fleming, & Davidson, 1983; Baum, Fleming, & Singer, 1983; Cuthbertson & Nigg, 1987; Dawson, 1993; Edelstein, 1988; Gist & Lubin, 1989; Kasperson & Pijawka, 1985; Roberts, 1993; Taylor, 1989; Vyner, 1988; Williams & Lees-Haley, 1993).

In this paper we will focus on technological disasters. Natural disasters have been defined as "acts of God" and are generally sudden events, such as earthquakes and tornados. Technological disasters, on the other hand, may be acute (airplane accidents or dam breaks) or chronic (long-term toxic chemical or ionizing radiation exposures). Baum (1988, p. 57) states, "Although there are exceptions, technological calamities, especially when they involve toxic substances, can cause more severe, or longer-lasting mental and emotional problems than do natural disasters." He suggests that the long-term nature of such technological disasters and the lack of a clear beginning or end of exposure contributes to these problems. Also, victims can relive the stress associated with the technological failure through lawsuits and claims, as they attempt to place blame on those felt to be responsible for something that was not supposed to happen.

A recent example of a chronic technological disaster is found among underground uranium miners who worked in largely unventilated conditions during the heyday of the uranium boom, from the late 1940s through the 1960s. During the Cold War, millions of tons of uranium ore were produced on the Colorado Plateau. In the 1950s and 1960s private companies, contracting solely with the Atomic Energy Commission (AEC), employed thousands of workers in uranium mining and milling. The majority of these workers lived on Indian reservations and in the states of Arizona, Colorado, New Mexico, and Utah. The uranium miners were often exposed to high levels of radon and silica dust. The results of these exposures were manifest years later. However, it was not until lawsuits and epidemiologic studies documenting the connection between mine exposures

and illnesses that Congress passed the Radiation Exposure Compensation Act (RECA) in 1990 (see Archer, 1983; Ball, 1986, 1993; Eichstaedt, 1994; Gottlieb & Husen, 1982; and Samet et al., 1984). RECA provided compensation to underground uranium miners as well as nuclear testsite workers and residents who lived downwind from nuclear testing. Uranium millworkers were not included in this compensation because studies did not provide enough conclusive evidence linking work and illness.

Past research includes only epidemiologic mortality studies of white millworkers. These did not indicate an increase in overall mortality rates (Archer, Wagoner, & Lundin, 1973; Wagoner, Archer, Carroll, Holaday, & Lawrence, 1964; Waxweiler, Archer, Roscoe, Watanabe, & Thun, 1983). However, these researchers hypothesized that millworkers may experience excess deaths due to lung, lymphatic, and hematopoietic cancers; nonmalignant respiratory diseases (NMRD); and chronic renal disease (see U.S. Department of Health and Human Services, 1990).

Wagoner et al. (1964) found no statistically significant excesses of cancer or other major diseases. Archer et al. (1973), however, did find a significant excess of malignant diseases related to lymphatic and hematopoietic tissues. Archer later suggested that the higher level of lymphomas "might be a result of accumulation of long-lived radioactive materials such as uranium or thorium in lymph nodes" (Archer, 1981, p. 505). Although the difference was not statistically significant, Waxweiler et al. (1983) also found an excess of deaths from lymphatic malignancies. In addition, a statistically significant increase of NMRD, including emphysema, fibrosis, silicosis, and chronic obstructive pulmonary disease (COPD) was found by Waxweiler et al. (1983). An important possible contributing factor to NMRD is smoking behavior, which the study did not consider. Waxweiler et al. (1983) also found that mortality from renal disease was greater for millers than for controls, but the difference was not statistically significant.

Our research was initiated when some American Indian former millworkers requested that a study be conducted documenting their worklives. We felt it important to study millworkers' perceptions of their occupational, environmental, and health histories, including the potential linkages between uranium millwork, physical health problems, and psychosocial stress. Thus, we wanted to explore the possibility of former millworker experiences as a form of occupationally-related posttraumatic stress disorder (Baker & Karasek, 1995; Roberts, 1993; Schottenfeld & Cullen, 1985; and Vyner, 1988). Baker and Karasek (1995, p. 396) suggest:

> Any situation that evokes feelings of intense fear, helplessness, loss of control, or annihilation may precipitate the disorder. The trauma may be massive and discrete like an accident or may be [comprised] of episodes of exposure to a dangerous chemical or work process. The cardinal feature is repeated reexperiencing of the traumatic event.

Vyner (1988), based upon his in-depth case study of atomic veterans, identified a delayed-onset posttraumatic stress disorder he called radiation response syndrome (RRS). He found that the veterans were suffering psychosocial stress as they associated current illnesses with their past radiation exposures.

SAMPLE AND METHOD

There were more than 40 uranium mills in the western United States by the end of the 1960s, with each employing approximately 100 workers at a time. Key informants suggested that there may have been tens of thousands of millworkers altogether; however, a complete sampling frame was not available for this study. Many mills have been shut down since the late 1960s or early 1970s, and several mill companies are no longer in business. In addition, we were not successful in acquiring employee lists for several mills because of privacy concerns. Furthermore, many Public Health Service (PHS) medical records of millworkers who worked prior to 1965 were destroyed in a fire. The National Institute of Occupational Safety and Health (NIOSH) also has an extensive list of former millers who were involved in a previous study, but the names are confidential and were not available to us. At this time there is no known comprehensive list from which to draw a representative sample (National Institute of Occupational Safety and Health [NIOSH], 1995).

This research was largely exploratory, and thus we felt it was appropriate to develop many open-ended questions. This would allow respondents to have a wide latitude of responses from their own perceptual frameworks. To do this, we interviewed key informants: epidemiologists, government officials, industry experts, physicians, and former uranium millworkers. In addition, several questions were derived from an earlier study of uranium miners (Dawson, 1993). No previously developed standardized scales were used. The questions were pretested among millworkers and were found to be appropriate and understandable. All interviews were conducted in person and lasted approximately an hour.

The data were gathered during two periods over 17 months. The first part was conducted on the Navajo Nation from August through October of 1992, and the second part was conducted off the reservation in Utah from September 1993 through January 1994. During both phases, the names of possible respondents were first identified by key informants who knew former uranium millers. Following initial interviews, a snowball sample was employed: each individual was asked to identify the names of other millworkers known to him. During the process, some millworkers also provided partial employee lists they had saved over the years. All of those contacted, with the exception of seven non-Indians, agreed to be interviewed. The process yields a nonprobability sample.

The sample contained 170 former millworkers, including 83 American Indians and 87 non-Indians. (Several respondents indicated that they prefer the term American Indian to Native American; consequently, this term will be used throughout the article.) To be included in the study, millworkers needed to have worked for at least one year in a uranium mill. They were asked questions about their employment at six mills. The Indians were mostly from the Navajo tribe; however, respondents from other tribes included three Hopi, one Choctaw, and one unidentified tribal member. The non-Indian group consisted of 82 Anglos and 5 Hispanics. Five of the millers were women. Ages ranged from 45 to 90, the average age being 63, and the average level of education was 8 years for the Indians and 12 years for the non-Indians. There were 104 (61.2%) workers who were employed in uranium milling only, and 66 (38.8%) who had been employed as uranium miners and millers. The median average of years worked in the mills was 8, ranging from 1 to 32 years. We asked all respondents about their millwork experiences. In addition, those respondents who had been uranium miners and had lived near uranium mines were asked how they felt about living near these uranium sources.

Several key informants encouraged us to interview widows and family members of deceased millers. The key informants felt the widows/family members would be knowledgeable about the deceased millers. There were 34 widows and 2 children of deceased millers within the sample. We felt it was appropriate to analyze the widows/childrens' responses concerning health and environmental conditions. Included among the questions were: "Did the miller bring his workclothes home?" "Did he live close to the worksite?"

Major changes in national health and safety legislation occurred in the 1970s with the creation of the U.S. Mine Safety and Health Administration (MSHA) and the U.S. Nuclear Regulatory Commission (NRC). In this study, all workers were employed in uranium milling prior to the enactment of these stringent regulations. A majority were employed before 1970 only. Although a few worked both pre- and post-1970, there was no one within the sample who worked post-1970 only.

The initial data were gathered two years after the passage of RECA. Because there was intense publicity through the media, all of our respondents were aware of the act and its exclusion of millworkers. On the other hand, none of them indicated an awareness of any of the studies conducted of millworkers. Even we had difficulty in identifying the most comprehensive study, by Waxweiler et al. (1983), which was published only in a proceedings of a professional meeting.

FINDINGS

WORKPLACE ENVIRONMENT

The nuclear fuel cycle involves four stages: mining, milling, enriching, and fuel fabricating. Within the milling process there are several job tasks, including crushing and grinding of the ore (the grinding machines are called ball or rod mills), extracting uranium through various leaching processes, and drying and barreling the uranium concentrate, which is commonly known as yellowcake. There are many other tasks associated with a mill, such as administration, laboratory work, and maintenance.

The greatest hazard confronting most millworkers, according to the NRC, is dust produced from yellowcake and/or uranium ore (U.S. Nuclear Regulatory Commission [USNRC], 1986). Although it is recognized that millworkers were possibly exposed to chemical and physical hazards associated with large-scale industry, we limited our examination to dust problems. The NRC worker handbook (USNRC, 1986) states:

> The potential effects of breathing or swallowing uranium are the reason that special attention must be given to cleanliness in the mill. Smoking and eating are limited to clean areas of the mill facility to guard against breathing or swallowing the dust. Using work clothing that is left at the mill and laundered there helps to ensure that uranium dust is not carried home where it would unnecessarily expose you and your family. (p. 16)

We asked the respondents two interrelated questions regarding mill dust conditions: "Did yellowcake and/or ore dust get on your clothing?" and "Were the workclothes washed off the worksite?" In addition to the former millworker respondents, we found that widows and children were able to make judgments about dust on clothing because they saw the millers before and after work and generally discussed work dust conditions with them.

Because some workers were employed at more than one mill, we were able to identify 180 descriptions of working conditions for the 170 respondents. The presence of yellowcake and/or ore dust on work clothing was identified in 159 (88.3%) of the mill descriptions. Those who identified dust on workclothes were also asked to assess approximately how much they noticed. In 3 mill descriptions the respondents were unable to make an assessment. Of the remaining 156 descriptions, 49 (31.4%) indicated "light" amounts, 61 (39.1%) indicated "moderate" or "varying" amounts, and 46 (29.5%) indicated generally "heavy" amounts. Respondents were also asked to indicate how often they noted dust on their clothing. There were 155 descriptions of working conditions, with 4 unable to make a judgment. Of those who made a determination, 73 (47.1%) responded "very little/sometimes", 11 (7.1%) said "usually," and 71 (45.8%) said they "always" had dust on their workclothes.

Many workers commented on the dusty mill conditions. One who worked at two mills said, "Some of those guys, if you'd see them at the store, you'd see yellowcake under their fingernails and in their ears. You'd see yellowcake on the brim of their hats and inside the hatband." Another worker noted, "The crusher was so dusty you couldn't see down the ramp."

It was also found that 95% of the respondents reported taking workclothes off the worksite, at least during certain periods of their employment. Some made unsolicited comments about this practice. One worker noted, "They never told us to leave our workclothes there at the mill." Another reported:

> We washed the clothes once a week. It was messy. We were expecting our first child. I had to shake my clothes outside. There was yellow sand left at the bottom of the washer. All of the clothes were washed together. Nobody told us that uranium was dangerous—a problem. My wife would get yellowcake on her. I would remove my coveralls in the kitchen. Put them with the rest of the [family's] laundry.

During one interview a miller's spouse interjected, "I had to wash his clothes first and then put another load of family clothes in the same water. My oldest son helped wash. Real yellow dirt in [her husband's] clothes. It was in his ears, around his face, and shoes." Furthermore, one widow said:

> That uranium gets inside you—all through you. They used special soap at work. Yellowcake breaks[down] the clothes. It's hard on clothes. Yellowcake stings. It feels funny. There was a lot on his clothes. When you picked them up, it was left on the ground. I washed his clothes with the family clothes.

PHYSICAL AND EMOTIONAL HEALTH PROBLEMS

We identified self-reported physical and emotional health histories. Only 11 respondents, 6.5% of the total, reported no physical health problems. Those with health problems reported a number of symptoms, as well as diagnosed illnesses. Among them were heart, hypertension, eye, hearing, kidney, prostate, skin rash, and respiratory problems.

Respiratory problems were the most often reported category among the respondents. Respiratory symptoms and/or illnesses were identified by 89 people, or 56% of those who reported health problems. About 8 of 10 millers with respiratory problems reported symptoms that included shortness of breath, persistent cough, and wheezing. Almost 20% reported diagnosed illnesses that included emphysema, silicosis, chronic obstructive pulmonary disease (COPD), pneumoconiosis, pulmonary fibrosis, tuberculosis, and lung cancer (Dawson, Madsen, & Spykerman, in press). These results of respiratory problems among this sample are consistent with the previous research of Waxweiler et al. (1983).

Following the lead of Vyner's (1988) research of atomic veterans, we wanted to identify whether our respondents, who were suffering from physical ailments, were also suffering from emotional stress related to their physical problems. The link between physical and emotional problems was examined to try

TABLE 1
Anxiety and/or Depression Among Indians and Non-Indians With Physical Health Problems

Anxiety and/or Depression	Indians	Non-Indians	Total
Yes	50.6% (40)	27.5% (22)	39.0% (62)
No	49.4% (39)	72.5% (58)	61.0% (97)
Total (N)	100.0% (79)	100.0% (80)	100.0% (159)

NOTE: τ-b = .24. Z = 2.99. χ^2 = 8.94. $p < .003$.

to rule out emotional difficulties experienced because of other life events, such as death of a loved one or divorce. Moreover, we wanted to know whether they attributed their health problems to their former uranium millwork.

A majority of the respondents reported experiencing physical health problems. A number of them also reported experiencing emotional problems related to their physical health, including frustration, anger, not sleeping well, anxiety, and depression. Anxiety and depression were most often cited, with 49 (30.8%) reporting the former and 39 (24.5%) reporting the latter. In all, 62 (39.0%) reported anxiety, depression, or both. The data are presented in Table 1. It can be seen that the Indians identified anxiety and/or depression almost twice as much as the non-Indians, and the difference was statistically significant.

Did respondents attribute health problems to their millwork? There were four widows whose husbands did not discuss with them whether they believed health problems were related to their millwork. Of the remaining 155 with health problems, 89 (57.4%) stated they felt they had one or more health problems related to working at the mill(s). One can see from Table 2 that there was a higher percentage of Indians than non-Indians making such attributions, and the difference was statistically significant.

Why did more Indians than non-Indians make attributions that health problems were related to their millwork? One possible explanation is that they recognized that other workers who worked in uranium mills experienced similar health problems. Wegman, Levy, and Halperin (1995, pp. 63-64) indicate that

TABLE 2
Attribution of Health Problems to Millwork by Indians and Non-Indians

Attributed Health Problems to Millwork	Indians	Non-Indians	Total
Yes	81.8% (63)	33.3% (26)	57.4% (89)
Unsure	10.4% (8)	14.1% (11)	12.3% (19)
No	7.8% (6)	52.6% (41)	30.3% (47)
Total (N)	100.0% (77)	100.0% (78)	100.0% (155)

NOTE: τ-b = .53. Z = 6.98. χ^2 = 41.91. $p < .001$.

asking about knowledge of other workers' illnesses/symptoms "may be the most important clue to recognizing work-related disease."

We asked all respondents whether they noticed if other workers at the mill became ill. Fifty-two (62.7%) of the 83 Indian respondents identified other workers, whereas only 28 (32.6%) of the 86 non-Indians reported other workers who were ill. One non-Indian did not respond to the question. This difference between Indians and non-Indians was statistically significant (>.01) using chi square analysis. Some respondents noticed health problems in other millworkers when they were working, whereas others identified former workers presently experiencing health problems. Both Indians and non-Indians most often identified respiratory symptoms, such as persistent coughing.

In addition, the Indians exhibited a strong social network. Almost all of the former Indian millworkers had lived most of their lives on reservations and were part of a closeknit clan-based social structure. On the other hand, many of the non-Indians had moved to different areas, likely making it difficult to continue their relationships with other millworkers.

When millers attributed health problems to their work, were they more likely to experience emotional problems than the sample as a whole? The data indicate that this is so. Overall, 39.0% of the respondents with health problems reported anxiety and/or depression (see Table 1); however, of the 89 who attributed health problems to their millwork, 53.9% identified health-related emotional stress as reported in Table 3. This

TABLE 3
Anxiety and/or Depression Among Indians and Non-Indians Who Attribute Physical Health Problems to Millwork

Anxiety and/or Depression	*Indians*	*Non-Indians*	*Total*
Yes	60.3% (38)	38.5% (10)	53.9% (48)
No	39.7% (25)	61.5% (16)	46.1% (41)
Total (*N*)	100.0% (63)	100.0% (26)	100.0% (89)

NOTE: τ-b = .20. Z = 1.88. χ^2 = 3.54. p < .06.

represented 60.3% of the Indians and 38.5% of the non-Indians. The difference between Indians/non-Indians was statistically significant only at the .06 level.

One miller reported, "I worry a lot about what is going to happen to me because of uranium." And another noted, "I worry about my eyes and stay around the house mostly. I worry because I wasn't told that the job was dangerous. I also worry about what's going to happen to me." Both of the above respondents attributed health problems to working at the mills.

What about the 11 respondents who did not report experiencing any health problems? Did they express concerns about health issues for themselves or others? There were 5 who indicated concerns about possibly developing health problems related to the millwork or possible exposures to others. For example, one said, "I didn't realize there could be health hazards. If I had, maybe I wouldn't have worked at the mill." Another respondent noted:

> I didn't really have any knowledge of the danger part of it. I just thought it was a good job because it paid more money than my other job. I didn't know about the dangers until people started talking about cleaning up the tailings, and people started talking about the dangers of what we were exposed to.

LIVING ENVIRONMENT: PROXIMITY TO MINES AND MILLS

Minewaste and mill tailings, the byproducts of uranium mining and milling, can be found in close proximity to residential

TABLE 4
Indians and Non-Indians Who Experienced Selected Living Conditions

	Indians (*N* = 83)	*Non-Indians* (*N* = 87)	*Total* (*N* = 170)
Near uranium mine[a]	33.7% (28)	18.4* (16)	25.9 (44)
Near uranium mill[a]	75.9 (63)	19.5** (17)	47.1 (80)
Children play near uranium mine/mill	36.0 (30)	11.8** (10)	24.4 (40)
Bring home uranium materials and scrap[b]	58.0 (47)	46.5 (40)	52.1 (87)

a. Refers to living within half a mile of either a uranium mine or mill.
b. The uranium materials or scrap could be from mines and/or mills.
*Difference between Indians and Non-Indians, p < .05. **difference between Indians and Non-Indians, p < .001.

areas of workers and their families. Because these low-level radioactive substances are suspected of causing health problems, we felt it was important to identify whether millworkers and their families had lived in close proximity (within a half mile) of a uranium mine(s) and/or mill(s). We also asked whether the workers brought any materials home from the sites.

All respondents who lived close to uranium mines did so for a median average of 3 years, whereas those residing close to the mills averaged 5 years. The figures in Table 4 show that the Indians experienced these environmental factors more than the non-Indians. The Indians were almost twice as likely to have lived within a half mile of a uranium mine/minewaste, and almost 4 times as likely to have lived near a uranium mill/mill tailings. Seventy (84.3%) of the Indians had lived in close proximity to a uranium mine and/or mill; only 24 (27.6%) of the non-Indians did so. Most of those who did live near mill or mine sites lived there when employed. At one mill the foundations of several homes were constructed partially of mill tailings. In addition, Indian children were 3 times more likely to have played near minewaste and/or mill tailings. All of these comparisons between Indians and non-Indians were statistically significant.

The following open-ended question was asked of the 94 respondents who had lived close to a mine and/or mill: "How do you feel about living close to a uranium source?" Thirty (31.9%)

did not express an opinion, and 10 (10.6%) said they had no worries associated with being close to a mine or a mill. The rest (57.4%) indicated several concerns. A content analysis of responses yielded three prominent types, with some respondents indicating more than one.

The first concern was the lack of radiation risk notification as noted by 34 respondents. Examples included: "I don't think anybody was aware until somebody came along and told us about the dangers. This was after the mill shut down." "It was just a day-to-day living. I didn't know anything about the dangers. Nobody knew, I think." "I didn't know until later that it could affect your health. Then I felt it was okay, but not now."

A second concern was worry about being exposed to radiation. Seventeen responses mentioned this, including the following typical comments: "I feel [the tailings pile] is not protected. I'm aware of gamma rays. Even though it's covered, I don't think it's safe. Wind would blow the tailings." "I don't think it was wise [to have lived near the mill] because of the radiation." "I think it will still be in the air. About 15-20 years later, you will begin to feel it."

The third concern identifies family members and others as possibly having health problems related to living near a mine or mill. Twenty respondents talked about such fears. For example, one miller stated:

> [The pollution] was bad in our part of town. The prevailing winds would blow. The acids would rot the clothes on the clothesline. We didn't get the gas and smoke, but others did. . . . We have two kids who were born [with disabilities] while I was working at the mill. We feel [their problems] might be caused by radiation. Every doctor diagnoses them different. The doctors don't seem to know what this is.

Another worker said:

> At the time the job was a form of employment. We never thought of it as being hazardous. It was only afterward that I knew it could be dangerous. We lived in a company house. I rented a mobile home for three years. I understand the materials the mobile homes were put on were radioactive. My wife died about 12 years ago. She lived at the mill housing for three years with me. She washed my mill clothes. She would shake the coveralls to get rid of the dust. She was diabetic and had kidney problems.

Several workers raised concerns about their children, who had played at the sites. One respondent said, "The boys would go play all day at the mill because their dad was in there. They would come home with dust on them. I thought it was okay [at the time]."

LIVING ENVIRONMENT: BRINGING BYPRODUCTS HOME FROM MILL/MINES

Materials (lumber, scrap metal, and uranium ore) were reported to have been brought home from mine and/or mill worksites by 52.1% of the workers, including 58.0% of the Indians and 46.5% of the non-Indians. This difference is not statistically significant. We did not ask the respondents if these materials had been inspected for radiation; however, some of them commented that they knew the materials had been inspected whereas others were unsure. Some of the respondents no longer had these items on their premises, others did. One worker said:

> The mill sold me three 55-gallon drums for hauling water. . . . Drums were stored among uranium ore. Dust was all over. The company brought in high-grade ore from [another town]. I feel the drums were contaminated with radiation. No one checked them. A lot of guys bought these drums.

Another reported that he had brought home used canvas vent bags (yellowcake area filters), which his wife had sewn together for mattress pads. Still another worker said, "[I] used scrap sheet metal from the mill that was left in a scrap pile. Used it for a sheep corral. I've still got it. I didn't know any dangers, but now I feel it is kind of dangerous."

A widow, whose husband hauled uranium ore by truck to the mills, reported that her husband would sometimes store the ore in their backyard between trips. She said, "He dumped uranium in the backyard when hauling from [the mines]. The kids played on the ore. He started out with one truck, then bought another truck. Kept a load at home [20-30 feet from the house] so he could go back and forth. They never told us [if it was dangerous]."

In addition, two respondents explained that they witnessed officials placing monitoring devices on their homes and surrounding land, but the respondents were never informed about the meaning and results of the monitoring. In one case, the resident looked outside to see officials in "moonsuits" monitoring her yard. She worried that she was not wearing protective clothing and had never been informed of a hazard. Further concern was expressed by members of three families who were not former millworkers. They heard that we were interviewing millworkers and approached us about their fears related to perceived environmental contamination of their homes and land, which were situated close to uranium millsites.

DISCUSSION

The results of this study indicate that a majority of the respondents perceive they have been victimized as a result of being associated with the uranium industry. More than half felt they had health problems related to the millwork, with Indians more likely than non-Indians to make this attribution. In addition, a number of those who lived in close proximity to mines and mills also expressed concerns that family members and friends also may have been adversely affected.

These findings are similar to Dawson's study (1992) of uranium miners and Vyner's study (1988) of the atomic veterans in that they provide some evidence of occupation-related post-traumatic stress disorder. It is not possible to compare these findings with other workers because, as Baker and Karasek (1995, p. 381) state, "The number of stress-related disorders is unknown among the general population of workers."

The psychological distress indicated by the responses of many former millworkers is consistent with Vyner's (1988)

observations of individual responses to invisible environmental contaminants, such as radiation. He states that (1988, p. 156):

> Some of the people who are exposed to an invisible environmental contaminant will either become concerned about whether that exposure has biologically harmed them, or they will actually become convinced that it has harmed them. Either circumstance will lead a person to want to become vigilant about the health effects of that exposure.

Furthermore, Vyner recognizes that it is difficult to assess one's situation without sufficient information, and it is therefore hard to attack the perceived problem adequately. Because of this, people have problems gathering information about the nature of their situation and the resolution of their problems. He says people may then become hypervigilant, with nonadaptive behaviors such as becoming preoccupied with either existing illnesses or possible future environment-related illnesses. For some individuals, hypervigilant behavior may be acute, whereas for others it may lead to chronic traumatic neuroses. We did not ask questions that could tap hypervigilance, such as how many health care professionals were contacted within a certain period. Such questions need to be asked in future research to ascertain how preoccupied the respondents are about their health.

In this case, the millworkers are unable to contact many of the uranium mill companies because they have long been out of business. Furthermore, records of exposures are not readily available, if at all. Medical and personnel records kept during their mill employment, in many cases, have either been destroyed or are unavailable. NIOSH is now attempting to identify exposure and personnel data for the uranium mills that were in operation before the 1970s (NIOSH, 1995).

Another problem confronting the millworkers is the lack of definitive epidemiologic studies linking illnesses with occupational exposures. Because such a long period of time has passed since this group of workers was employed, it will be difficult to construct adequate sampling frames for mortality and/or morbidity studies. We feel every attempt should be made to conduct new studies on these workers. The latest study (Waxweiler et al., 1983) was based on data ending in 1977, and an important contributing causative factor in illness, smoking data, is absent from this study.

Special attention needs to be directed toward the American Indian millworkers and their families. They appear as a group to have greater levels of stress than the non-Indians as they view their health related to the millwork. Large-scale representative samples are needed to assess both physical and emotional levels of health. In addition, it is critical to study Indians, because they are known to have a low smoking incidence.

A better dialogue needs to be established between experts (legal, governmental, medical, and scientific) and the uranium millworkers so that there can be a greater exchange of information, concerns, and needs related to this area. This would aid the millworkers in better understanding their situation. We interviewed several professional key informants who indicated to us differing levels of awareness about the millworkers' situation, ranging from some who believe the millworkers should be compensated for exposure to others who believe exposure was negligible. This difference of opinion among professionals can cause former millworkers increased uncertainty. Moreover, having incomplete information about occupational and environmental exposures can also lead to worries and concerns.

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Comment: Environmental Racism and Public Health

Equity and justice have emerged as central issues in environmental health policy in this decade,[1] although the debate is far from new. This change in agenda has been prompted, in part, by hundreds of grassroots organizations and community action groups that have focused attention on the environmental problems facing disadvantaged communities.

The environmental movement of the 1960s and 1970s was dominated by the White middle class.[2] It succeeded in building an impressive political base for environmental reform and regulatory relief. However, it failed to address charges that poor and minority communities are dumping grounds for environmental hazards.

The environmental justice movement of the 1980s and 1990s initially focused on claims that race and poverty are involved in the siting of undesirable facilities.[3] Today, the charge has broadened to include all issues of environmental degradation. Communities are demanding stronger participation in decisions that affect their health and homes.

In February 1994, President Clinton signed Executive Order 12 898, which requires all federal agencies to develop comprehensive strategies for achieving environmental justice. As a result, increased agency staff and more research funds have been allocated to address local environmental concerns. The US Environmental Protection Agency (EPA) created the Office of Environmental Equity to coordinate agency activities and provide technical assistance. Dr Kenneth Olden, the director of the National Institute of Environmental Health Sciences, has made his agency more responsive to the needs of environmentally degraded communities.

"Environmental racism" is a charge leveled by many communities of color, as they draw the lines in defense of their embattled environments. Sexton et al.[4] prefer the terms "environmental equity" or "environmental justice" to "environmental racism." These concepts extend concern to "the underlying principle that fairness and equity are inherent in society's efforts to protect the health of all citizens from the adverse effects of environmental agents."[4(p686)] Greenberg[5] further distinguishes between two forms of equity. Outcome equity requires balanced spatial and temporal distribution of benefits and burdens. Process equity requires application of equitable environmental, health, physical, legal, economic, and political criteria to arrive at environmental policy.

These distinctions, while useful, are inadequate to protect the public's health, especially for the most vulnerable among us. They also fail to recognize that racism pervades US society and that environmental protection is not immune.

In this issue of the Journal, Mapel et al.[6] document "environmental (in)justice" against Native American miners in at least three ways. First, the authors demonstrate a disparate burden of nonmalignant respiratory disease among them. Second, Mapel et al. observe ethnic differences in the spirometric criteria used to predict lung function, differences not being taken into account in the current standards. And third, they find prevailing compensation procedures for mining-related disease to be biased against Native Americans.

Here, it seems clear, deliberate discrimination on the basis of race has contributed to an undue burden of respiratory disease among Native American uranium miners. "Dog holes," as the earliest mines were known, were infamous for their lack of ventilation and poor working conditions. Local men were recruited to work in the mines, which were often located on Native American reservations.[7]

Environmental racism has parallels in other public health spheres and needs to be confronted. Prominent public health professionals have recently been maligned by Dr. Satel for proposing social solutions to public health problems. In particular, the fire has been directed against initiatives to advance the health of minorities and other disadvantaged groups.[8,9] These attacks, either disingenuous or ill informed, fail to recognize the historic understanding that societies shape patterns of disease.[10–12]

To discount racism as a potential contributor to disparities in health by race and ethnicity is to ignore well-established social history, not to mention the experience of many afflicted persons. Denial serves to perpetuate inequity. It also forecloses studies of racism focusing specifically on ill health and premature mortality.

Sorting out the health effects of racism is no simple task. The relationships between race, ethnicity, social class, segregation, discrimination, and patterns of disease are complex.[13–15] The research problems are thorny and difficult to assess, especially in data collected for other purposes. These difficulties have not and should not keep rigorous, compassionate, and creative public health researchers from trying.[16–20] Indeed, the gaps in rates of morbidity and mortality between African Americans and White Americans (which not only persist[21,22] but grow wider[23]) demand that we do no less. Public health has a fundamental role in preventing disease and a secure and legitimate role in helping to formulate policies and initiate programs toward that end. Engagement should be no less vigorous than on any other health initiative.

The core of the problem surely lies in the racial segregation that continues to afflict most urban and other communities in the United States. A number of reports support the commonplace observation that disadvantaged locales bear a disproportionate share of environmental hazards.[3,24,25] A widely cited, if hotly con-

Editor's Note. See related article by Mapel et al. (p 833) in this issue.

tested, study was published by the Commission for Racial Justice of the United Church of Christ.[25] Zip code areas containing one hazardous waste site had, on average, 24% people of color, compared with 12% in areas without a hazardous waste site. Zip code areas containing either (1) two or more facilities or (2) one of the five largest hazardous waste landfills in the nation had, on average, 38% people of color.

The experience of West Harlem, a largely African-American and Latino community, is a cogent illustration. The Clean Water Act barred the dumping of raw sewage into the Hudson River. New York City responded by constructing the enormous North River Water Pollution Control Plant on West Harlem's waterfront. The decision was political, not scientific. Developers had managed to block construction at an earlier site in a diverse, more affluent community downstream from West Harlem.[2,26] The West Harlem community united in outrage at the foul odors and emissions from the plant once it became operational, but it could not be shut down. Any resident of West Harlem will endorse this experience as a case of environmental racism. So do we.

Besides low-income people and racial and ethnic minorities, other groups have been victims of environmentally unjust policies and practices.[27,28] Multiple and often greater exposures affect workers in hazardous occupations.[6,29] At the same time, susceptibility to environmental insults is greatest among other vulnerable populations: the young,[30] the old, the immunocompromised, and the infirm.[29]

Environmental health researchers need to consider all populations threatened by environmental hazards, deprived or not. Legislation to protect health and the environment must win broad-based support if it is to avoid being perceived as serving narrow interests.[31] Nonetheless, this broader conceptual range does not remove racism from the social and economic equation. It is hard to overlook the historic contribution of redlining to the decline of major urban centers. Indeed, present-day siting and zoning decisions still place people of color under environmental siege.

Lead provides a compelling example. According to Max Weintraub of the National Safety Council, Washington DC, African-American children are four times more likely than White children to have elevated blood lead levels and seven times more likely to require medical evaluation for lead poisoning (letter, *Am J Public Health*, in press). These differences are largely due to housing and other environmental factors. Such exposures are direct consequences of the extreme residential segregation of African-American communities in old and poor neighborhoods.[32] Leaded paint in deteriorated housing and emissions from heavy traffic combine with poverty, limited access to health care, poor nutrition, and pica to raise blood lead levels in African-American children. Severe neurologic impairment and death are now rare, but subtle cognitive effects that often go unnoticed persist. Some believe that lead may even contribute to the disproportionately high numbers of African-American youth in New York City's special education classes,[2] an explanation that lies within the realm of possibility.

How, then, to best protect the public from environmental health risks? First, rigorous studies are required to fully address the distribution of environmental hazards by locality and their relationships with suspected health risks. Careful attention needs to be given to which populations are at risk, the hazards assessed, the geographic areas compared, and the epidemiologic and statistical methods applied in the research.[5] Especially promising are advanced mapping capabilities available in geographic information systems. These can incorporate data on both environmental exposures and disease outcomes and can relate both kinds of data in spatial analyses.

Second, appropriate environmental interventions need to take account of the social and cultural dimensions of affected communities. Alliances at the local level are more likely to result in the effective remedy of recognized or discovered hazards as well as in continued protection.[33] Funds are necessary to carry out such studies. The EPA and the National Institute of Environmental Health Sciences, as well as state and local health departments, have begun to support community-driven research, but more sustained funding is needed.

Third, careful monitoring of specific environmental hazards and exposures as well as overall surveillance of potential health risks is required.[34] Goals such as the more equitable distribution of undesirable and desirable environmental features must be formulated with community participation. The extent of progress when new policies are implemented needs to be evaluated and broadly reported. Here, occupational surveillance can serve as a useful model for environmental surveillance.[35]

Finally, the environmental justice movement can profit from the experience of past public health campaigns that have successfully intervened in a broad way against identified hazards. As in the antismoking crusade, the key is to set about building a public health initiative in a conscious and purposeful way.[36]

Unprecedented attacks on environmental legislation by the 104th Congress provoked a backlash by an American public unwilling to dismantle two and a half decades of progress towards environmental protection. Stronger safeguards are now being proposed: for example, the EPA recently announced stricter air-quality standards for small particulate matter and ozone.

Environmentalists have often been cast by the spokepersons for heavy industry as a threat to jobs and profits. Today, the country at large understands that environmentalism is not merely the preserve of a privileged elite protecting their open spaces. Instead, urban and rural grassroots organizations, established environmental groups, and government agencies are assembling in force to address local environmental concerns. Environmental activists provide their communities with materials and data to help them make informed choices with regard to environmental policies. As public health campaigns have often demonstrated, when people are informed, action follows.

Environmental concerns have always been inextricably tied to public health and development. Many exposures are broad in scope. The interventions to address them require public health policy and action. Already hazards exist for which community and even national action will not suffice to protect public health. International cooperation is necessary to deal with marine dumping, deforestation, burning of fossil fuels and, the thinning of the ozone layer.[37,38] Thus, when global solutions need to be found, environmental issues enter the domain of foreign policy.

As momentum builds, all levels of the environmental justice movement must engage with public policy, work with government agencies, and advocate for legislation and regulation as needed.[36] In this way, progress towards "environmental justice"[39] might be sustained, not only through the current administration but beyond. □

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Topics for Our Times: Affirmative Action and Women's Health

This past November, the California Civil Rights Initiative, Proposition 209, was approved by California voters. Although its proponents describe it as antidiscriminatory, the text of the measure explicitly bans outreach and remedial and recruitment efforts to help minority and female students with math, science, and entry to higher education. It also threatens to bar women from a range of occupations in ways that hark back to the era prior to passage of the Civil Rights Act of 1964.

Despite its equally threatening assaults on opportunity for both women and minorities, advocates of Proposition 209 tried to enlist women (implicitly as Whites) and to depict the opposition as minority (implicitly as males). Such dichotomies are not only politically divisive but also spurious; the categories are neither mutually exclusive nor homogenous—a woman may also be a member of a minority group. The term "minority woman," in turn, comprises a range of experiences. Too often, even the proponents of affirmative action restrict advocacy primarily to one group. It is necessary to understand the diversity and specificity of both gender and ethnic status to assess the implications of affirmative action for women's health.

Broadly speaking, affirmative action has two general goals—social justice and efficacy. The former assumes that because of past and present experiences of discrimination the playing field is not level for

"ENVIRONMENTAL JUSTICE": THE CENTRAL ROLE OF RESEARCH IN ESTABLISHING A CREDIBLE SCIENTIFIC FOUNDATION FOR INFORMED DECISION MAKING

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Although much of the evidence is anecdotal and circumstantial, there are mounting concerns that environmental health risks are borne disproportionately by members of the population who are poor and nonwhite. We examine the central role of environmental health research in defining the dimensions of the problem, understanding its causes, and identifying solutions. Environmental health sciences, including epidemiology, exposure analysis, pharmacokinetics, toxicology, and surveillance monitoring, must be employed to determine the extent to which society has achieved "equity" and "justice" in safeguarding the health and safety of its citizens. By improving our ability to identify, evaluate, prevent, and/or reduce risks for all members of society, environmental health research can contribute directly to fair and equitable protection for everyone, regardless of age, ethnicity, gender, race, or socioeconomic status.

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3. Key Words: environmental equity, environmental health research, environmental health risks, environmental justice.

4. Abbreviations: ATSDR, Agency for Toxic Substances and Disease Registry; CEQ, Council on Environmental Quality; EPA, Environmental Protection Agency; GAO, General Accounting Office; NIEHS, National Institute of Environmental Health Sciences; OEE, Office of Environmental Equity; PCB, polychlorinated biphenyls; UCC, United Church of Christ.

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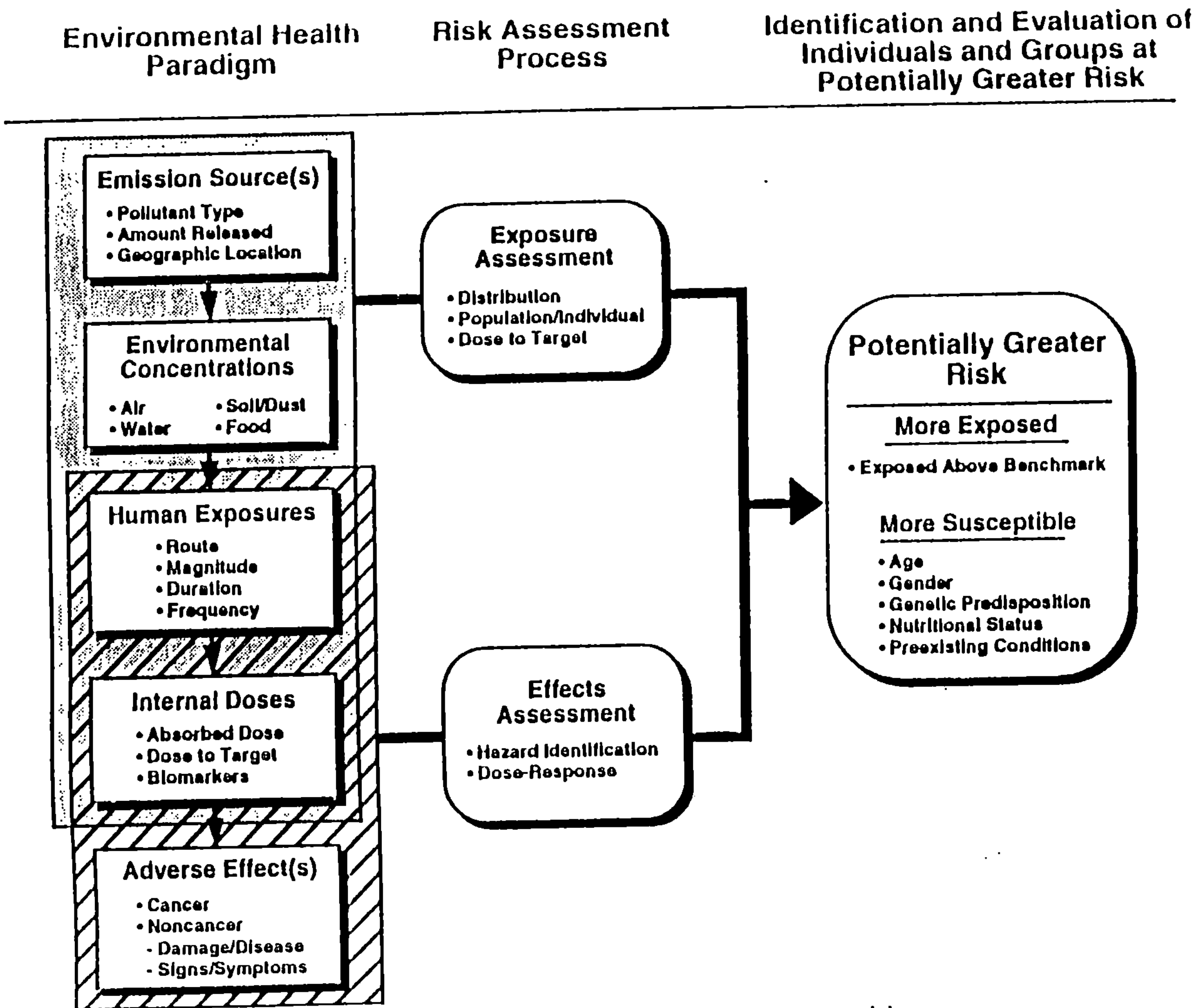

FIGURE 7. Identification and evaluation of groups potentially at greater risk.

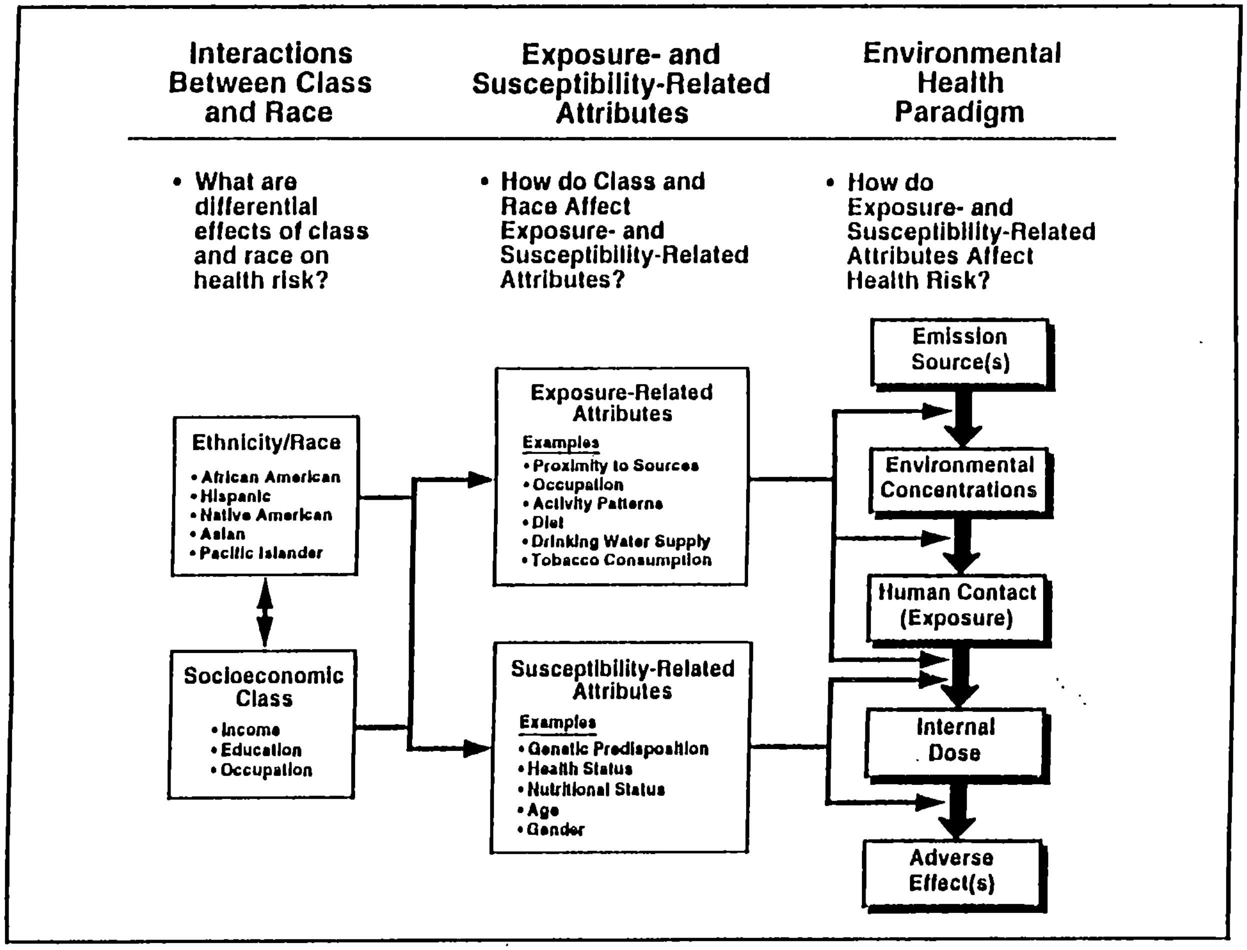

FIGURE 9. Conceptual model for generating testable hypotheses about causal relationships between demographic variables and environmental health risks.

5

PERSONAL EXPOSURE TO INDOOR AIR POLLUTION

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INTRODUCTION

The term *personal exposure* refers to pollutant contact with an individual as he or she moves through various environmental settings, and is represented by the concentration at the boundary prior to ingestion, dermal uptake, and/or inhalation of that contaminant by the individual.

Accurate characterization of personal exposure is needed for valid assessment of health effects and the design of more effective intervention strategies. Misclassified exposures reduce the sensitivity of epidemiologic studies to detect the effects of pollutants or lead to spurious associations. For example, use of ambient air pollution levels to characterize exposures for residents of a community will not classify personal exposures accurately if there are indoor sources of the same pollutant and/or a large proportion of time is spent indoors. Further, exposure to pollutants of outdoor origin will be modified by infiltration and reaction indoors. In the context of an epidemiologic study, if these factors are randomly distributed across communities (i.e., exposure groups), then the estimate of the magnitude of the health effect might be underestimated (Shy, Kleinbaum, and Morgenstern 1978; Ozkaynak et al. 1986). However, if there are systematic differences in the distribution of indoor sources, or mitigating factors, then it is possible that positive or negative associations might be incorrectly attributed to the "assumed" exposure variable.

Personal exposure data might improve the cost effectiveness of control and mitigation strategies. If a personal exposure study indicates that the major portion of the total exposure is attributable to automobiles, one control strategy would be to restrict motor vehicle emissions, reducing exposures to those people in transit or pursuing activities near traffic. Restrictions on stack emissions from a local power

Indoor Air Pollution: A Health Perspective
(JM Samet and JD Spengler, Eds.)
Baltimore: The Johns Hopkins University Press
1991 pp. 109 - ~~127.~~

plant, although effective in reducing the total ambient pollutant burden of the community, might have little impact on total exposure to respirable particles inside residences. Investigations of personal exposures may also identify subgroups of the population whose particular behaviors would place them at risk for elevated exposures. Evaluation of activity patterns and exposures to specific sources may facilitate understanding of the determinants of the exposures and serve as a basis for intervention.

Several factors have contributed to the growing awareness of the importance of adequate estimation of personal exposure. The first is the development of new personal monitoring instrumentation, which is small and unobtrusive (Wallace and Ott 1982). The measurements using personal monitors have demonstrated clearly the inadequacies of assuming personal air pollution predicted by measurements made at outdoor sites, the usual approach for many community air pollutants. The error is particularly large for pollutants such as carbon monoxide (CO) and nitrogen dioxide (NO_2), which are emitted from localized sources such as automobiles, kerosene space heaters, and gas cooking ranges (Akland et al. 1985; Quackenboss et al. 1986), but also has been demonstrated for more uniformly distributed regional pollutants such as ozone (O_3) and fine particulate matter, whose concentrations in indoor settings are mediated by building structures and surfaces (Spengler and Soczek 1984; Spengler et al. 1985; Contant et al. 1987). Second, the complexities of human behavior and movement may play a major role in determining personal exposure. Yet it has proven difficult to develop mathematical models for estimating individual exposure based on outdoor fixed-site or area measurements. Further, even for modeling population exposures, there is a lack of population-based data on activity patterns suitable for exposure risk analysis (World Health Organization 1982; Ott 1985; Sexton and Ryan 1988). This chapter develops a conceptual framework for exposure assessment in the indoor setting. The current monitoring methods are reviewed as they relate to strategies for personal exposure assessment, and exemplary applications are described. A more detailed treatment of air pollution measurement is provided in Chapter 4.

CONCEPTS AND DEFINITIONS

Figure 5.1 presents a conceptual framework for understanding personal exposure within the sequence of events between the emission of a pollutant from its source and the health effect experienced by a person who comes into contact with that pollutant. After release of a pollutant at a source, the pollutant moves through an environment in which it may be diluted and transformed by physical and chemical processes. As illustrated in the third component of the sequence, some of the pollutant (or the product of a transformation) eventually comes into contact with people, resulting in an "exposure." The link between the presence of a chemical contaminant in the environment and its contact with people is complex and in part determined by patterns of human behavior. The portion of exposure which is adsorbed, ingested, or inhaled into the body is termed the *dose*. It is this final

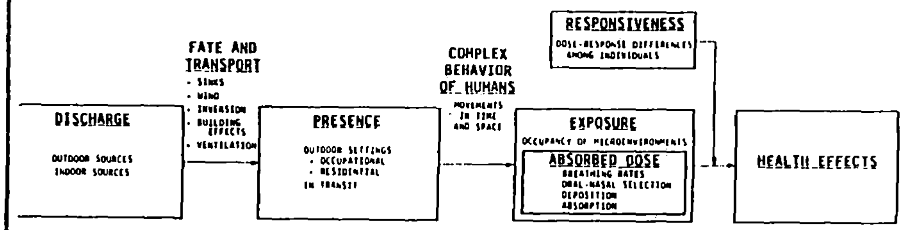

Figure 5.1. The biologic impact pathway.

amount of the chemical contaminant which produces the health effect. In the following sections, the terms *concentration*, *exposure*, and *dose* are more fully defined.

CONCENTRATION

The amount of a chemical contaminant at a particular location in a particular medium is termed the *concentration*. The concentration of an air pollutant is the amount of the material contained in a specified volume of air. Most air pollutant concentrations are expressed in mass per volume units (e.g., $\mu g/m^3$); however, gaseous pollutants may also be presented in units of a mixing ratio with air, typically in parts per million by volume (i.e., ppm_v). For certain particulate contaminants such as asbestos, the actual number of particles per unit volume is used (i.e., number count/m^3).

EXPOSURE

Exposure is defined as the contact of pollutant with a susceptible surface of the human body (Duan 1982; Ott 1985). For most air pollutants, this is the contact of pollutant with the skin, eyes, tissue in the nose, mouth, or throat, or the epithelium of the respiratory tract, the lining of the airways and alveoli. Thus, exposure can be simply defined as the simultaneous presence of a person and a pollutant in his or her immediate environment.

Exposure normally is considered to include within its definition an element of time. For example, exposures are typically given units of concentration multiplied by time (e.g., $\mu g/m^3$-h), connoting an equivalent exposure experienced by an individual subject to a fixed concentration for a period of time. This allows exposures to be placed on a scale and quantified. One may see from this that a complete description of exposure requires knowledge of three components: magnitude of pollutant concentration in the exposure environment; duration of the exposure; and the time pattern of the exposure. The first two components require little further explanation. The pattern of exposure is of importance because of possible differences in the effects of varying concentrations relative to fixed values. Further discussion can be found below.

Several commonly used means of characterizing exposure are presented in

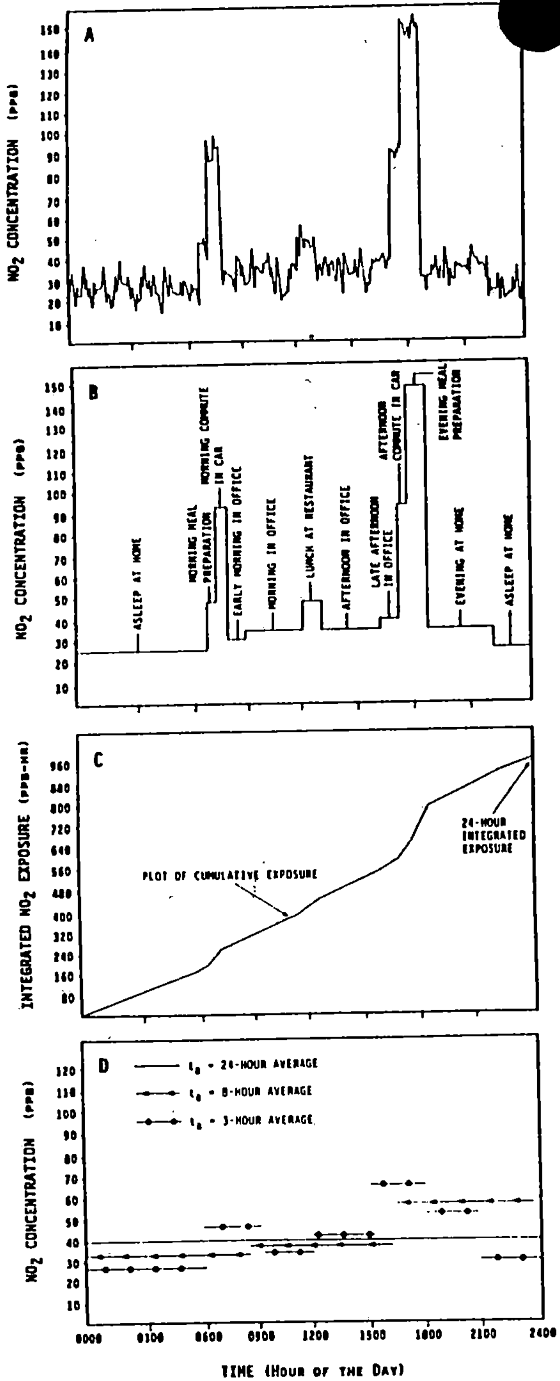

Figure 5.2. Examples of different ways to characterize an individual's personal NO_2 exposure profile. *Source:* Adapted from Sexton and Ryan (1988), with permission.

[illegible]igure 5.2. Graph A [illegible]s the five-minute mean NO_2 concentrations (part [illegible] billion or ppb) measured by a continuous monitor worn by an individual over a twenty-four-hour period. Some periods of the exposure profile are characterized by highly variable exposures to peak levels as high as 200 ppb, whereas other periods are characterized by fairly constant low levels of exposure. These exposures may be compartmentalized by averaging the concentrations within the time period of a specific activity. As graph B illustrates, an individual moves through several diverse exposure settings in the course of a day. Graph C shows the cumulative integrated exposure as the individual moves during the day. The rate of increase in integrated exposure is greater for certain exposure settings, such as cooking meals on a gas range. Note that the twenty-four-hour integrated exposure for this individual is 960 ppb-h. Graph D presents average exposure measurements for various lengths of averaging times. The longer averaging times effectively dampen the variation in personal exposure. Although the twenty-four-hour mean exposure was 40 ppb, mean exposure during the six-hour interval comprised of night sleep was 25 ppb, and the three-hour interval comprising the evening commute and meal preparation was 65 ppb. In this particular example of the different ways of averaging personal exposure, the biologically relevant measure of exposure is not known. Transient exposures to peak levels of NO_2 and/or long-term chronic exposures may be associated with oxidant damage and increased susceptibility to respiratory infection.

DOSE

Dose refers to that amount of chemical contaminant which crosses a boundary of the body and reaches the site of toxic action. Time is implied in the concept because dose is typically expressed as mass or number of molecules. Dose, therefore, varies not only with the exposure profile (i.e., concentration and time course) but also with the physiologic state of the individual. For example, consider two individuals who are indoors at home. One sits in a chair and watches television, and the other rides an exercycle for one-half hour while also watching television. Although both individuals are equally exposed to radon present in the room air, the physically active person who is breathing faster, more deeply, and through the mouth receives a greater pulmonary dose relative to the person at rest.

If the site of toxic action is the lung epithelium, as for ozone, the amount of pollutant deposited on the lung epithelium is equivalent to the dose. If the pollutant is absorbed across the lung epithelium (see Chapter 8 on CO) into the blood, where it is transported to the target organ, the amount absorbed is the dose to the body, while the pollutant reaching the site of action is considered to be the biologically effective dose.

For particulate matter and water soluble gases, the route of breathing will affect the amount of chemical contaminant that reaches the lung. During nasal breathing, particles with an aerodynamic diameter of 2–5 μm are more likely to be filtered out in the nasal turbinates by impaction and adsorption onto mucus whereas particles of a smaller diameter pass through the nasal passageways of the head and on to the lower airways and alveoli where they may be deposited (Schlesinger 1988). Removal in the nasal passages is bypassed during mouth breathing. For nonreactive gases such as CO, the route of breathing does not affect the delivery of nonreactive gases to the deep lung. Therefore, for certain pollutants, estimates of pulmonary dose should consider ventilation and the route of inhalation along with the physical and chemical characteristics of the contaminant. Direct monitoring of breathing rates or level of physical exertion may be used to make a crude correction for oral breathing.

The definition of *biologically effective dose* can be refined further. Some inhaled contaminants undergo chemical transformation, and it is the metabolic products that are actually responsible for the toxic effect. Different metabolites may be formed depending upon the received dose, the rate of dosing, and the physiologic conditions. Hence, the effective biologic dose may be a fraction of the pollutant initially inhaled.

TIME-ACTIVITY PATTERNS

People encounter different concentrations in different settings, and depending upon source use and ventilation, among other factors, the concentrations in these settings will change over time. It may be important, therefore, to understand the patterns of human behavior relevant to exposures. Thus, an understanding of the settings and activities in which people spend their time could identify populations and/or behaviors at risk of high exposure. Such studies may reveal effective exposure mitigation opportunities, while providing the basis for modeling exposures which incorporate data from fixed location microenvironmental monitoring. For example, human behavior related to source use, such as the use of an exhaust fan while cooking, the use of a gas range for space heating, the substitution of microwave ovens for gas ranges will result in differential exposures for subgroups.

MODELING PERSONAL EXPOSURE

Personal exposure may be modeled by considering a series of locations with air pollutant concentrations present. A person moves through these locations over time. A given location could be subdivided if activities, ventilation, or mixing cause changes in source use, strength, or dilution. In the generalized model (Ott 1985; Duan 1982; Fugas 1986), the mean concentrations experienced in successive settings, or *microenvironments*, are time weighted and summed to generate a total integrated exposure for some specified time interval, usually a twenty-four-hour period:

$$E = \Sigma f_i C_i$$

Where,

Σ = Sum over all times and concentrations

E = Total exposure

C_i = Concentration of pollutant in microenvironment *i*

f_i = Fractional time spent in microenvironment *i*

When this model is applied to an individual's daily exposure profile, the total exposure is identical to the twenty-four-hour integrated exposure, or the cumulative exposure described in Figure 5.2, graph C. *Microenvironments* are specific situations of exposure, and as defined by Duan (1982), they are locations in space and time over which pollutant concentrations are assumed uniform and constant. Therefore, a kitchen location with cooking activity on a gas range is a microenvironment that is different and distinct from the same location before cooking began. Levels of pollutant concentration at certain locations (e.g., kitchen, garage, or traveling inside a car) may display high temporal variability, and therefore the choice of classification of the microenvironment, and hence averaging time, will influence the variability of the exposure measure. Quackenboss et al. (1986) suggested that although some variability in exposures may be lost by combining microenvironments into broad classes, the differences in variability within a class are likely to be smaller than those between microenvironmental classes (e.g., between indoor and outdoor locations or between residences and workplace). For certain pollutants, such as CO, continuous monitoring or a high resolution microenvironmental classification may be needed to characterize exposure adequately for accurate estimates of uptake by the body due to the time-exposure relationship for carboxyhemoglobin (COHb). In comparison, longer averaging times and more coarse characterization of microenvironments may be appropriate for pollutants such as lead, where body burden is the measure of interest.

The generalized model of total personal exposure may be applied to a specific group of people, or a *community*. The distribution of individual personal exposures made on a sample is combined with time-activity data on the population to estimate the distribution of total exposures for the population. The upper tail of the distribution for some pollutant exposures may identify a subgroup of the population with higher-than-average risk. This is of particular interest to decisionmakers concerned with public health. It should be recognized that this area of the distribution is somewhat more difficult to characterize than is the mean (Sexton and Ryan 1988), and many personal exposure measurements must be obtained to estimate accurately the frequency, magnitude, and duration of high-exposure events, which may be relatively rare. Examples of relatively lower frequency situations include faulty auto exhaust systems that result in high in-vehicle CO concentrations and the improper venting of furnaces that then leak emissions into residences.

ASSESSMENT OF PERSONAL EXPOSURE

Techniques for the assessment of personal exposure to air pollution can be divided into two major classes. The first approach measures the concentrations of the pollutant using monitors worn on the person or located in specific settings frequented by the person (i.e., home, workplace, or car), and the second estimates exposures from measurements of biologic markers such as the pollutant concentrations in blood and breath samples (Sexton and Ryan 1988).

AIR POLLUTANT MONITORING

In his review of total exposure assessment, Ott (1985) separated exposure measurement into two general methodologies, direct and indirect.

Direct Method In this approach, individuals wear personal monitors that measure the concentrations of pollutants in their breathing zone. While wearing the monitor, the subject maintains a diary record of locations visited and activities pursued. A variety of passive sampling devices that can provide integrated measurements of personal exposure is available, and continuous monitoring instrumentation with data-logging capacity continues to evolve (Wallace and Ott 1982; see Chapter 4 on environmental monitoring). However, implementing the direct method is labor intensive and time consuming, which may preclude its application to large samples, and personal monitors are not presently available for all pollutants of concern.

The direct method of personal exposure assessment has been applied in several surveys. The Environmental Protection Agency (EPA) obtained personal CO measurements on large probability samples of the residents of metropolitan Denver and Washington, D.C. (Akland et al. 1985; Wallace et al. 1988), which allowed the evaluation of the efficacy of outdoor monitoring networks to estimate actual population exposures. Personal exposures to CO have also been measured in a subgroup of Los Angeles men who have ischemic heart disease (Lambert 1990). The exposure patterns of these susceptible individuals were comparable to those measured in the general population at Denver and Washington, D.C. Nitrogen dioxide exposure has been characterized by direct monitoring carried out in conjunction with the Harvard six cities study (Quackenboss et al. 1986) and in probability samples of residents in Boston and Los Angeles (Ryan et al. 1989; Spengler et al. forthcoming). In the Total Exposure Assessment Methodology (TEAM) studies, the EPA surveyed personal exposure to various species including CO, volatile organic compounds (VOCs), pesticides, and particulate matter in several U.S. metropolitan areas (Wallace 1987; see also Chapter 11). The methodology of the EPA's carbon monoxide and VOC studies will be presented in detail in a later section of this chapter.

Indirect Method This method avoids the practical and logistic constraints of direct monitoring. The indirect approach uses area or microenvironment monitors and time-activity data to estimate personal exposures. Ideally, a mathematical model relating personal exposure to area measurements and behavioral parameters should be developed and validated prior to the implementation of a large-scale monitoring program.

The indirect method has been applied to estimate the ozone exposure of asthmatics residing in Houston (Contant et al. 1987). This study will be discussed later under "Applications of Personal Exposure Monitoring Techniques." A simplified application of this method has also been used to study the exposures of infants to NO_2 in residences in Albuquerque, New Mexico (Harlos et al. 1987). Mothers reported the time-activity patterns of their children inside the residence, and total personal exposure to NO_2 was weighed according to the time that the child spent in the particular rooms in which the samplers were located (Table 5.1). The time-weighted estimate of personal exposure agreed closely (R = .81) with measurements made by a sampler worn on the child. This result supported the choice of area monitors for a larger scale study that will longitudinally measure the child's exposure from birth to age 18 months.

BIOLOGIC MONITORING

In performing a biologic assessment of exposure, samples of sputum, urine, blood, or expired breath are obtained and analyzed for the presence of the pollutant or its metabolite. Biologic monitoring is particularly useful if highly sensitive and specific markers of exposure are available, and it may be considered an indirect method of exposure assessment. Good markers of exposure are available for CO (Coburn, Forster, and Kane 1965; Joumard et al. 1981; Lambert, Colome, and Wojciechowski 1988), lead (Annest 1983; Billick 1983), and the nicotine component of environmental tobacco smoke (U.S. Department of Health and Human Services 1986). Biologic monitoring may be a more relevant measure than ambient concentrations for defining populations at risk or for conducting health effects research. However, although providing a surrogate measure of dose and an integrated measure of exposure, relating the biologic marker's level to personal exposure is often problematic for some contaminants due to the complex metabolic pathways involved and the variability in physiologic parameters affecting uptake

Table 5.1 Time-Weighted Contribution of Exposures to NO_2 in Several Residential Locations to Total (Twenty-Four-Hour) Exposures

	Time[a]		Mean NO_2[b]		Exposure Contribution	
Location	Hours	S.D.	ppb	S.D.	ppb-hour	Percent Total
Bedroom	14.1	6.2	42.9	15.3	604.9	61.4
Living room	6.3	4.5	50.2	22.4	316.3	32.1
Kitchen	0.78	0.73	65.5	31.5	51.1	5.2
Outdoor[c]	0.22	0.32	12.2	8.6	2.7	0.3
Travel[c]	0.80	0.98	12.2	8.6	9.8	1.3
Total	24.0				948.8	

Estimated average infant exposure = 41 ppb

Source: Harlos et al. (1987), reprinted with permission.
[a]Time-location for all forty-six infants.
[b]NO_2 levels for twenty homes with complete data.
[c]Outdoor and travel levels are the seven-day average outdoor NO_2 values for the twenty homes.

and elimination (Wallace et al. 1988). Nevertheless, it must be recognized that environmental controls and mitigation strategies will be predicated upon reducing concentrations, and perhaps exposures. It is these more conventional measurements that lend themselves to the precise definitions necessary for enforcement. On the other hand, reduction of a biological marker like blood lead or COHb provides useful trends data and displays the effectiveness of source reduction.

TIME-ACTIVITY MONITORING

Human beings are not stationary, and the environments people inhabit may support several kinds of activities. Therefore, accurate estimates of exposure require assessments of the movements of people and the activities undertaken at various locations. Sociologists and geographers have collected information on activities and movement using self-administered diaries and recall interviews (Robinson 1988). With the diary method, subjects record activities and locations as they engage in activities through the day (Figure 5.3). If faithfully performed, this method can provide information with fine time resolution and good reliability (Michelson 1985). An alternative approach is the twenty-four-hour recall interview in which the respondent recalls the activities and locations of the preceding day within a structured line of questioning by an interviewer. Although providing a record of activities at a more coarse level of time than the diary approach, the interviewing process is generally regarded to produce a more complete and logical

Nothing		Light			Heavy				Max[illegible]
0	0.5	1	2	3	4	5	6	7	8 9

RID _ _ . _ _ _ DATE _ _ / _ _ / _ _

TIME BEGAN	WHAT WERE YOU DOING? (ANYTHING ELSE AT THE SAME TIME?)	WHERE WERE YOU? (ROOM IN HOUSE, OR NEAREST INTERSECTION.)	WERE YOU NEAR ANY OF THESE ACTIVITIES? CHECK (✓).	LEVEL [illegible] EXERT[illegible]
			( ) Running autos ( ) Gas stove/oven ( ) Tobacco smoking ( ) Woodburning ( ) Running engines	
			( ) Running autos ( ) Gas stove/oven ( ) Tobacco smoking ( ) Woodburning ( ) Running engines	
			( ) Running autos ( ) Gas stove/oven ( ) Tobacco smoking ( ) Woodburning ( ) Running engine	

Figure 5.3. Example of a page from a time-activity diary to monitor personal activity while wearing an air pollution monitor.

sequence of information (Michelson 1985). Standard formats for diaries and interviews have been described (Michelson 1985; Robinson 1988).

APPLICATIONS OF PERSONAL EXPOSURE MONITORING TECHNIQUES

In this section, several study designs are presented to illustrate some specific methodologic aspects of the measurement of personal exposure. The first study is the Denver–Washington, D.C., CO study conducted by the EPA. This study represents the first large-scale application of the direct and indirect methods of population exposure assessment and creatively uses direct exposure measurement and biologic markers to characterize exposure. The second study presented uses the indirect method to estimate personal exposure to ozone for asthmatics living in Houston. The third study considers the measurement and modeling of personal exposure to nitrogen dioxide in Boston and Los Angeles. The fourth study is also one of the TEAM studies, conducted by the EPA to characterize population exposures. This chapter briefly focuses on the TEAM study of exposures to VOCs, although the EPA has conducted other exposure studies on pesticides and particulates that utilize the TEAM concepts.

CARBON MONOXIDE

During the winters of 1982 and 1983, the EPA measured personal exposures to CO in statistically representative samples of the Denver and Washington, D.C., metropolitan areas (Akland et al. 1985). The goal of the research program was to generalize the direct measurement of personal exposures to the entire adult nonsmoking population residing in these areas. The sampling scheme was stratified and included disproportionately large numbers of individuals who commuted and who lived in residences with gas-fueled appliances or an attached garage. In each urban area, five hundred individuals were monitored; subjects wore a portable, continuously recording instrument and maintained a time-activity diary for one day in Washington, D.C., and two days in Denver. End-expired breath samples were collected from subjects at the end of each twenty-four-hour monitoring period to estimate blood COHb levels. The population estimates of personal exposure were derived from adjusted sampling weights. The results indicated that more than 10 percent of the personal exposures of residents of Denver, and 4 percent of the Washington, D.C., residents exceeded the eight-hour 9-ppm federal standard. Ambient fixed site monitoring data underestimated the distribution of these personal exposures (Figure 5.4). The exposures experienced in transit and outdoors near active roadways were identified as important contributors to total CO exposure. The observation that people spent more than one hour per day in transit and more than twenty-two hours per day indoors is important. The mean levels of CO measured in specific indoor microenvironments are presented in Chapter 9.

The breath samples were used to provide an additional measure of exposure for the Washington, D.C., sample (Wallace et al. 1988). Carbon monoxide levels in end-expired breath were used to estimate blood COHb concentration, a measure of

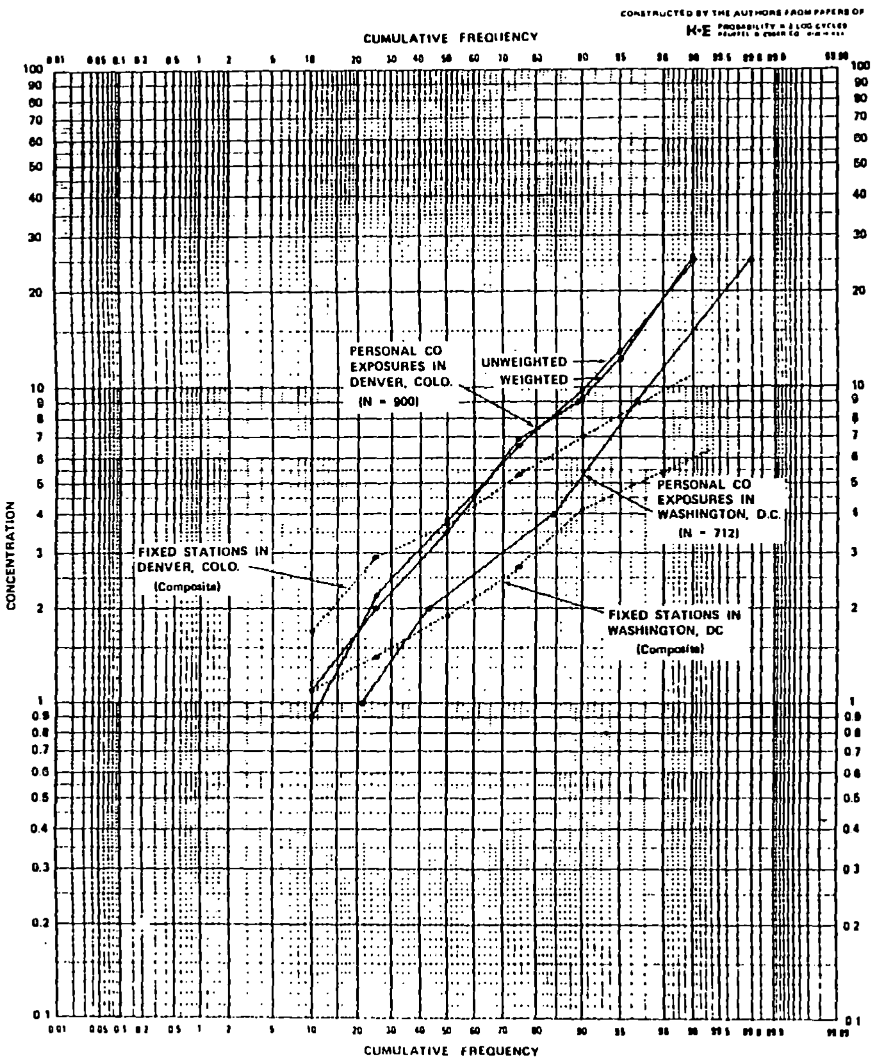

Figure 5.4. Frequency distribution of maximum eight-hour CO personal exposures and ambient concentrations for population samples in Denver, Colorado, and Washington, D.C., during the winters of 1982 and 1983. *Source:* Reprinted with permission from Akland G.G., et al. Measuring human exposure to carbon monoxide in Washington, D.C., and Denver, Colorado, during winter 1982–1983. *Environ Sci Technology* 19:911–18. Copyright 1985 American Chemical Society.

the cumulative exposure to CO. Exposure measurements from the continuous monitors were input into the pharmacokinetic model to calculate COHb levels at the end of the twenty-four-hour monitoring period (Coburn, Forster, and Kane 1965). The modeled COHb levels were 40–50 percent lower than those estimated from samples of end-expired breath. The availability of this alternative measure of exposure prompted the investigators to reevaluate the accuracy of the electronic monitors. Differences in the sensitivity of monitoring instrumentation, declining sensitivity with battery discharge, and improper calibration methods may have biased the measurements low in some monitors. Therefore, the investigators used the breath measurements to calculate individual correction factors to revise upwardly the distribution of personal exposures. Without the biologic marker data, the monitoring instrumentation would have underestimated the sample's exposures.

The efficacy of outdoor monitoring networks to estimate personal exposure was tested using the data derived from the Denver field survey. The exposure profiles were used to validate a population exposure model, the simulation of human activity and air pollution exposure (SHAPE) model (Ott 1988). Two days of personal monitoring data were available for each of 336 individuals living in Denver. The distributions of microenvironmental exposures and the ambient monitoring network data from the first day of monitoring of each individual were used to predict the personal exposures on the second day. The distribution of microenvironmental concentrations on the second day were calculated by adding microenvironmental source inputs onto the ambient background concentration measured on the second day. Using the actual time-activity data from the second day of monitoring, exposures in microenvironments were assigned by Monte Carlo sampling from the microenvironmental CO distributions. SHAPE was successful at predicting the mean of the cumulative distribution, but it tended to underestimate exposures in the tails of the distribution (Figure 5.5). Of particular concern was the underestimation of high exposures.

OZONE

Ideally, exposure models are constructed and validated with actual personal exposure data. It is not always necessary to perform this validation on a sample the size of that used in the EPA CO studies. For example, the O_3 exposure model developed by the University of Texas School of Public Health was validated in a community sample of relatively small size (Stock et al. 1985; Contant et al. 1987). Data to construct the model were obtained from twelve homes of asthmatics by measuring indoor and outdoor residential levels of O_3 with a mobile monitoring van and by measuring personal exposure with portable instruments carried by a field technician who followed the research subject. Fixed-site monitoring data were regressed on the indoor and outdoor residential measurements to define the relationship between levels of O_3 from the ambient monitoring network and the concentrations occurring at the residential sites. Hourly averages of O_3 concentration at indoor and outdoor residential sites were computed. The exposures of each individual were weighted according to records of personal activity maintained by

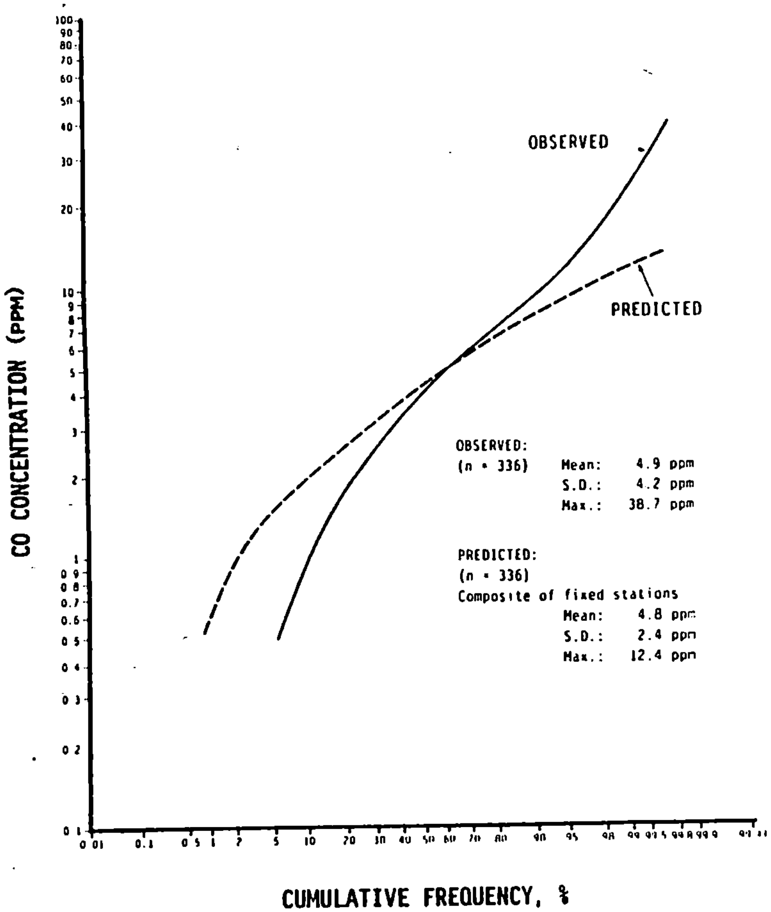

Figure 5.5. Logarithmic probability plot of cumulative frequency distributions of the maximum moving average eight-hour personal exposure to CO predicted by SHAPE using the ambient background concentration calculated from a composite measure from all fixed-site stations along with observed frequency distribution of the measured personal exposures for day 2 in Denver, Colorado. *Source:* Adapted from Ott et al. (1988), with permission.

the subjects. When compared with the actual hourly measurements of personal exposure, the model underestimated exposure by approximately 20 percent (Figure 5.6). However, use of the model to estimate personal exposure is considerably more accurate than using untransformed fixed-site measurements, for the indoor concentrations of O_3 were, on average, substantially less (<10%) than levels simultaneously measured at the nearest fixed site. Outdoor O_3 concentrations at homes were approximately 80 percent of those measured at fixed sites, but a

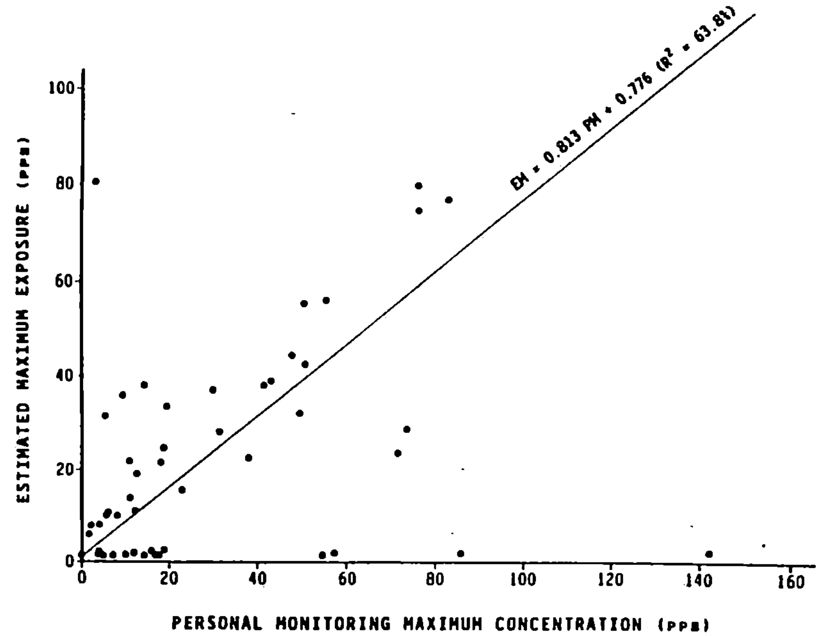

Figure 5.6. Scatter plot of O_3 exposure model estimate of maximum hourly average personal exposure versus maximum hourly average measurement of O_3 exposure by personal monitoring for forty-nine daytime monitoring periods between 7 A.M. and 7 P.M., with a mean duration of eight hours. *Source:* Adapted from Contant et al. (1987), with permission.

relatively small proportion of daily time is spent outdoors around the place of residence. This research demonstrated that large improvements in the accuracy of O_3 exposure assessments can be achieved by the simple weighting of personal activity patterns into indoor and outdoor classes.

NITROGEN DIOXIDE

Direct and indirect approaches to exposure assessment have been combined to strengthen the design of surveys to measure personal exposure to NO_2 in the community. The Harvard School of Public Health developed a model of personal exposure based on ambient monitoring information and coarse activity pattern information on time spent indoors at home, indoors at work, outdoors, and in transit (Ryan et al. 1988a, 1988b, 1989; Spengler et al. forthcoming). Comparison of the estimates of the initial model with actual personal monitoring data demonstrated the importance of refining the model to account explicitly for exposures in three other microenvironments with potentially elevated NO_2 concentrations: in-home cooking areas with unvented combustion appliances, travel on roadways during commuting hours, and certain occupational settings. Personal activity diaries were modified to collect information on the time spent in these special settings.

Personal exposure surveys on representative samples of urban residents were conducted to determine the population distributions of NO_2 exposures. Utilizing an integrating diffusion badge, personal exposures were quantified for approximately three hundred individuals in Boston and seven hundred residents in Los Angeles. Subjects wore one badge while indoors and a different badge when outdoors. Outdoor measurements were also made at each subject's residence. Ambient levels of NO_2 were higher in Los Angeles (30–70 ppb) than they were in Boston (20–30 ppb). Unlike Boston, in Los Angeles approximately 40 percent of the variance in personal exposures and 60 percent in indoor residential concentration was explained by ambient measurements made outside the residence. These results suggest that in areas of higher ambient pollution with substantial spatial variation, outdoor concentrations can influence exposure. This occurs through the contribution of outdoor concentrations to indoor concentrations because the modeled prediction does not improve when the fractional times spent outdoors are included as an independent variable.

VOLATILE ORGANIC COMPOUNDS

Wallace and co-workers at the EPA have measured personal exposures to VOCs in several metropolitan areas across the United States in a group of interrelated studies called the TEAM studies. In each metropolitan location, random stratified samples were selected on the basis of proximity to point sources and socioeconomic class, geographic area, and demographic characteristics including age, marital status, tobacco smoking status, and occupational class. Personal exposure to VOCs was measured with personal samplers; end-exposed breath samples were obtained at the end of each twenty-four-hour period; water samples from the homes were taken for VOC analysis; and outdoor sites were monitored (see Chapter 11 for further details). Sources of exposure were inferred by questionnaire data on personal activities and proximity to potential sources.

Table 5.2 presents a summary of the results of the TEAM survey in one urban location, the Bayonne and Elizabeth, New Jersey, survey. The exposures experienced outdoors and indoors were highly variable, both from compound to compound and within a compound. However, indoor concentrations were consistently higher than outdoor concentrations. The higher concentrations observed indoors were unexpected because this study site has many industrial sources of VOCs.

Breath measurements did not correlate well with ambient concentration measurements, further indicating that ambient data do not represent population exposures accurately. However, for some specific VOCs, elevated personal exposures as measured by breath samples were associated with certain types of activities. For example, personal exposure to benzene was correlated with visits to service stations, and tetrachloroethylene was correlated with visits to dry cleaning businesses.

The TEAM VOC studies have had a major impact on the way in which the research community views environmental exposures to VOCs. In a review of the

Table 5.2 Summary of Median and Maximum Concentrations ($\mu g/m^3$) for Elizabeth-Bayonne, New Jersey, *TEAM* Study of Volatile Organic Compounds

Compound	Outdoor[a]	Indoor[b]	Ratio[c]
Chloroform	0.74[d] (21.5)	2.94 (215)	3.97 (10.0)
1,1,1-Trichloroethane	4.20 (40.0)	15.60 (880)	3.71 (22.0)
Benzene	7.00 (91.0)	13.00 (120)	1.86 (1.32)
Carbon tetrachloride	0.81 (14.0)	1.38 (14.0)	1.70 (1.00)
Trichloroethylene	1.34 (15.0)	2.00 (47.0)	1.49 (3.13)
Tetrachloroethylene	2.60 (27.0)	5.60 (250)	2.15 (9.26)
Styrene	0.67 (11.0)	1.80 (53.5)	2.69 (4.86)
m,p-Dichlorobenzene	0.80 (13.0)	2.80 (915)	3.50 (70.4)
Ethylbenzene	3.20 (20.0)	6.10 (320)	1.91 (16.0)
o-Xylene	3.00 (27.0)	4.98 (46.0)	1.66 (1.70)
m,p-Xylene	9.90 (70.0)	15.50 (120)	1.57 (1.71)

Source: Adapted from Wallace et al. (1986) with permission.
[a] Outdoor heading corresponds to overnight outdoor air in TEAM nomenclature.
[b] Indoor heading corresponds to overnight personal air in TEAM nomenclature. Summary statistics presented include a small number of personal exposures not in indoor environments.
[c] Ratio of indoor median to outdoor median (ratio of indoor maximum to outdoor maximum).
[d] Median (maximum).

EPA's research on total human exposure, Ott et al. (1986) acknowledged these major contributions of the TEAM studies: (a) Variability of two to three orders of magnitude in exposures is found over small geographic regions, suggesting a need to reconsider epidemiologic approaches that assume homogeneous exposures across broad areas; (b) personal and indoor exposures consistently exceed outdoor concentrations; (c) although inhalation is the prime exposure route to many VOCs, ingestion by drinking water can be a major route of exposure to chloroform and other species; and (d) breath samples are a reliable biologic marker for VOC exposure and correlate well with personal exposures.

SUMMARY

The majority of daily activity is spent in indoor settings, and therefore, on a time-weighted basis, indoor exposures may dominate the total exposure of most individuals when concentrations experienced in other microenvironments are of comparable magnitude. An understanding of the personal exposures in the indoor setting is essential and will continue to be an important focus in air pollution epidemiology and public health planning. This chapter has reviewed the basic concepts of human exposure assessment and has presented some of the methodologic considerations. These approaches to the estimation of actual personal exposures offer encouraging prospects for improvement of our understanding of the relationship between air pollutant exposures and health effects and the potential for intervention to reduce those exposures.

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Preliminary Inventory of Uranium Mining Processing and Exploration Sites in Southern Eastern Agency, Navajo Nation

Mine/Claim Name[1]	T-R-S-qS	Appx. Dist. from HRI[2]	Gamma Rate Background	Gamma Rate[3] Range (uR/hr)	Type of Mining Operation(s)[4]	Period of Operation[5]	Nearby # Homes	Topo Quad Name	NAMLRD Site #
Alpha	14N.13W.12.SW		13		EO; NM	---		Thoreau	53
Becenti[6]	15N.17W.28.NW	11	12	12-320	OPUMw/DH	1952-58	n/a	Gallup East	91
Black Jack #1[7]	15N.13W.12.NE	23		40-475	UGUM/RM	1959-68	3 w/in .25 mi	Hosta Butte	65
Black Jack #2	15N.13W.18.NE	19		30-100	UGUM/RM	1959-70	n/a	Hosta Butte	68
Borrego Pass	16N.10W.7&18		13		EO; NM	---		Laguna Castillo	93
Canyon	17N.13W.34.S1/2		13		EO; NM	---		Crownpoint	141
Canyon	17N.13W.34.N1/2		16		EO; NM	---		Crownpoint	141
CD & S (Section 35)	16N.17W.35.SE	5			OPUM	1957	n/a		
Chaco Canyon Drill Hole CC-3	20N.8W.09.NW				EO; NM	---		Pueblo Pintado	162
Christian	15N.16W.04.SE	5			UGUM	1953-55; 57-58	n/a	Church Rock	
Church Rock #1 (Kerr McGee)[8]	17N.16W.35.NE	4.2			UGUM/RM	1972-86	15-20 w/in 1 mi[2]	Hard Ground Flats	
Church Rock #1E (Kerr McGee)	17N.16W.36.NW	4.2		150-180	UGUM	1972-86	15-20 w/in 1 mi[2]	Hard Ground Flats/Oak Sprgs	152
Church Rock 8 & 2	17N.16W.09.		12		EO; NM	---		Hard Ground Flats	147
Crownpoint Section 29	17N.12W.29.NE		12		EO; NM	---		Crownpoint	136
Crownpoint-Conoco/Westinghouse	17N.13W.24.SE	23			SB/P, RM; NM	(1978-79)		Crownpoint	
Dalton Pass	17N.14W.24,25		12.5		EO; NM	---		Dalton Pass	143
Dalton Pass	17N.13W.30.S1/2		12.5		EO; NM	---		Dalton Pass	140
Dalton Pass	17N.13W.30.N1/2		12.5		EO; NM	---		Dalton Pass	140
Diamond 2 (Largo)	15N.17W.33.NE	7		70-200	UGUM/RM	1953-64	n/a		
Eagle 1-6	14N.12W.18.SE		6		LQw/DH	unk.	5 w/in 1 mi	Thoreau	48
Foutz #2	15N.16W.05.NE	4.2	12	14-38	UGUM	1953-54	5 w/in 1-5 mi	Church Rock	87
Foutz #3 (Yellow Jacket)	16N.16W.31.SE	3.9		50-280	UGUM	1953-55	14 w/in 1 mi	Church Rock	120
Grace Nuclear/Section 23	16N.17W.23.NE	3.2	<15	100-240[9]	UISL-Pilot/RM	1975	7 w/in 1 mi	Church Rock	126
Hogback #3 and #4[10]	15N.18W.12.NE	10			UG/OPUM	1952-60	n/a	Gallup East	
HRI Church Rock Section 8	16N.16W.08.SE		12	12-32	EO; NM; PISL	---	35-40 w/in 2 mi	Hard Ground Flats	
June	14N.13W.14.NE	24	9-16	11-20	UG+OPUMw/DH	unk.	2 w/in 1-5 mi	Thoreau	55
Largo (3 claims)	14N.13W.14.NW		11		EO; NM	---		Thoreau	54
Last Chance #2	14N.14W.02.NW		13		EO; NM	---		Continental Divide	57
Mac #1	15N.14W.12.SE	17		24-70	UGUM/RM	68-70;76-78;80	n/a	Mariano Lake	79
Mac #2	15N.13W.18.SE	18		30-340	UGUM/RM	1968-70	3 w/in 1 mi	Hosta Butte	69
Mancos Section 7	16N.16W.07.SW		13		EO; NM	---		Hard Ground Flats	104
Mariano Lake	15N.14W.12.NW	17	11	11-35	UGUM/RM	1977-82	n/a	Mariano Lake	78
Mobil Section 9 Pilot	17N.13W.09.SW	20			UISL-Pilot	1979-80; 80-86	n/a	Crownpoint	
Moe Mine (Sections 32 & 33)	15N.11W.32.SE	32		42-260	UGUM/RM	1960-64	1 w/in 1 mi	Thoreau NE	60

Mine/Claim Name	T-R-S-qS	Appx. Dist. (in mi) HRI	Gamma Rate Background	Gamma Rate Range (uR/hr)	Type of Mining Operation(s)	Period of Operation	Nearby # Homes	Topo Quad Name	NAMLRD Site #
Narrow Canyon	17N.14W.02		11		EO; NM	---		Dalton Pass	142
NE Church Rock	17N.15W.31.NW		13		EO; NM	---		Oak Spring	146
NE Church Rock #1 (UNC)	**17N.16W.35.SE**	**4**		**150-300**	**UGUM**	**1969-1982**	**20-25 w/in 1.5 mi**	**Hard Ground Flats**	**150**
NE Church Rock #1 (UNC)(11)	**16N.16.03.NE**	**3.8**		**30-300**	**UGUM**	**1969-1982**	**20-25 w/in 1.5 mi**	**Hard Ground Flats**	**101/151**
NE Church Rock #2 (Kerr-McGee)	17N.16W.27.NE			50	SB/P; NM	(1976?)	20-25 w/in 1.5 mi	Hard Ground Flats	149
NE Church Rock #3	17N.16W.21.NE		11		EO; NM	---		Hard Ground Flats	148
Nicholson-Brown	15N.14W.25.SE		13		EO; NM	---		Mariano Lake/Continental Div.	80
Nose Rock	19N.12W.32				EO; NM	---		Antelope Lookout	160
Nose Rock #1 (Phillips)	19N.11W.31.NW				SB/P, RM; NM	(1979)	n/a	Becenti Lake	159
Old Church Rock Mine (HRI CR-17)	**16N.16W.17.NE**	**0**	**10-15**	**22-350**	**UGUM/PISL**	**1960-62; 79-82**	**35-40 w/in 2 mi**	**Church Rock**	**112**
Pyramid Group	16N.16W.22.NE		12-15		EO; NM	---		Church Rock	117
Ruby #1 and #2 decline	**15N.13W.21.NW**	**21**		**24-130**	**UGUM/RM**	**1976-79**	**n/a**	**Hosta Butte**	**71**
Ruby #2 Ore Body	15N.13W.27.NW		13		EO; NM	---		Hosta Butte	75
Ruby #3 and #4 decline	**15N.13W.25.NE**	**25**		**16-90**	**UGUM/RM**	**1980-82; 84-85**	**n/a**	**Hosta Butte**	**72**
Ruby #4 Ore Body	15N.13W.26.SE		12		EO; NM	---		Hosta Butte/Thoreau	74
Section 24	15N.12W.24.		12		EO; NM	---		Casamero Lake	63
Section 3 (Santa Fe Christensen)	**15N.16W.03.SW**	**5**		**42-1,400**	**UGUM**	**1957-58**	**5 w/in 1-5 mi**	**Church Rock**	**83**
Section 34	**14N.11W.34.SW**	**38**	**12**	**12-30**	**UG/OPUMw/DH**	**unk.**	**1 w/in 1-5 mi**	**Thoreau**	**42**
Section 4 (2 claim sites)	14N.10W.04.NE		11-12		EO; NM	---		Thoreau	5, 6
South Pod Ore Body	15N.13W.25.SE		11		EO;NM	---		Thoreau	73
South Trend Development	17N.13W.16.		13		EO; NM	---		Crownpoint	139
Teton Exploration-UNC	**16N.17W.13.SW**	**2.5**	**12-14**		**UISL-Test**	**1980**	**20-25 w/in 1.5 mi**	**Church Rock**	**123**
UNC Uranium Mill/Superfund	**16N.16W.02.**	**3.2**			**UM+TD/RM**	**1977-1982**	**20-25 w/in 1.5 mi**	**Hard Ground Flats**	
Unknown (Canoncito)	**10N.03W.22.SE**	**>100**		**70-300**	**UG/OPUMw/DH**	**unk.**	**>10 w/in 1-5 mi**		
Unknown, or no name given	16N.16W.17.NW		11-13		EO; NM	---		Church Rock	111
Unknown, or no name given	16N.16W.18.SW		13-16		EO; NM	---		Church Rock	114
Unknown, or no name given	16N.16W.19.SW		12-14		EO; NM	---		Church Rock	116
Unknown, or no name given	16N.16W.22.NE		13-16		EO; NM	---		Church Rock	117
Unknown, or no name given	16N.16W.23.NE		13-14		EO; NM	---		Church Rock/Pinedale	118
Unknown, or no name given	16N.17W.24.NE		11-14		EO; NM	---		Church Rock	127
Unknown, or no name given	16N.17W.13.SW		12-14		EO; NM	---		Church Rock	123
Unknown, or no name given	17N.14W.27.SW		12		EO; NM	---		Dalton Pass	144
Unknown, or no name given	16N.13W.05.SW		12.5		EO; NM	---		Crownpoint	95
Unknown, or no name given	16N.16W.07.NW		16		EO; NM	---		Hard Ground Flats	103

Mine/Claim Name	T-R-S-qS	Appx. Dist. (in mi) HRI	Gamma Rate Background	Gamma Rate Range (uR/hr)	Type of Mining Operation(s)	Period of Operation	Nearby # Homes	Topo Quad Name	NAMLRD Site #
Unknown, or no name given	16N.16W.09.SE		12		EO; NM	---		Hard Ground Flats	107
Unknown, or no name given	16N.16W.09.NW?		11		EO; NM	---		Hard Ground Flats	108
Unknown, or no name given	16N.16W.21.SW		13		EO; NM	---		Pinedale	100
Unknown, or no name given	15N.14W.02.		13		EO; NM	---		Mariano Lake	76
Unknown, or no name given	15N.14W.03.		12.5		EO; NM	---		Mariano Lake	77
Unknown, or no name given	15N.14W.34.		13		EO; NM	---			
Unknown, or no name given	15N.13W.13.SE		12		EO; NM	---		Hosta Butte	67
Unknown, or no name given	15N.13W.13.NE		11		EO; NM	---		Hosta Butte	66
Unknown, or no name given	16N.13W.14.		12.5		EO; NM	---		Hosta Butte	96
Unknown, or no name given	15N.12W.23.NE		12		EO; NM	---		Casamero Lake	62
Unknown, or no name given	16N.14W.02.		11		EO; NM	---		Mariano Lake	
West Eagle 1-3	14N.13W.24.SE	26	11		explor. Pits	unk.	2 w/in 1 mi	Thoreau	56
West Largo	15N.10W.17.SW		13		EO; NM	---		Borrego Pass	58
Westwater #1	**15N.16W.02.S1/2**	**6**			**UGUM**	**1957-60**	**n/a**	**Church Rock**	
Williams & Reynolds (U Mine)	**15N.16W.04.SW**	**5**	**13-20**	**13-100**	**OPUM**	**1953-58**	**n/a**	**Church Rock**	

Notes:

[1]Most of these mines/claims were taken from inventories of the Navajo Abandoned Mine Land Reclamation Dept. (NAMLRD, 1996); others were derived from Hilpert (1969) and McLemore and Chenoweth (1991).

[2]Approximate distances, in miles, are given from HRI's proposed Church Rock ISL mine in T16N.R16W.secs. 8 and 17 to the locations of mines which are documented to have had actual production.

[3]Gamma radiation rates, in microRoengtens per hour, were derived in most cases from the site assessment documentation in NAMLRD 1996.

[4]Abbreviations used in this column are: EO;NM = exploration only, no mining; OPUM = open pit uranium mine; w/DH = with dangerous highwall; UGUM = underground uranium mine with remedial measures;
/RM = with remedial measures; SH/P = shaft built, plugged; LQ= limestone quarry;UISL = uranium in situ leach; PISL = proposed in situ leach.

[5]Periods of operation taken in most takes from Hilpert (1969); others from Franke (1999, Table 2).

[6]Mine/claim sites shown in boldface had actual production or processing.

[7]Black Jack #1 is located within 2 mi. of Smith Lake Chapter House, housing area, and elementary school. The 1990 chapter population was 515, much of which is concentrated near the chapter house and adjacent housing area.

[8]Church Rock #1 and #1E were part of the same underground mine complex.

[9]Data from USNRC Grace Energy Site Visit report, March 31, 1995.

[10]This site is located approximately 3 mi. from downtown Gallup, a city of about 20,000 people.

[11]A shaft associated with the UNC Northeast Church Rock Mine in Section 3 is part of the same underground mine complex centered in Section 35.

NAVAJO ABANDONED MINE LAND RECLAMATION DEPARTMENT
SHIPROCK AML PROGRAM

EASTERN AGENCY INVENTORY

February 7, 1995

No.	STATUS		#	MINE NAME	TOPO QUAD NAME	LOCATION
1	W1/2NE1/4, E1/2NE1/4, & SW1/4 Indian Allotments		5	Section 4	Goat Mountain	14N 10W Sec. 4 NE 1/4 & SW 1/4
2	W1/2NE1/4,E1/2NE1/4, & SE1/4 Indian Allotments		6	Section 4	Thoreau	14N 10W Sec. 4 NE 1/4 & SE 1/4
3	Indian Allotment		42	Section 34	Thoreau	14N 11W Sec. 34 SW 1/4 NE 1/4 NE 1/4
4	Navajo Tribal Trust		48	Eagle #1-6	Thoreau	14N 12W Sec. 18 SW 1/4 SE 1/4
5	Navajo Tribal Trust		52	Tietjen-Lewis No. 1	Thoreau	14N 13W Sec. 8
6	Navajo Tribal Trust		53	Alpha	Thoreau	14N 13W Sec. 12 SW 1/4 SW 1/4 SW 1/4
7	Navajo Tribal Trust		54	Largo	Thoreau	14N 13W Sec. 14 NW 1/4 NW 1/4 NW 1/4
8	Navajo Tribal Trust		54	Largo	Thoreau	14N 13W Sec. 14 NW 1/4 NW 1/4 NW 1/4
9	Navajo Tribal Trust		54	Largo	Thoreau	14N 13W Sec. 14 NW 1/4 NW 1/4 NW 1/4
10	Navajo Tribal Trust		55	June	Thoreau	14N 13W Sec. 14 NE 1/4 NE 1/4 NE 1/4
11	Navajo Tribal Trust		56	West Eagle 1-3	Thoreau	14N 13W Sec. 24 SE 1/4 SW 1/4 NE 1/4
12	Navajo Tribal Trust		57	Last Chance #2	Continental Divide	14N 14W Sec. 2 SW 1/4 NE 1/4 NW 1/4
13	Indian Allotment		58	West Largo	Borrego Pass	15N 10W Sec. 17 SW 1/4
14	Indian Allotment		60	Section 32 33	Thoreau NE	15N 11W Sec. 32 SE 1/4 NE 1/4 NE 1/4
15	Navajo Tribal Trust		62	Unknown	Casamero Lake	15N, 12W Sec. 23 NE1/4NE1/4
16	Navajo Tribal Trust		63	Unknown	Casamero Lake	15N 12W Sec. 24
17	Indian Allotment		65	Black Jack #1	Hosta Butte	15N 13W Sec. 12 NE 1/4 NE 1/4 SW 1/4
18	Navajo Tribal Trust		66	Unknown Section 13	Hosta Butte	15N 13W Sec. NE1/4 NE1/4
19	Navajo Tribal Trust		67	Unknown Section 13	Hosta Butte	15N 13W Sec. 13 SE1/4
20	Indian Allotment		68	Black Jack #2	Hosta Butte	15N 13W Sec. 18 SW 1/4 NE 1/4 NE 1/4

21	Indian Allotment		69	Mac #2	Hosta Butte	15N 13W Sec. 18 NE 1/4 SE 1/4 SE 1/4
22	Indian Allotment		70	Section 20	Hosta Butte	15N 13W Sec. 20 SW 1/4 NE 1/4 NE 1/4
23	Navajo Tribal Trust		71	Ruby #1 and #2 decline	Hosta Butte	15N 13W Sec. 21 NE 1/4 SW 1/4 NW 1/4
24	Navajo Tribal Trust		72	Ruby #3 and #4	Hosta Butte	15N 13W Sec. 25 SE 1/4 NE 1/4 NE 1/4
25	Navajo Tribal Trust		73	South Pod Ore Body	Thoreau	15N 13W Sec. 25 SE 1/4 SE 1/4
26	Indian Allotment		74	Ruby #4 Ore Body	Hosta Butte/Thoreau	15N 13W Sec. 26 NE 1/4 & SE 1/4
27	Navajo Tribal Trust		75	Ruby #2 Ore Body	Hosta Butte	15N 13W Sec. 27 NE 1/4 NW 1/4
28	Indian Allotment		76	Unknown	Mariano Lake	15N 14W Sec. 2
29	Navajo Tribal Trust		77	Unknown	Mariano Lake	15N 14W Sec. 3
30	Indian Allotment		78	Mariano Lake	Mariano Lake	15N 14W Sec. 12 SE 1/4 SW 1/4 NW 1/4
31	Indian Allotment		79	Mac #1	Mariano Lake	15N 14W Sec. 12 SW 1/4 NE 1/4 SE 1/4
32	Navajo Tribal Trust		80	Nicholson-Brown	Mariano Lake/Continental Divide	15N 14W Sec. 25 SW 1/4 NE 1/4 SE 1/4
33	Navajo Tribal Trust		83	Section 3	Church Rock	15N 16W Sec. 3 NE 1/4 SW 1/4 SW 1/4
34	Navajo Tribal Trust		87	Foutz #2	Church Rock	15N 16W Sec. 5 NE 1/4 NE 1/4 NE 1/4
35	Navajo Tribal Trust		89	Unknown	Church Rock	15N 16W Sec. 15
36	Indian Allotment		90	Anomaly	Gallup East	15N 17W Sec. 28 SE 1/4 NW 1/4 NW 1/4
37	Indian Allotment		91	Section 28	Gallup East	15N 17W Sec. 28 NE 1/4 SW 1/4 NW 1/4
38	Private Indian Allotment		93	Borrego Pass	Laguna Castillo	16N 10W Sec. 7 & 18
39	Navajo Tribal Trust		95	Unknown	Crownpoint	16N 13W Sec. 5 SW 1/4
40	Indian Allotment		96	Unknown	Hosta Butte	16N 13W Sec. 14
41	Indian Allotment		97	Unknown	Hosta Butte	16N 13W Sec. 26 SW 1/4
42	Indian Allotment NE1/4NE1/4NW1/4 &NW1/4NW1/4NE1/4		99	Unknown	Mariano Lake	16N 14W Sec. 34
43	Navajo Tribal Trust		100	Unknown-Section 21	Pinedale	16N 15W Sec. 21 SW 1/4
44	Navajo Tribal Trust		101	Unknown	Hard Ground Flats	16N 16W Sec. 3 NE 1/4 NE 1/4 NE 1/4
45	Navajo Tribal Trust		103	Unknown Section 7	Hard Ground Flats	16N 16W Sec. 7 NE 1/4 SW 1/4 NW 1/4
46	Navajo Tribal Trust		104	Mancos-Section 7	Hard Ground Flats	16N 16W Sec. 7 NW 1/4 SW 1/4 SW 1/4

73	Indian Allotment		139	Crownpoint South Trend	Crownpoint	17N 13W Sec. 16
74	Indian Allotment		140	Dalton Pass-Section 30	Dalton Pass	17N 13W Sec. 30
75	NW1/4 Public Domain; NE1/4,SE1/4 & SW1/4 are Indian Allotment		141	Canyon	Crownpoint	17N 13W Sec. 34
76	Navajo Tribal Trust		142	Narrow Canyon	Dalton Pass	17N 14W Sec. 2
77	Navajo Tribal Trust		143	Dalton Pass	Dalton Pass	17N 14W Sec. 24 & 25
78	Navajo Tribal Trust		144	Unknown	Dalton Pass	17N 14W Sec. 27 SW 1/4
79	Navajo Tribal Trust		145	Dalton Pass	Dalton Pass	17N 14W Sec. 28 SE 1/4
80	Navajo Tribal Trust		146	N.E. Church Rock-Section 31	Oak Spring	17N 15W Sec. 31 NW 1/4
81	Navajo Tribal Trust		147	Churchrock 8 and 2	Hard Ground Flats	17N 16W Sec. 9
82	Navajo Tribal Trust		148	N.E. Churchrock #3	Hard Ground Flats	17N 16W Sec. 21 NW 1/4 NE 1/4
83	Navajo Tribal Trust		149	N.E. Churchrock #2	Hard Ground Flats	17N 16W Sec, 27 NE 1/4
84	Navajo Tribal Trust		150	N.E. Churchrock #1	Hard Ground Flats	17N 16W Sec. 35 NE 1/4
85	Navajo Tribal Trust		151	N.E. Churchrock	Hard Ground Flats	17N 16W Sec. 35 NE 1/4
86	Navajo Tribal Trust		152	N.E. Churchrock #1 East	Hard Ground Flats/Oak Spring	17N 16W Sec. 36 NW 1/4
87	Navajo Tribal Trust		153	Standing Rock	Dalton Pass	18N 14W Sec. 35 SW 1/4
88	Navajo Tribal Fee		154	Farr Ranch	Star Lake/Rincon Marquez	19N 6W Sec. 13 & 14
89	Navajo Tribal Fee		155	Farr Ranch	Star Lake/Rincon Marquez	19N 6W Sec. 15 SE 1/4 SW 1/4
90	Navajo Tribal Fee		156	Farr Ranch	Rincon Marquez	19N 6W Sec. 23 SE 1/4 SE 1/4 SW 1/4
91	Navajo Tribal Fee		157	Farr Ranch	Rincon Marquez	19N 6W Sec. 25 & 26
92	Navajo Tribal Fee		158	Nose Rock	Nose Rock/Seven Lakes NW	19N 11W Sec. 10
93	Navajo Tribal Fee		159	Nose Rock #1	Becenti Lake	19N 11W Sec. 31 SW 1/4 SW 1/4 NW 1/4
94	Navajo Tribal Trust		160	Nose Rock	Antelope Lookout Mesa	19N 12W Sec. 32
95	Navajo Tribal Trust		162	Chaco Canyon-Drill Hole CC-3	Pueblo Pintado	20N 8W Sec. 9 NW 1/4 NW 1/4 NW 1/4
96	Navajo Tribal Trust		165	Herrera Ranch	Herrera	11N 2W Sec. 16 NE 1/47

47	Navajo Tribal Trust		107	Unknown-Section 9	Hard Ground Flats	16N 16W Sec. 9 SE 1/4
48	Navajo Tribal Trust		108	Unknown	Hard Ground Flats	16N 16W Sec. 9 NW 1/4 NW 1/4 SE 1/4
49	Navajo Tribal Trust		111	Unknown	Church Rock	16N 16W Sec. 17 NW 1/4
50	Navajo Tribal Trust		112	Unknown	Church Rock	16N 16W Sec. 17 NE 1/4 NW 1/4 NE 1/4
51	Navajo Tribal Trust		113	Unknown	Church Rock	16N 16W Sec. 18 NW 1/4 NW 1/4 NW 1/4
52	Navajo Tribal Trust		114	Unknown	Church Rock	16N 16W Sec. 18 SW 1/4 NW 1/4 NW 1/4
53	Indian Allotment		115	Unknown	Church Rock	16N 16W Sec. 18 NE 1/4 SW 1/4 SW 1/4
54	Navajo Tribal Trust		116	Unknown	Church Rock	16N 16W Sec. 19 NE 1/4
55	NE1/4 Indian Allotment; NW1/4SW1/4&SE1/4 Public Domain		117	Pyramid Group	Church Rock	16N 16W Sec. 22
56	Indian Allotment		118	Unknown Section 22	Church Rock	16N 16W Sec. 22 NE 1/4
57	Navajo Tribal Trust		119	Unknown Section 23	Church Rock/Pindeale	16N 16W Sec. 23 NW 1/4 NE 1/4
58	Navajo Tribal Trust		120	Foutz #3	Church Rock	16N 16W Sec. 31 SE 1/4 SE 1/4 SE 1/4
59	Navajo Tribal Trust		123	Unknown-Section 13	Church Rock	16N 17W Sec. 13 SW 1/4 NE 1/4 SW 1/4
60	Navajo Tribal Trust		124	Unknown-Section 13	Church Rock	16N 17W Sec. 13 NW 1/4 NW 1/4 SE 1/4
61	Navajo Tribal Trust		125	Unknown Section 14	Church Rock	16N 17W Sec. 14 NW 1/4
62	Navajo Tribal Trust		126	Section 23 Grace Nuclear	Church Rock	16N 17W Sec. 23 NW 1/4 NE 1/4 NE 1/4
63	Indian Allotment		127	Unknown-Section 24	Church Rock	16N 17W Sec. 24 NE 1/4
64	Indian Allotment		128	Unknown-Section 25	Church Rock	16N 17W Sec. 25 NW 1/4 SE 1/4 NE 1/4
65	Navajo Tribal Trust		129	Unknown-White Cliffs	Gallup East	16N 17W Sec. 31 SE 1/4 NE 1/4 NE 1/4
66	Navajo Tribal Trust		130	C D and S	Church Rock	16N 17W Sec. 35 NW 1/4 NW 1/4 SE 1/4
67	Indian Allotment		131	Delter	Church Rock	16N 17W Sec. 36 SE 1/4 NW 1/4 NW 1/4
68	Navajo Tribal Trust		134	Crownpoint	Church Rock	17N 12W Sec. 19 NE 1/4 NW 1/4 SW 1/4
69	Escheated to Navajo Tribe		135	Monument	Crownpoint/Heart Rock	17N 12W Sec. 28 SE 1/4 SE 1/4 NW 1/4
70	Indian Allotment		136	Crownpoint	Crownpoint	17N 12W Sec. 29 NE 1/4 NW 1/4 NE 1/4
71	Indian Allotment		137	Crownpoint North Trend	Crownpoint	17N 13W Sec. 4
72	Indian Allotment		138	Crownpoint-Section 9	Crownpoint	17N 13W Sec. 9 NE 1/4 NE 1/4 SW 1/4

MINE SITE VISIT REPORT
NAVAJO AML RECLAMATION DEPARTMENT

DATE(S) OF VISIT: January 22 to 26, 1996

MINE/PROJECT NAME: Eastern Navajo Agency Non-coal Inventory

DURATION OF VISIT: Varied daily from 9:30 a.m. - 4:30 p.m.

PURPOSE OF VISIT: Field investigation and inventory of known mining claims for possible non-co mining activities, and to document the extent of mining activities and any physical hazards present o these mining claims. Ms. Rose Grey, Reclamation Specialist II, assisted with this task.

OBSERVATIONS: This week's field investigation and inventory was concentrated on in the communitie of Becenti, Pueblo Pintado, and Star Lake. The following claims were investigated this week:

Monday - January 22, 1996:
The day was spent locating and accessing the Nose Rock and Nose Rock # 1 claims. Two differe access roads leading to the Nose Rock claim and the access road leading to the Nose Rock # 1 clai were investigated. The access roads leading to these claims are fenced and the gates locked.

Tuesday - January 23, 1996:
Nose Rock # 1 - SW¼SW¼NW¼ Section 31, T19N, R11W. This claim has a backfilled and concre capped vertical shaft. Other features located on this site consisted of a large prefabricated met building, two small metal buildings enclosing archaeological sites, two steel storage tanks, a 6' diamet concrete enclosed steel culvert tunnel, a 8' L x 5' W x 6' H inclined concrete box, and numerous concre slabs. Other associated features include a 110' L x 110' W sewage pond, a 80' L x 30' W x 1' - 8' trench containing industrial waste, and two large retention ponds (?). Dismantled equipment and the parts are scattered throughout the site. Impacted area is approximately 32.7 ± acres. This area fenced and is being used as rangeland for livestock.

Nose Rock - Section 32, T19N, R12W. This claim has numerous concrete capped and steel pipe stak drill holes located throughout the entire section. There are now signs of any mining related activities this claim. This site is fenced and being used as rangeland for livestock.

Wednesday - January 24, 1996:
Nose Rock - Section 10, T19N, R11W. This claim did not have any drill holes or signs of mini activities. This section is fenced and is being using as rangeland for livestock.

Chaco Canyon-Drill Hole CC-3 - NW¼NW¼NW¼ Section 9, T20N, R8W. This claim has one 1 diameter drill hole. The drill hole is encased with a steel pipe and there are no signs of mining activitie This ¼ section is in an open area and is being used as rangeland for livestock.

Thursday - January 25, 1996:
Farr Ranch - SE¼SE¼SW¼ Section 23, T19N, R6W. This claim did not have any drill holes or sig of mining activities. This ¼ section is fenced and is being used as rangeland for livestock.

Farr Ranch - SE¼SW¼ Section 15, T19N, R6W. This claim did not have any drill holes or signs mining activities. This ¼ section is fenced and is being used as rangeland for livestock.

Friday - January 26, 1996:
Farr Ranch - Sections 13 & 14, T19N, R6W. This claim covering two sections did not have any drill hole: or signs of mining activities. These two sections are fenced and are being used as rangeland fc livestock.

Farr Ranch - Sections 25 & 26, T19N, R6W. This claim covering two sections did not have any drill hole or signs of mining activities. These two sections has a paved public road traversing them and are fence and are also being used as rangeland for livestock.

A U.S.G.S. 7.5 minute quadrangle map for the area is used to located the section or quarter corner an pinpoint the claim area. Once the section or quarter corner is found, it is used as a reference point t insure that the right area where the claim is located is investigated. All of the claims were traversed o foot or where feasible by vehicle. Hiking to a fenced in claim and traversing it on foot is more feasible however, it is time consuming.

FOLLOW UP: Contact Levon Benally, Jr., for the radiological data that he obtained during h. radiological survey of the Nose Rock # 1 site.

CONTACTS: The following individuals were contacted for information on access to the mining clairr and/or drilling operations or mining activities: Ms. Helen Antone, Becenti Chapter, Mr. Calvin Murph. BIA Roads, Emery Chee, BIA Natural Resource Management, Allen Y. Nez, Navajo Land Departmer Tom Allen, Becenti Chapter, Ms. Edith Charley (?), Becenti Chapter, Mr. Leo Charley, Torreon Chapte The Secretaries at the Becenti, Pueblo Pintado, and Torreon Chapters were also contacted fc information on individuals familiar with the area being investigated. See Public Involvement/Communi Meetings Documentation for further clarifications.

James Benally

James Benally
Reclamation Specialist II

SHIPROCK AML FIELD OFFICE

PUBLIC INVOLVEMENT/COMMUNITY MEETINGS DOCUMENTATION

m Navajo-Nose Rock, **DATE:** January 22-26, 1996
intada & Ricon Marquez

TYPE OF CONTACT:

(Indicate meeting type, contact person, (address/telephone number), problems/concerns encountered, how handled, outcome of meeting or contact).

Monday - January 22, 1996
An attempt to get to Nose Rock and Nose Rock #1 claims was unsuccessful. A local resident living within the area suggested that we locate Helen and Jake Antones, who are the gate keepers of Section 10, T19N, R11W (Nose Rock) and live in Crownpoint. As we entered Crownpoint we stopped at BIA Roads to obtain more information. We chose BIA Roads because they maintain and have access to certain roads in eastern Navajo. Mr. Calvin Murphy was our point of contact. We obtained a road map nd direction to the Antone's resident at NHA housing. Helen Antone said that there was no actual ining in Sec. 10 but some drilling activity had taken place. She mentioned that they locked their gate because of cattle rustling. She also directed us to BIA Land Operation to obtain more information. Emery Chee was the informant and suggested that we talk to Allen Nez of Navajo Land Administration. Mr. Nez had the gate key to Nose Rock Mine. An arrangement was set up to meet him the following day. Ms. Antone never agreed to open her gate.

Tuesday - January 23, 1996
nventory on Nose Rock Mine#1 located in Section 31, T19N, R11W was completed. Mr. Allen Tom, the landuser, was present and agreed to released any information he had. He said that there was no actual mining that had taken place. The demand for uranium went down. The company disassembled as much as they can and vacated. This occurred around the early eighties-1981 or 1982. He then occupied the area and is using it for rangeland. We also informed Becenti Chapter that we are in the area checking mining claims. We talked to e chapter secretary. She mentioned one of the best sources for directions or information would be the Senior itizens bus driver as goes for all the communities. The daughter of Edith Charley who lives in Section 32, T19N, R12W was also our contact. We wanted to reenforce the information given to us by Ms. Antone. Her information was very similar to Ms. Antone.

Thursday - January 25, 1996
At Torreon Chapter, we talked to the chapter secretary and made her aware that we will be in the area for two days. She directed us to Mr. Leo Charley, Land Board Member, for any information needed. He was very familiar with the community and gave good directions for getting to Sections 13, 15, 23, 25, T19N, R6W. He also said that there was no actual mining but a lot of drilling activity had taken place.

RECOMMENDATIONS:
We found out that it was easier to stop at the community's chapter house to ask about on an area we need to get to. Typically, the chapter house is very informative and cooperative to give us direction and recommendations. They are also very familiar with the community members. So we decide that at each new area/community, we will always ask about at the chapter house. Mr. James Benally, Reclamation Specialist II, is the other project personnel for the Eastern Navajo Inventory project.

SUBMITTED BY: Rose M. Grey **ACKNOWLEDGE:** ____________________
Rose M. Grey, Reclamation Specialist II — Perry H. Charley, Reclamation Specialist III

MINE SITE VISIT REPORT
NAVAJO AML RECLAMATION DEPARTMENT

DATE(S) OF VISIT: January 29 to 31, 1996

MINE/PROJECT NAME: Eastern Navajo Agency Non-coal Inventory

DURATION OF VISIT: Varied daily from 9:30 a.m. to 4:15 p.m.

PURPOSE OF VISIT: Field investigation and inventory of known mining claims for possible non-coal mining activities, and to document the extent of mining activities and any physical hazards present on these mining claims. Ms. Rose Grey, Reclamation Specialist II, assisted with this assignment.

OBSERVATIONS: This week's field investigations and inventory was concentrated on in the community of Nahodishgish (Dalton Pass). The following claims were investigated this week:

Monday - January 29, 1996:
Dalton Pass - Sections 24 & 25, T17N, R14W. This claim on two sections have numerous drill holes staked by plastic and steel pipes. There are no mining related activities on these sections. Earthmoving activities were limited to the drill pads constructed during explorations activities. The access road leading to these sections was muddy from melting snowcover. Cursory radiological data obtained averaged 12.5 μR/hr on this claim.

Dalton Pass - S ½ Section 30, T17N, R13W. The south half of this claim had some drill holes staked by plastic and steel pipes. Other activities were limited to drill pads constructed for exploration activities. The field investigation was not completed for this claim as the vehicle got stuck on a berm along the access road. The access road leading to this claim was muddy from melting snowcover. Cursory radiological data obtained averaged 12.5 μR/hr on the south half of this claim.

Tuesday - January 30, 1996:
Dalton Pass - N ½ Section 30, T17N, R13W. The north half of this claim also has drill holes staked by plastic and steel pipes. There are no mining related activities on this claim. Earthmoving activities were limited to the drill pads constructed during exploration activities. The access road leading to this claim was muddy from melting snowcover. Cursory radiological data obtained averaged 12.5 μR/hr on this claim.

Narrow Canyon - Section 2, T17N, R14W. This claim has plastic pipe staked drill holes. There are no mining related activities on this claim. Earthmoving activities were limited to the drill pads constructed during exploration activities. This claim is in an open area and is being used as rangeland and residential areas. Cursory radiological data obtained averaged 11.0 μR/hr on this claim.

Wednesday - January 31, 1996:
Unknown - SW¼ Section 27, T17N, R14W. This claim has numerous steel pipe staked drill holes located throughout the claim. There are no mining related activities on this claim. Earthmoving activities were limited to the drill pads constructed during exploration activities. The access road leading to this claim is fenced and the gate locked. The area is being used as rangeland for livestock. Cursory radiological data obtained averaged 12.0 μR/hr on this claim.

Dalton Pass - SE¼ Section 28, T17N, R14W. This claim did not have any drill holes or signs of mining activities. Earthmoving activities were limited to access roads and drill pads. The access road leading to this claim was muddy from the melting snowcover. Cursory radiological data obtained averaged 12.0 μR/hr on this claim.

Standing Rock - SW¼ Section 35, T18N, R14W. This claim was used as a gravel pit for road base and/or riprap material for Navajo Route 9 (?). Impacted area is approximately 1800' L x 75' - 225' W at approximately 6.19± acres. Cursory radiological data obtained averaged 12.0 μR/hr on this claim.

A U.S.G.S 7.5 minute quadrangle map for the township, range and section where the claim is located is used to locate the section, center or quarter comer and pinpoint the claim area. Once a known point is located, it is used as a reference point to insure that the right area where the claim is located is investigated. All the claims were traversed on foot or where feasible by vehicle.

CONTACTS: The following individuals were contacted for information on access to the mining claims and/or exploration and mining activities. Mr. Eddie Morgan, Community Services Coordinator, Arlene Chiquito, Chapter Secretary, Nahodishgish Chapter.

James Benally

James Benally
Reclamation Specialist II

SHIPROCK AML FIELD OFFICE

PUBLIC INVOLVEMENT / COMMUNITY MEETINGS DOCUMENTATION

PROBLEM AREA: Eastern Navajo - Dalton Pass **DATE:** January 29 - February 2, 1996

TYPE OF CONTACT:

(Indicate meeting type, contact person, (address / telephone number), problems/concerns encountered, how handled, outcome of meeting or contact).

Tuesday - January 30, 1996

The contact made with Nahodishgish Chapter (Dalton Pass) involved Chapter President, Ed Morgan and secretary, Arlene Chiquito. We informed Mr. Morgan of the purpose of our presence in the area. We asked him for his assistance in getting to the areas of interest. We also asked him if he or a community member would know of a mining that had taken place in the area. Mr. Morgan said that there was no actual / physical mining but many drilling explorations had taken place. He said most of the claims were probably just for drilling exploration. Mr. Morgan and Ms. Chiquito were very cooperative in exchanging any information.

RECOMMENDATIONS:

Inquiring at the chapter houses for information on landusers and abandoned mines is a good method to make public contacts and obtain information. Mr. James Benally, Reclamation Specialist II, is also involved with the project.

SUBMITTED BY: Rose M. Grey

Rose M. Grey
Reclamation Specialist II

ACKNOWLEDGE: ______________________

Perry H. Charley
Reclamation Specialist III

MINE SITE VISIT REPORT
NAVAJO AML RECLAMATION DEPARTMENT

DATE(S) OF VISIT: February 7 to 9, 1996

MINE/PROJECT NAME: Eastern Navajo Agency Non-coal Inventory

DURATION OF VISIT: Varied daily 9:30 a.m. - 3:30 p.m.

PURPOSE OF VISIT: Field investigation and inventory of known mining claims for possible non-coal mining activities, and to document the extent of mining activities and any physical hazards present on these mining claims. Ms. Rose Grey, Reclamation Specialist II, assisted with this task.

OBSERVATIONS: This week's field investigations and inventory were concentrated on in the community of Crownpoint. The following claims were investigated this week:

Wednesday - February 7, 1996:
Canyon - S½ Section 34, T17N, R13W. The south half of this claim has several drill holes staked with plastic and steel pipes on it. There are no mining related activities on the south portion of this claim. Disturbances and construction were limited to the access roads and drill pads during exploration activities. The access road leading to the southern portion of the claim is fenced and the gate locked. Additionally, the access road is extremely muddy and impassable in some places on top of the mesa. Cursory radiological data obtained averaged 13.0 μR/hr on the south portion of this claim.

Unknown - SW¼ Section 5, T16N, R13W. This claim has plastic and steel pipe staked drill holes. There are no mining related activities on this claim. Disturbances and construction were limited to the access roads and drill pads during exploration activities. The access road leading to this claim is fenced and the gate locked. Cursory radiological data obtained averaged 12.5 μR/hr on this claim.

THURSDAY - February 8, 1996:
Canyon - N½ Section 34, T17N, R13W. The north half of this claim has numerous drill holes staked with plastic and steel pipes on it. There are no mining related activities on the north portion of this claim. Disturbances and construction were limited to the access roads, drill pads, and two retention ponds measuring 100' L x 65' W x 11½' D and 80' L x 65' W x 5½' D. The access road leading to the northern portion of the claim is also fenced and the gate locked. Cursory radiological data obtained averaged 16.0 μR/hr on the northern portion of this claim.

Crownpoint-South Trend - Section 16, T17N, R13W. There were several drill holes staked with plastic and steel pipes located on this claim. There were no mining related activities noted on this claim. Disturbances and construction were limited to the access roads and drill pads. This claim is located in an open area and is being used as rangeland for livestock. Cursory radiological data obtained averaged 13.0 μR/hr on this claim.

Crownpoint - NE¼ NE¼ SW¼ Section 9, T17N, R13W. There were no drill holes noted on this claim or mining related activities. This claim is fenced and is being used as rangeland for livestock. Cursory radiological data obtained averaged 12.0 μR/hr on this claim.

Crownpoint- North Trend - Section 4, T17N, R13W. There were no drill holes nor mining related activities noted on this claim. This claim is fenced and is being used as rangeland for livestock. The Ludlum Mirco

R Meter was used to perform and obtain cursory radiological data averaging 11.0 μR/hr on this claim.

FRIDAY - February 9, 1996:
Crownpoint - NE¼ NW¼ NE¼ Section 29, T17N, R12W. Drill holes staked with plastic and steel pipes and a dozer cut measuring 100' L x 75' W x 1' D were noted on this claim. No other disturbances were noted on this claim. This area is fenced and is being used as rangeland for livestock. Cursory radiological data obtained averaged 12.0 μR/hr on this claim.

Monument - SE¼ SE¼ NW¼ Section 28, T17N, R12W. There were no drill holes or mining related activities noted on this claim. This claim is adjacent to the Chaco Canyon National Monument and there are numerous archaeological sites staked by steel T-posts marking their locations. This area is fenced and is being used as rangeland for livestock. Cursory radiological data obtained averaged 11.0 μR/hr on this claim.

A U.S.G.S 7.5 minute quadrangle map for the township, range and section where the claim is located is used to locate the section, center or quarter corner and pinpoint the claim area. Once a known point is located, it is used as a reference point to insure that the right area where the claim is located is investigated. All the claims were traversed on foot or where feasible by vehicle.

CONTACTS: The following individuals were contacted for information on access to the mining claims and/or exploration and mining activities. Mr. Allen Y. Nez, Mr. Billy Yazzie, Navajo Land Department, Mr. Emery Chee, BIA Natural Resources Management, Mr. Edward Tsosie, Ms. Carol Washee, Mr. & Mrs. Henry & Elsie Billy.

James Benally
James Benally
Reclamation Specialist II

Rose M. Grey
Rose M. Grey
Reclamation Specialist II

SHIPROCK AML FIELD OFFICE

PUBLIC INVOLVEMENT / COMMUNITY MEETINGS DOCUMENTATION

PROBLEM AREA: Eastern Navajo - Crownpoint **DATE:** February 7 - 9, 1996

TYPE OF CONTACT:

(Indicate meeting type, contact person, (address / telephone number), problems/concerns encountered, how handled, outcome of meeting or contact).

Wednesday - February 7, 1996

To reach north one-half of Section 34, T17N, R13W we had to go through a locked gate. Edward Tsosie of Crownpoint was the person we talked to on getting to the area. He directed us on which road to take. He also told us that Clara Washee and Henry Billy are the main landusers in the area. He didnot know of any actual mining but did mention the drilling exploration. Mr. Tsosie was very cooperative. Mr. Henry Billy was not home so we talk to Ms. Clara Washee on getting to Sec. 35 and south one-half of Sec. 34. She mentioned the drilling exploration and some subsidence that are taking places from the exploration. Her husband and daughter lead us to a subsidence that existed in their area. She said that some livestock had fallen in and died. There was really no subsidence but the family admitted to backfilling the hole. We told them that we would keep an eye on it. It was more of a complaint than a concern on their part. Other than the subsidence they were very cooperative in giving us direction to get to their area. Ms. Washee did mention the Billies and where we can locate them. We located Mr. Henry Billy, a custodian at Crownpoint Elementary School. We arranged with him to unlock his gate to get to the north one-half of Sec. 34. Mr. Billy didnot mentioned any type of mining or drilling exploration.

Thursday - February 8, 1996

Today's contact was with Mr. Billy Yazzie of Land Administration and Emery Chee of BIA Land Operation. We asked Mr. Yazzie for his assistance on Land status. He said his documents and maps are not updated and we are better off talking to BIA Land Operation. Mr. Emery Chee provided the landuser's name, Billy Martin, and where we can locate them to ask permission to get to their area (Sec. 28 T17N, R14W and Sec. 29, T17N, R12W).

Friday - February 9, 1996

Mrs. Billy Martin was very cooperative. She did mention the drilling exploration but no physical mining.

RECOMMENDATIONS:

Obtaining information from the public is very useful and can be time saving. Mr. James Benally, Reclamation Specialist II, is also involved with the Eastern Navajo Project inventory.

SUBMITTED BY: Rose M. Grey
Rose M. Grey
Reclamation Specialist II

ACKNOWLEDGE: ______________________
Perry H. Charley
Reclamation Specialist III

MINE SITE VISIT REPORT
NAVAJO AML RECLAMATION DEPARTMENT

DATE(S) OF VISIT: February 12 to 16, 1996

MINE/PROJECT NAME: Eastern Navajo Agency Non-Coal Inventory

DURATION OF VISIT: Varied daily 9:30 a.m. - 3:30 p.m.

PURPOSE OF VISIT: Field investigation and inventory of known mining claims for possible non-coal mining activities, and to document the extent of mining activities and any physical hazards present on these mining claims. Ms. Rose Grey, Reclamation Specialist II, assisted with this task.

OBSERVATIONS: This week's field investigations and inventory were concentrated on in the community of Church Rock. The following claims were investigated this week:

<u>MONDAY - February 12, 1996:</u>
Unknown - NE¼ NE¼ NE¼ Section 3, T16N, R16W. This claim has a backfilled and concrete capped vertical shaft (VO) on it. Other associated features located on this claim consisted of concrete slabs. Earthmoving and construction activities were limited to the vertical shaft and the access roads during mining activities. The access road leading to this claim is fenced and the gate locked. Cursory radiological data obtained ranged from 30 μR/hr to 300 μR/hr on this claim.

NE Church Rock # 1 and NE Church Rock - NE¼ Section 35, T17N, R16W. This area has two different claims on it and was worked by United Nuclear Corporation. This claim has a backfilled and concrete capped vertical shaft on it. Other features located on this site consisted of a large prefabricated metal office building, one small metal building, and numerous concrete slabs. Impacted area is approximately 13.89± acres. Cursory radiological data obtained ranged from 150 μR/hr to 300 μR/hr on this previously worked claim.

NE Church Rock # 1 East - NW¼ Section 36, T17N, R16W. This claim was worked by Kerr McGee Corporation and still has some personnel on site. This claim has a backfilled vertical shaft (VO) on it. Other associated features located on this claim consisted of a large metal building and concrete slabs. The access road leading to this claim is fenced and the gate locked. Impacted area is approximately 40.00± acres. Cursory radiological data obtained ranged from 150 μR/hr to 180 μR/hr on this worked claim.

NE Church Rock - NW¼ Section 31, T17N, R15W. This claim has drill holes staked with plastic and steel pipes on it. There are no mining related activities on this claim. Disturbances and construction were limited to the access roads and drill pads during exploration activities. The access road leading to the claim is fenced and the gate locked. Cursory radiological data obtained averaged 13.0 μR/hr on this claim.

<u>TUESDAY - February 13, 1996:</u>
Unknown - NE¼ SW¼ NW¼ Section 7, T16N, R16W. This claim has numerous drill holes staked with plastic and steel pipes on it. There are no mining related activities on this claim. Disturbances and construction were limited to the access roads and drill pads. This claim is located in a fenced area and is being used as rangeland for livestock. The access roads leading to the claim from the north and south are fenced and the gates locked. Cursory radiological data obtained averaged 16.0 μR/hr on this

claim.

Mancos - Section 7 - NW¼ SW¼ SW¼ Section 7, T16N, R16W. There are numerous drill holes staked with plastic and steel pipes located on this claim. There were no mining related activities noted on this claim. Disturbances and construction were limited to the access roads and drill pads. This claim is located in a fenced area and is being used as rangeland for livestock. The access roads leading to the claim are fenced and the gates locked. Cursory radiological data obtained averaged 13.0 μR/hr on this claim.

Unknown - Section 9 - SE¼ Section 9, T16N, R16W. There are numerous drill holes staked with plastic and steel pipes located on this claim. There were no mining related activities noted on this claim. Disturbances and construction were limited to the access roads and drill pads. This claim is located in a fenced area and is being used as rangeland for livestock. The access road leading to this claim is fenced and the gate locked. Cursory radiological data obtained averaged 12.0 μR/hr on this claim.

Unknown - NW¼ NW¼ SE¼ Section 9, T16N, R16W. There are numerous drill holes staked with plastic and steel pipes located on this claim. There were no mining related activities noted on this claim. Disturbances and construction were limited to the access roads and drill pads. This claim is located in a fenced area and is being used as rangeland for livestock. The access road leading to this claim is fenced and the gate locked. Cursory radiological data obtained averaged 11.0 μR/hr on this claim.

<u>WEDNESDAY - February 14, 1996:</u>
Church Rock 8 & 2 - Section 9, T17N, R16W. Drill holes staked with plastic pipes were noted on this claim. There were no mining related activities noted on this claim. Disturbances and construction were limited to the access roads and drill pads. This claim is located in a fenced area and is being used as rangeland for livestock. The access road leading to this claim is fenced and the gate locked. Cursory radiological data obtained averaged 12.0 μR/hr on this claim.

NE Church Rock # 3 - NW¼ NE¼ Section 21, T17N, R16W. Drill holes staked with plastic pipes were noted on this claim. There were no mining related activities noted on this claim. Disturbances and construction were limited to the access roads and drill pads. This claim is located in an open area and is being used as rangeland for livestock. Cursory radiological data obtained averaged 11.0 μR/hr on this claim.

NE Church Rock # 2 - NE¼ Section 27, T17N, R16W. This claim has been worked and reclaimed by the previous operator(s). An area measuring 625' L x 500' W has been regraded, topsoiled, and revegetated. Several small plots have been fenced in on the regraded area. There are three 8", one 10", and one 36" monitoring wells located on the regraded area. The area and the access road to this claim is fenced and the gate locked. Cursory radiological data obtained averaged 50 μR/hr on this claim.

<u>THURSDAY - February 15, 1996:</u>
Unknown - White Cliffs - NW¼ SE¼ NE¼ Section 31, T16N, R17W. There were no drill holes or mining related activities noted on this claim. This claim is located in a fenced area and is being used as rangeland for livestock. The access road is fenced and traverses through several residential areas. Cursory radiological data obtained averaged 14.0 μR/hr on this claim.

Anomaly - SE¼ NW¼ NW¼ Section 28, T15N, R17W. There were no drill holes or mining related activities noted on this claim. This claim is located in a fenced area and is being used for residential and rangeland for livestock. The access road is fenced and traverses through three residential areas. Cursory radiological data obtained averaged 11.0 μR/hr on this claim.

Section 28 - NE¼ SW¼ NW¼ Section 28, T15N, R17W. There were no drill holes or mining related activities noted on this claim. This claim is located south of the Anomaly claim in a fenced area and is being used for residential and rangeland for livestock. The access road is fenced and traverses through three residential areas. Cursory radiological data obtained averaged 10.0 μR/hr on this claim.

FRIDAY - February 16, 1996:

Unknown - Section 15, T15N, R16W. There were no drill holes or mining related activities noted on this claim. This claim is located in an open area and is being used as rangeland for livestock. Cursory radiological data obtained averaged 14.0 μR/hr on this claim.

A U.S.G.S 7.5 minute quadrangle map for the township, range and section where the claim is located is used to locate the section, center or quarter corner and pinpoint the claim area. Once a known point is located, it is used as a reference point to insure that the right area where the claim is located is investigated. All the claims were traversed on foot or where feasible by vehicle.

CONTACTS: The following individuals were contacted for information on access to the mining claims and/or exploration and mining activities. Mr. Ed Morrales, UNC, Mr. Tom Atcitty, Ms. Marilyn Livingston, Mr. Sampson Jim, Mr. Tim Whitman, and Mr. Melvin Gurule, BIA Branch of Land Operations.

James Benally
James Benally
Reclamation Specialist II

Rose M. Grey
Rose M. Grey
Reclamation Specialist II

SHIPROCK AML FIELD OFFICE

PUBLIC INVOLVEMENT / COMMUNITY MEETINGS DOCUMENTATION

PROBLEM AREA: Eastern Navajo - Hard Ground Flats **DATE:** February 12 - 16, 1996
Gallup East

TYPE OF CONTACT:

(Indicate meeting type, contact person, (address / telephone number), problems/concerns encountered, how handled, outcome of meeting or contact).

Monday - February 12, 1996
Section 3 and 9, T17N, R16W, consisted of claims from UNC (United Nuclear Corp.). The company is no longer mining. Some employees are still occupying the buildings. Mr. Ed Morrales was the person we talk to after checking out section 3 and 9. We asked of him if any actual mining at taken place. He gave us the location and told us that the copies of the claims are documented in Window Rock. He said the vertical shafts was capped with concrete and the Tribe wanted certain structures to remain. He did mention that Kerr-McGee has some claims in the area.

Tuesday - February 13, 1996
Today's contact was Mr. Tom Atcitty and Ms. Marilyn Livingston. Mr. Atcitty is the gatekeeper on routes that lead into north one-half of Section 7, T16N, R16W. We asked of him if he knew of any mining activities. He said that he was only aware of some drilling exploration in the area. He was very cooperative in providing information on the drilling exploration and directions to section 7. Ms. Livingston lived on the south end of section 7. We informed her of whom we are and what our task is. She was very cooperative. She also mentioned that only some drilling has taken place in the area. She didnot knew of any actual mining.

Thursday - February 15, 1996
The claim in Gallup East involved section 31, T16N, R17W. The area of interest was near Samson Jim's resident. Mr. Jim was not aware of any mining or drilling. He said he had not been in the area long enough to know of such activity.

Friday - February 16, 1996
Mr. Tim Whitman is a resident of Church Rock and is the landuser of Section 32. He informed us that there are some portals existing in Section 31, T16N, R16W. He said he had to remove the gate and replace with fence to keep the teenagers from partying inside the portals. He also told us that he used to work with the company that did the mining. He did have some health problems and is in the process of working with the Uranium Worker Office in Shiprock.
Eastern Navajo is considered "checkerboard" where different landuse and owner's status exist. For more information on such issue we talked to Melvin Gurule of Land Operations at Crownpoint BIA. Mr. Gurule loan us a plat book to document and copy all land status of the area the claims exist. We made an agreement to return the book the following week.

RECOMMENDATIONS:
Obtaining public information is still important. Their information can by useful and time consuming. The terrain is rough and the gates to most of areas are lock, so asking permission to enter is important. Mr. James Benally, Reclamation Specialist II, is also conducting the inventory.

SUBMITTED BY: Rose M. Grey
Rose M. Grey
Reclamation Specialist II

ACKNOWLEDGE: ____________________
Perry H. Charley
Reclamation Specialist III

MINE SITE VISIT REPORT
NAVAJO AML RECLAMATION DEPARTMENT

DATE(S) OF VISIT: February 21 & 22, 1996

MINE/PROJECT NAME: Eastern Navajo Agency Non-coal Inventory

DURATION OF VISIT: Varied daily 9:30 a.m. - 3:30 p.m.

PURPOSE OF VISIT: Field investigation and inventory of known mining claims for possible non-coal mining activities, and to document the extent of mining activities and any physical hazards present on these mining claims. Ms. Rose Grey, Reclamation Specialist II, assisted with this task.

OBSERVATIONS: This week's field investigations and inventory were concentrated on in the community of Church Rock. The following claims were investigated this week:

<u>WEDNESDAY - February 21, 1996:</u>
Section 3 - NE¼ SW¼ SW¼ Section 3, T15N, R16W. Three attempts were made to access this claim. The east access road is fenced and the gate locked. The middle road is fenced and goes through two residential areas and does not access the claim. The west access road is unpassable by vehicle.

Foutz # 3 - SE¼ SE¼ SE¼ Section 31, T16N, R16W. This site is located approximately 1 mile south of the Springstead/Pinedale road. There was not enough time to hiked to the site as the access road is fenced and unpassable.

<u>THURSDAY - February 22, 1996:</u>
A scheduled field visit was made on the proposed road improvement projects N37 (Coal Mine Rd), N37A (Bass Lake Rd), and N7113 (Peshlakai Rd) upon Navajo Department of Transportation's request. The field investigation was made along with Mr. Greg Begay and Ms. Thomascita Shorty, Environmental Specialists, to determine if any abandoned or reclaimed coal and/or non-coal mines are located within the 150' right-of-ways.

Project N37A (Bass Lake Rd) was traversed by vehicle from the community of Twin Lakes to N37's (Coal Mine Rd) intersection. Project N37 (Coal Mine Rd) was also traversed by vehicle from the southern portion of the Coal Mine Road to Navajo Route 9's intersection. The field investigation did not disclose any coal outcrops or seams within the right-of-ways during the field visit. The southern segment of Coal Mine Road did contain some traces of coal deposits along the stream bed. NAMLRD's records indicate that there are several reclaimed coal mines within this vicinity of the proposed projects. The nearest reclaimed coal mine is located approximately 4,500' east of the proposed improvement project at the base of Coal Mine Hill, and the next closest mine is located at approximately 8,700' south-southeast of Coal Mine Spring. Other projects are located approximately 12,500' to the southwest of Coal Mine Road.

Project N7113 (Peshlakai Rd) was traversed by vehicle from the Mariano Lake School to where it intercepts Navajo Route 49 east of the Mariano Lake Trading Post. NAMLRD's records indicate that there are mining claims within Section 34, T16N, R14W, and within Sections 2 & 3, T15N, R14W. The proposed improvement project runs along the south section line of Section 3, and on the east/west section line for Sections 2 & 3. However, there were no abandoned coal or non-coal mines noted within the 150' right-of-way for N7113. Disturbances noted were limited to road grading and road ditches. Additional field investigations planned for the Mariano Lake area should detect any previous mining *activities along this route. Additional claims are located in Sections 12 & 25, T15N, further south-southeast of the scheduled road improvement project. These claims should not effect or impact the improvement project.*

CONTACTS: Ms. Louise Benally was contacted for information on the access roads to the mining claims and/or exploration and mining activities. Mr. Greg Begay and Ms. Thomascita Shorty, Environmental Specialists, Navajo Department of Transportation.

James Benally

James Benally
Reclamation Specialist II

Rose M. Grey

Rose M. Grey
Reclamation Specialist II

SHIPROCK AML FIELD OFFICE

PUBLIC INVOLVEMENT / COMMUNITY MEETINGS DOCUMENTATION

PROBLEM AREA: Church Rock and Mariano Lake **DATE:** February 20 - 23, 1996

TYPE OF CONTACT:

(Indicate meeting type, contact person, (address / telephone number), problems/concerns encountered, how handled, outcome of meeting or contact).

Wednesday - February 21, 1996

Getting to section 3, T16N, R16W was obstructed by a locked gate. Access was not accomplished. Ms. Louise Benally reside along the route taken to Section 3. We notified her of whom we are and our reason for our presence in the area. She gave direction and warned that there could be a locked gate on the way. She cannot recall any mining activity in Section 3. She didnot know who the landuser is that keeps the gate lock. We also returned the land status book to Melvin Gurule of Crownpoint BIA.

RECOMMENDATIONS:

At this stage of the inventory, public contact is still vital. The age of the person contacted also has an effect on the project. The senior person is more knowledgeable of the area just because they had been in the area longer. They also know key individual to contact. This in turn can be time saving. Mr. James Benally, Reclamation Specialist II, is one of the project personnel.

SUBMITTED BY: Rose M. Grey
Rose M. Grey
Reclamation Specialist II

ACKNOWLEDGE:
Perry H. Charley
Reclamation Specialist III

MINE SITE VISIT REPORT
NAVAJO AML RECLAMATION DEPARTMENT

DATE(S) OF VISIT: April 2 to 4, 1996

MINE/PROJECT NAME: Eastern Navajo Agency Non-Coal Inventory

DURATION OF VISIT: Varied daily from 8:30 a.m. to 4:30 p.m.

PURPOSE OF VISIT: Field investigation and inventory of known mining claims for possible non-coal mining activities, and to document the extent of mining activities and any physical hazards present on these mining claims. Ms. Rose Grey, Reclamation Specialist II, assisted with this task.

OBSERVATIONS: This week's field investigations and inventory were concentrated on in the community of Church Rock. The following claims were investigated this week:

TUESDAY - April 2, 1996:

Foutz # 3 - SE¼ SE¼ SE¼ Section 31, T16N, R16W. This claim has an open portal (P) and three partially collapsed portals (P) located in the southeast corner of the claim. Portal 1 is 6½' H x 9½' W x depth unknown. Radiological readings at the portal were: 120 μR/hr @ 1 m(eter) and 130 μR/hr on contact. Portal 2 is 5½' H x 11½' W x depth unknown. Radiological readings at the portal were: 190 μR/hr @ 1 m and 200 μR/hr on contact. Portal 3 is 6' H x 10½' W x depth unknown. Radiological readings at the portal were: 240 μR/hr @ 1 m and 240 μR/hr on contact. Portal 4 is 4' H x 6' W x depth unknown. Radiological readings at the portal were: 110 @ 1 m and 100 μR/hr on contact. Associated features includes: 150 linear feet of dangerous highwalls (DH), 250 yd^3 of waste material (DPE) covering 0.13± acre, 200' L x 16' W haul road (HR), and a 150' L x 30' W bench (BE). The radiological readings on the waste material ranged from 50 to 120 μR/hr @ 1 m and from 60 to 280 μR/hr on contact.

Foutz # 2 - NE¼ NE¼ NE¼ Section 5, T15N, R16W. This claim has a collapsed portal (P) and two backfilled portals (P). Portal 1 is completely collapsed and/or backfilled. Radiological readings at the portals were: 14 μR/hr @ 1 m and 14 μR/hr on contact. Portal 2 is partially backfilled with a 1' H x 2' W opening and the depth unknown. Radiological readings at the portal were: 14 μR/hr @ 1 m and 14 μR/hr on contact. Portal 3 is partially collapsed with a 1½' H x 2' W opening and the depth unknown. Radiological readings at the portal were: 32 μR/hr @ 1 m and 38 μR/hr on contact. Associated features includes: 175 linear feet of dangerous highwalls (DH), approximately 50 yd^3 of waste material (DPE) scattered over 1.44± acres, and a 500' L x 125' W bench (BE). The radiological readings on the waste material ranged from 12 to 30 μR/hr @ 1 m and 12 to 30 μR/hr on contact.

Williams and Reynolds Mine - NE¼ SW¼ Section 4, T15N, R16W. This mine is located on Bureau of Land Management (BLM) land. This mine feature is a pit measuring 200' L x 75' W x 1' - 12' deep. Radiological readings inside the pit range from 20 to 90 μR/hr @ 1 m and 13 to 100 μR/hr on contact. Approximately 3,500 yd^3 of overburden material is located on the west end of the pit. Approximately 1.94± acres have been disturbed overall.

Section 3 - NE¼ SW¼ SW¼ Section 3, T15N, R16W. This claim has ten portals (P) and three mine openings (MO). The east group of portals and one mine opening were numbered 1 thru 8 from west to east and the west group 9 thru 13 from west to east. All of the adits and prospects are driven into a coal seam at the base of a 80' to 100' thick Dakota (?) sandstone. Portal 1 is 4' H x 5' W x depth unknown. Portal 2 is 5' H x 6' W x depth unknown. Portal 3 is 4' H x 6' W x depth unknown. Portal 4 is 5' H x 6'

W x depth unknown. Portal 5 is 6' H x 6½' W x 20' depth (?). Feature 6 is a mine opening measuring 8' H x 7' W x 9' depth. Portal 7 is 6' H x 6½' W x depth unknown. Portal 8 is 4' H x 6' W x depth unknown. Radiological readings taken at the portals and on the waste material for the east group ranged from 52 to 180 μR/hr @ 1 m and 42 to 400 μR/hr on contact. Portal 9 is 6½' H x 5' W x 75' depth (?). Feature 10 is a mine opening measuring 4' H x 6' W x 7' depth. Portal 11 is 6' H x 6½' W x depth unknown. Feature 12 is a mine opening measuring 4' H x 11' W x 5' depth. Portal 13 is 6' H x 6½' W x depth unknown. Radiological readings taken at the portals and on the waste material for the west group ranged from 100 to 1,000 μR/hr @ 1 m and 140 to 1,400 μR/hr on contact. Associated features includes: approximately 3,625 yd^3 of waste/gob material (DPE) covering 1.00± acre, two haul roads measuring approximately 2,500' L x 15' W, a 25' to 30' wooden ladder, and a wooden chute to load protore and/or waste/gob material. Radiological readings taken on the four waste/gob piles varied from 52 to over 1,000 μR/hr @ 1 m and between 110 and 1,400 μR/hr on contact.

WEDNESDAY - April 3, 1996:
Unknown - NE¼ NW¼ NE¼ Section 17, T16N, R16W (Old Church Rock Mine). This claim has a backfilled and concrete capped vertical shaft (VO). Other associated features located on this claim consisted of a 80' L x 60' W metal building, concrete slabs, and five large retention ponds averaging 300' in length and 250' in width, numerous drill holes, and seven 5' steel water transfer boxes. Radiological readings throughout the claim ranged from 13 to 220 μR/hr @ 1 m and 13 to 240 on contact. The disturbed area is approximately 36.73± acres and is completely fenced in and the gates locked.

Unknown - NW¼ Section 17, T16N, R16W. This claim has numerous drill holes staked with steel posts on it. There are no mining related activities noted on this claim. Disturbances were limited to the access roads and drill pads during exploration activities and an existing pipeline in the southeast portion of the claim. The claim is located in an open area and is being used as rangeland for livestock. Radiological readings throughout the claim ranged from 11 to 13 μR/hr @ 1 m and 12 to 14 μR/hr on contact.

Unknown - NW¼ NW¼ NW¼ Section 18, T16N, R16W. There were no drill holes or mining related activities noted on this claim. This claim is located adjacent to a residential area and a highly used grazing area. Portions of this claim is fenced with two gates. Radiological readings at this claim ranged from 12 to 16 μR/hr @ 1 m and 12 to 16 μR/hr on contact.

Unknown - SW¼ NW¼ NW¼ Section 18, T16N, R16W. There were no drill holes or mining related activities noted on this claim. This claim is located in an open area highly used for residential and livestock grazing. Radiological readings on this claim ranged from 12 to 16 μR/hr @ 1 m and 12 to 16 μR/hr on contact.

Unknown - NE¼ SW¼ SW¼ Section 18, T16N, R16W. This claim has some drill holes staked with steel pipes on it. There were no mining related activities noted on the claim. This claim is located in an open area and is being used as rangeland for livestock. Radiological readings on this claim ranged from 13 to 15 μR/hr @ 1 m and 13 to 16 on contact.

Unknown - NE¼ Section 19, T16N, R16W. This claim has drill holes staked with steel pipes on it. There were no mining related activities noted on the claim. Phillips Petroleum Company has a pipeline traversing the length of the claim from the northeast to the southwest. This claim is located in an open area used as rangeland for livestock. Radiological readings on this claim ranged from 12 to 14 μR/hr @ 1 m and 12 to 14 μR/hr on contact.

Unknown - NE¼ Section 22, T16N, R16W. This claim has several drill holes staked with steel posts on it. Disturbances were limited to the access roads and drilling pads during exploration activities. This claim is located in an open area used as rangeland for livestock. Radiological readings on this claim ranged from 13 to 16 μR/hr @ 1 m and 13 to 16 μR/hr on contact.

Unknown - NW¼ NE¼ Section 23, T16N, R16W. This claim has drill holes staked with steel posts on it. Disturbances were limited to the access roads and drilling pads during exploration activities. This claim is partially located in an open area and in a fenced farm plot adjacent to several residences. Radiological readings on this claim ranged from 13 to 14 μR/hr @ 1 m and averaged 14 μR/hr on contact.

THURSDAY - April 4, 1996:

Pyramid Group - Section 22, T16N, R16W. This claim has drill holes staked with steel pipes on it. Earthmoving activities were limited to access roads and drill pads during exploration activities. The east portion of the claim is fenced and the gate locked. The rest of the claim is located in a wooded open area and used as rangeland for livestock. Radiological readings averaged from 12 to 15 μR/hr @ 1 m and 12 to 15 on contact.

Unknown Section 14 - NW¼ Section 14, T16N, R17W. There were no drill holes or mining related activities noted on this claim. Disturbances were noted and limited to access roads and drill pads on previously investigated claims (Hard Grounds Flat). This claim is located in a wooded fenced area limiting access to the claim. Radiological readings averaged 11 to 14 μR/hr @ 1 m and 11 to 14 μR/hr on contact.

Unknown Section 24 - NE¼ Section 24, T16N, R17W. This claim has drill holes staked with steel pipes on it. Disturbances were limited to access roads and drill pads during exploration activities. This claim is located in an open area and is being used as rangeland for livestock. Radiological readings ranged from 11 to 14 μR/hr @ 1 m and 11 to 14 μR/hr on contact.

Unknown Section 13 - SW¼ NE¼ SW¼ Section 13, T16N, R17W. This claim has a number of drill holes staked with steel pipes on it. Disturbances noted were limited to access roads and drill pads. This claim is located in an open area and is being used as rangeland for livestock. Radiological readings ranged from 12 to 14 μR/hr @ 1 m and 12 to 14 μR/hr on contact.

Unknown Section 13 - NW¼ NW¼ SE¼ Section 13, T16N, R17W. This claim has drill holes staked with steel pipes on it and is located to the southwest of the previous claim investigated. Disturbances are limited to the access roads and drill pads constructed during exploration activities. This claim is located in an open area and is being used as rangeland for livestock. Radiological readings averaged from 12 to 14 μR/hr @ 1 m and 12 to 14 μR/hr on contact.

Section 23 - Grace Nuclear - NW¼ NE¼ NE¼ Section 23, T16N, R17W. This claim has three retention ponds averaging 30' L x 30' W x 2' depth and one pond measuring 45' L x 30' W x 2' depth on it. The ponds had been lined with polypropylene material and are scattered over the claim. Six uncapped 6" steel pipes were also located around the four retention ponds. The steel pipes have water in them and *the depth range from 13' to 20'. Several of the steel pipes are level with the ground and need to be capped or blocked. Approximately 2.30± acres has been disturb by in situ mining activities.*

Unknown Section 25 - NW¼ SE¼ NE¼ Section 25, T16N, R17W. This claim has an old shack set in the ground and a concrete slab measuring 28' L x 10' W with a 8½' capped steel pipe on it. The shack houses electrical junction boxes and fuses approximately 8' below ground level. The concrete slab is located to the southeast of the shack at approximately 175'. This claim is fenced and is being used as rangeland for livestock. Radiological readings averaged 12 to 13 μR/hr @ 1 m and 13 μR/hr on contact.

Delter - SE¼ NW¼ NW¼ Section 36, T16N, R17W. There were no drill holes or mining activities noted on this claim. The claim is located against a mesa with steep sides and adjacent to a highly used public road and is being used as rangeland for livestock. Radiological readings averaged 12 μR/hr @ 1 m and 12 μR/hr on contact.

A U.S.G.S. 7.5 minute quadrangle map for the townships, ranges, and sections depicting the claims is used to locate the section, center or quarter corners and pinpoint the claim areas. The known reference point is used to insure that the proper area and the claim is investigated. All of the claims investigated this week were traversed on foot or where feasible by vehicle.

CONTACTS: The following individuals were contacted for information on access roads to the mining claims and/or exploration and mining activities. Lawrence Morgan, Council Delegate, Pinedale Chapter, Janice Arviso, Adeline Livingston, Harrison Livingston, Linc Livingston, Marilyn Livingston, Betty Stump, and Leonard Yazzie, Residents, Church Rock Community.

James Benally

James Benally
Reclamation Specialist II

Rose M. Grey

Rose M. Grey
Reclamation Specialist II

SHIPROCK AML FIELD OFFICE

PUBLIC INVOLVEMENT / COMMUNITY MEETINGS DOCUMENTATION

PROBLEM AREA: Eastern Navajo - Church Rock -Pinedale **DATE:** April 2 - 4, 1996

TYPE OF CONTACT:

(Indicate meeting type, contact person, (address / telephone number), problems/concerns encountered, how handled, outcome of meeting or contact).

Tuesday - April 2, 1996

Mr. Lawrence Morgan, Council Delegate of Pinedale community informed us that he has no knowledge of any mining activities in the Pinedale area except in Church Rock. He did mentioned that some drilling explorations had taken place in the area. He was not specific about the area and who did the drilling. Ms. Janice Arviso resides along the route to Section 3, 4, and 5, T15N, R16W. She did informed us of the mining activities that had taken places. She could not remember the exact date or year of the mining. She also mentioned that the road to the sites no longer exists. She did mentioned that uranium was being mined.

Wednesday - April 3, 1996

The Old Church Rock Mine is located in Section 17, T16N, R16W. Mr. Leonard Yazzie is the landuser who resides near the site. Mr. Yazzie recalls the closure of the mine around the late seventies. He also mentioned there were some drilling activities that had taken place in the area. Ms. Marilyn Livingston resides in Section 13. Since she was the nearest residence of Sections 18 and 19, T16N, R16W and Sections 24 and 13, T16N, R17W we asked for some information. She recalls that the only mining activities was the Old Church Rock Mine. The rest were drilling explorations.

Thursday - April 4, 1996

Ms. Marilyn Livingston informed us that there was no actual mining in Sec. 14, T16N, R17W. To her knowledge there was only drilling exploration. Linc Livingston was a little bit hesitate to give any information and permit us to enter the area, Sec. 13, T16 N, R17 W. He claimed he doesnot know alot about the mining and explorations that had taken place in the Church Rock area. He did mention that his father will probably know more. At the time his father was not home. Harrison Livingston is the landuser in Sec.23, T17N, R16W. A family member was who we talked to. The person didnot give his name. He did confirm the Grace in-situ leach test that was conducted in the area. Adeline Livingston is the landuser residing in Sec. 25, T16N, R16W. A family member informed us that there was a drilling exploration that had taken place in Sec. 25, T16N, R17W. The roof of an underground storage building was very noticeable. Betty Stump resides in Sec. 36 , T16N, R17W. She does not recall any mine related activities in Sec. 35 and 36, T16N, R17W.

RECOMMENDATIONS:

Community involvement is still vital to the inventory process. They know the area well and their direction to the claims is time saving. Mr. James Benally, Rec. Spec. II is also part of the project.

SUBMITTED BY: Rose M. Grey **ACKNOWLEDGE:** ____________________

Rose M. Grey
Reclamation Specialist II

Perry H. Charley
Reclamation Specialist III

MINE SITE VISIT REPORT
NAVAJO AML RECLAMATION DEPARTMENT

DATE(S) OF VISIT: April 8, 10, and 11, 1996

MINE/PROJECT NAME: Eastern Navajo Agency Non-Coal Inventory

DURATION OF VISIT: Varied daily from 8:30 a.m. - 4:45 p.m.

PURPOSE OF VISIT: Field investigation and inventory of known mining claims for possible non-coal mining activities, and to document the extent of mining activities and any physical hazards present on these mining claims. Ms. Rose Grey, Reclamation Specialist II, assisted with this task.

OBSERVATIONS: This week's field investigations and inventory were concentrated on in the communities of Church Rock, Pinedale, and Mariano Lake. The following claims were investigated this week:

MONDAY - April 8, 1996:
CD & S - NW¼ NW¼ SE¼ Section 35, T16N, R17W. There were no exploration or mining related activities noted on this claim. Disturbances and construction were limited to the access roads and drill pads during exploration activities. The access road leading to this claim is fenced and the gate locked. Cursory radiological data obtained averaged 12.5 μR/hr on this claim.

Unknown - Section 21 - SW¼ Section 21, T16N, R15W. This claim has numerous drill holes staked with steel pipes on it. There were no mining related activities noted on this claim. Disturbances and construction were limited to the access roads and drill pads during exploration activities. This claim is located in a residential area and is fenced around the residential areas. The access road leading to the claim is fenced off in various places. Cursory radiological data obtained averaged 13.0 μR/hr on this claim.

Unknown - Section 2, T15N, R14W. There were several drill holes staked with plastic and steel pipes located on this claim. There were no mining related activities noted on this claim. Disturbances and construction were limited to the access roads and drill pads. This claim is located in an open area and is being used as rangeland for livestock. Cursory radiological data obtained averaged 13.0 μR/hr on this claim.

Unknown - Section 3, T15N, R14W. There were drill holes staked with plastic pipes located on this claim. There were no mining related activities noted on this claim. Disturbances and construction were limited to the access roads and drill pads. This claim is located in an open area and is being used as rangeland for livestock. Cursory radiological data obtained averaged 12.5 μR/hr on this claim.

Unknown - Section 34, T15N, R14W. There were several drill holes staked with plastic and steel pipes located on this claim. There were no mining related activities noted on this claim. Disturbances and construction were limited to the access roads and drill pads. This claim is located in an open area and is being used as rangeland for livestock. Cursory radiological data obtained averaged 13.0 μR/hr on this claim.

WEDNESDAY - April 10, 1996:
Mariano Lake - SE¼ SW¼ NW¼ Section 12, T15N, R14W. This claim has been worked and reclaimed

by the previous operator(s). An area measuring 1,400' L x 900' W has been regraded and revegetated. The reclaimed area is fenced and the gates locked. Cursory radiological data obtained in and around the reclaimed ranged from 11.0 μR/hr to 35.0 μR/hr on this claim.

Mac # 1 - SW¼ NE¼ SE¼ Section 12, T15N, R14W. This claim has been also worked and reclaimed by the previous operator(s). Two prefabricated metal building are still located on the claim. An area measuring 1,200' L x 1,200' W has been regraded and revegetated. The area and the access road are fenced and the gate locked. Cursory radiological data obtained ranged from 24 μR/hr to 70 μR/hr on this claim.

Mac # 2 - NE¼ SE¼ SE¼ Section 18, T15N, R13W. This claim has a backfilled inclined shaft located on it. Other associated features located on this claim consisted of three waste piles (DPE) of approximately 2,230 yd³ covering 0.282± acre, industrial/residential waste covering 0.01± acre, and five concrete slabs. Area of impact is approximately 2.30± acres. This claim is located in an open area and is being used as rangeland for livestock. Cursory radiological data obtained ranged from 30 μR/hr to 340 μR/hr on this claim.

Black Jack # 2 - SW¼ NE¼ Section 18, T15N, R13W. This claim has been worked and regraded by the previous operator(s). A prefabricated metal building and a storage shed are still located on the claim. An area measuring 1,000' L x 750' W has been regraded and the area around a air vent north of the building has been regraded at appproximately 200' L x 100' W. This area is located in a fenced area and is being used as rangeland for livestock. Cursory radiological data obtained ranged from 30 μR/hr to 100 μR/hr on this claim.

Section 20 - SW¼ NE¼ NE¼ Section 20, T15N, R13W. This claim did not have any drill holes or signs of mining activities. This claim is located in an open range and is being used as rangeland for livestock. Cursory radiological data obtained averaged 12.0 μR/hr on this claim.

Ruby 1 & 2 Decline - NE¼ SW¼ NW¼ Section 21, T15N, R13W. This claim has been worked and regraded by the previous operator(s). An area measuring approximately 775' L x 350' W has been reclaimed. A 72' L x 44' W concrete slab is located to the east of the reclaimed area. This area is located in an open area and is being used as rangeland for livestock. Cursory radiological data obtained ranged from 24.0 μR/hr to 130.0 μR/hr on this claim.

Ruby 3 & 4 - SE¼ NE¼ NE¼ Section 25, T15N, R13W. This claim has also been worked and reclaimed by the previous operator(s). An area measuring 575' L x 450' W has been reclaimed. A 15' L x 12' W concrete slab is located to the southwest of the reclaimed area. This area and the access road is fenced and the gate locked and is being used as rangeland for livestock. Cursory radiological data obtained ranged from 16.0 μR/hr to 90.0 μR/hr on this claim.

<u>THURSDAY - April 11, 1996:</u>
Ruby 2 Ore Body - NE¼ NW¼ Section 27, T15N, R13W. This claim has drill holes staked with plastic pipes on it. There were no mining activities noted on this claim. Disturbances and construction activities were limited to the access roads and drill pads. This claim is located in a fenced area and is being used as rangeland for livestock. An access road located to the west of the fenced area is not fenced and gated. Cursory radiological data obtained averaged 13.0 μR/hr on this claim.

Ruby 4 Ore Body - NE¼ & SE¼ Section 26, T15N, R13W. This claim has drill holes staked with plastic pipes on it. There were no mining activities noted on this claim. Disturbances and construction activities were limited to the access roads and drill pads. This claim is located in a fenced area and is being used as rangeland for livestock. As with Ruby 2 Ore Body, the access road is not fenced and gated. Cursory radiological data obtained averaged 12.0 μR/hr on this claim.

Unknown - Section 13 - NE¼ NE¼ Section 13, T15N, R13W. This claim has drill holes staked with plastic pipes on it. There were no mining activities noted on this claim. Disturbances and construction activities were limited to the access roads and drill pads. This claim is located in a fenced area and is being used as rangeland for livestock. Cursory radiological data obtained averaged 11.0 μR/hr on this claim.

Unknown - Section 13 - SE¼ T15N, R13W. This claim has drill holes staked with plastic pipes on it. There were no mining activities noted on this claim. Disturbances and construction activities were limited to the access roads and drill pads. This claim is located in a fenced area and is being used as a residential and as rangeland for livestock. Cursory radiological data obtained averaged 12.0 μR/hr on this claim.

A U.S.G.S 7.5 minute quadrangle map for the township, range and section where the claim is located is used to locate the section, center or quarter corner and pinpoint the claim area. Once a known point is located, it is used as a reference point to insure that the right area where the claim is located is investigated. All the claims were traversed on foot or where feasible by vehicle.

CONTACTS: The following individuals were contacted for information on access to the mining claims and/or exploration and mining activities. Maggie Billy, Annie Brown, Mary Cayeditto, Kenneth & Julia Largo, Sandy Simpson, Henry Tom, Residents, and Raquel Warner, Community Services Coordinator, Mariano Lake Chapter.

James Benally	*Rose M. Grey*
Reclamation Specialist II	*Reclamation Specialist II*

SHIPROCK AML FIELD OFFICE

PUBLIC INVOLVEMENT / COMMUNITY MEETINGS DOCUMENTATION

PROBLEM AREA: Eastern Navajo - Pinedale Mariano Lake **DATE:** April 8 - 11, 1996

TYPE OF CONTACT:

(Indicate meeting type, contact person, (address / telephone number), problems/concerns encountered, how handled, outcome of meeting or contact).

Monday - April 8, 1996

Ms. Annie Brown resides in Sec. 21, T16N, R17W in the Pinedale community. She confirmed the drilling exploration that had taken place in the area. She said the only mine she knew of is the Old Church Rock Mine. Mariano Lake Chapter officials were very cooperative and provided names of landusers that we could talk for any information. They are Henry Tom, Raquel Warner and Sandi Simpson. Mr. Tom did confirm that there was no mining activity in certain areas. There were several places that he confirmed were mined. This is Black Jack No. 2, Ruby 1, 2, 3 and 4. He said most of these areas were reclaimed. Ms. Maggie Billy lives in Sec. 34, T16N, R14W. She informed us that there was only drilling explorations that took place. She gave us direction and permission to go and look at the area. She did warned us of lock gates at certain places.

Wednesday - April 10, 1996

Kenneth Largo and Julie Largo are sibling and resides side by side in Sec. 18, T15N, R13W. We ask for permission to access the gate to Black Jack No. 2 site. Mr. Largo said he does not remember much about the site. He had been in the military when the mining was in progress. Ms. Largo's daughter said she is too young to remember such thing. She did mention that her mother will be home the next day if we needed more information. Ms. Mary Cayedito resides east of Ruby well. We made an arrangement with her to use the road going through her land to get to a claim in Section 21, T15N, R13W. She did also mentioned that Ruby 3 and 4 were once active and are reclaimed. She said that uranium was mined. She cannot recall when it was reclaimed or who did the mining. She was very cooperative.

RECOMMENDATIONS:

Public information is still vital. Inquiring at the community chapter house is still very helpful because some of the chapter houses have community maps. Mr. James Benally, Reclamation Specialist II, is part of the project.

SUBMITTED BY: Rose M. Grey
Rose M. Grey
Reclamation Specialist II

ACKNOWLEDGE: ______
Perry H. Charley
Reclamation Specialist III

MINE SITE VISIT REPORT
NAVAJO AML RECLAMATION DEPARTMENT

DATE(S) OF VISIT: April 17 & 18, 1996

MINE/PROJECT NAME: Eastern Navajo Agency Non-Coal Inventory

DURATION OF VISIT: Varied daily from 8:30 a.m. - 4:45 p.m.

PURPOSE OF VISIT: Field investigation and inventory of known mining claims for possible non-coal mining activities, and to document the extent of mining activities and any physical hazards present on these mining claims. Ms. Rose Grey, Reclamation Specialist II, assisted with this task.

OBSERVATIONS: This week's field investigations and inventory were concentrated on in the communities of Mariano Lake and Smith Lake. The following claims were investigated this week:

<u>WEDNESDAY - April 17, 1996:</u>
Black Jack 1 - NE¼ NE¼ SW¼ Section 12, T15N, R13W. This claim has a backfilled and concrete capped vertical shaft (VO) on it. Other features located on this site consisted of approximately 6,000 yd^3 of waste material (DPE) covering 0.76± acre, large and small concrete slabs, an upright 2' diameter steel culvert, a 20' L x 10' W storage shed, and two 3' diameter steel air vents. A subsidence (S) around one of the air vent located northeast of the mine site is occurring. The fill material is collapsing into a drift (?) where the air vent is located. Discarded parts and pieces of electrical equipment are scattered throughout the site. Impacted area is approximately 10.80± acres. This area is fenced and is being used as rangeland for livestock. Cursory radiological data obtained ranged from 40 μR/hr to 475 μR/hr on this claim.

Unknown - SW¼ Section 26, T16N, R13W. There were no drill holes noted on this claim or mining related activities. This claim is fenced and is being used as rangeland for livestock. The access road passes through a residential area and several gates. Cursory radiological data obtained averaged 12.0 μR/hr on this claim.

<u>THURSDAY - April 18, 1996:</u>
Nicholson-Brown - SW¼ NE¼ SE¼ Section 25, T15N, R14W. There were several drill holes staked with plastic pipes located on this claim. There were no mining related activities noted on this claim. Disturbances and construction were limited to the access roads, drill pads, and small and shallow dozer cuts. This claim is located in a fenced area and is being used as rangeland for livestock. The access road is fenced and the gate locked. Cursory radiological data obtained averaged 13.0 μR/hr on this claim.

A U.S.G.S 7.5 minute quadrangle map for the township, range and section where the claim is located is used to locate the section, center or quarter corner and pinpoint the claim area. Once a known point is located, it is used as a reference point to insure that the right area where the claim is located is investigated. All the claims were traversed on foot or where feasible by vehicle.

CONTACTS: The following individuals were contacted for information on access to the mining claims and/or exploration and mining activities. Frank Ettcitty, Nora Paige, Paul Ration, Residents, and Viviane Barbone, Secretary, Smith Lake Chapter.

James Benally

James Benally
Reclamation Specialist II

Rose M. Grey

Rose M. Grey
Reclamation Specialist II

SHIPROCK AML FIELD OFFICE

PUBLIC INVOLVEMENT / COMMUNITY MEETINGS DOCUMENTATION

PROBLEM AREA: Eastern Navajo - Hosta Butte - Mariano Lake **DATE:** April 15 - 18, 1996

TYPE OF CONTACT:

(Indicate meeting type, contact person, (address / telephone number), problems/concerns encountered, how handled, outcome of meeting or contact).

Wednesday - April 17, 1996

Frank Etsitty resides in Sec. 12, T15N, R13W. Within this section also lies Blackjack Number One. Mr. Etsitty is the allottee in the area. He escorted us to look at an open vertical shaft. He said that himself and his family keep the livestock and children away from the opening. He was very concern about the shaft. He also said that another official had came and look at it. Other than that, he has not heard anything on what the outcome will be. Nora Page resides in Section 15, T16N, R13W. We asked of her who the gate keeper is in Section 14. She told us who, (Joe and Mary Smiley) and that they reside in Smith Lake area. Ms. Page did mentioned the drilling exploration only. She does not recall or know of any actual digging for coal or uranium in the area.

Thursday - April 18, 1996

Mr. Paul Ration was conducting business at Smith Lake Chapter House at the time we spoke to him. We asked of him how we can contact the Smileys for access through their gate. He told us that Mr. Smiley works for one of the quarries within the vicinity. Mr. Ration also said that he is very familiar with the area and he does not know of any mining activity in Section 14, T16N, R13W. He said the only event that took place is the drilling exploration. He offered his help for future site investigation. He said he will be more than happy to escort or give us directions on any other places. Ms. Vivian Barbone is the Smith Lake Chapter House secretary. She was the person who put us in contact with Mr. Ration.

RECOMMENDATIONS:

None for this report. Mr. James Benally, Reclamation Specialist II, is part of the project.

SUBMITTED BY: Rose M. Grey

Rose M. Grey
Reclamation Specialist II

ACKNOWLEDGE: ____________________

Perry H. Charley
Reclamation Specialist III

MINE SITE VISIT REPORT
NAVAJO AML RECLAMATION DEPARTMENT

DATE(S) OF VISIT: April 22, 24, & 25, 1996

MINE/PROJECT NAME: Eastern Navajo Agency Non-coal Inventory

DURATION OF VISIT: Varied daily 8:30 a.m. - 4:45 p.m.

PURPOSE OF VISIT: Field investigation and inventory of known mining claims for possible non-coal mining activities, and to document the extent of mining activities and any physical hazards present on these mining claims. Ms. Rose Grey, Reclamation Specialist II, assisted with this task.

OBSERVATIONS: This week's field investigations and inventory were concentrated on in the community of Borrego Pass, Casamero Lake, and Smith Lake. The following claims were investigated this week:

MONDAY - April 22, 1996:
Unknown - Section 14, T16N, R13W. This claim has plastic and steel pipe staked drill holes. There are no mining related activities on this claim. Disturbances and construction were limited to the access roads and drill pads during exploration activities. The access road leading to this claim is fenced and the gate locked. Cursory radiological data obtained averaged 12.5 μR/hr on this claim.

A field visit was made on the proposed road improvement project N9000 for the Red Lake community, and the proposed preschool and senior citizen's center tracts for the Iyanbito, Lukachukai, and Pinedale communities. The field investigations were conducted on the Navajo Department of Transportation's request. The field investigation was made to determine if any abandoned or reclaimed coal and/or non-coal mines are located within and/or adjacent to the proposed projects.

Project N9000 was traversed by vehicle from the intersection of Navajo Route 12 and N9000 to the Red Lake Chapter. The field investigation did not disclosed any abandoned coal and/or non-coal mines located within the 150' right-of-way for the proposed road improvement project. Additionally, NAMLRD's mining documents and files do not indicate any coal or non-coal mineral occurrences within the immediate area. The field investigation did note a basaltic quarry on an intrusive plug located adjacent to the proposed road improvement. Additional work on and/or proposed reclamation of this quarry using explosives in the future may have a minor affect on the road's surface.

The proposed preschool and the senior citizen's center tracts for the Iyanbito, Lukachukai, and Pinedale communities were also investigated for abandoned coal and/or non-coal mines. The field investigations did not disclosed any abandoned mines located within or adjacent to the proposed preschool or the senior citizen's center tracts. NAMLRD's mining documents and files indicate that the nearest non-coal mining claim and mineral occurrence is 3,500' to the southeast of the proposed Pinedale's senior citizen's center. The claim and mineral occurrence is located in the NW¼ of Section 21, T16N, R15W. However, this claim and occurrence should have no effect or impact on the proposed center.

WEDNESDAY - April 24, 1996:
Borrego Pass - Sections 7 & 18, T16N, R10W. There were drill holes staked with plastic pipes located on this claim. There were no mining related activities noted on this claim. Disturbances and construction were limited to the access roads and drill pads. This claim is located in an open and fenced area and is being used as rangeland for livestock. Cursory radiological data obtained averaged 13.0 μR/hr on this

claim.

Section 24 - Section 24, T15N, R12W. There were drill holes staked with plastic pipes located on this claim. There were no mining related activities noted on this claim. This claim is fenced and is being used as rangeland for livestock. Cursory radiological data obtained averaged 12.0 μR/hr on this claim.

Unknown - NE¼ NE¼ Section 23, T15N, R12W. There were drill holes staked with plastic pipes located on this claim. There were no mining related activities noted on this claim. This claim is fenced and is being used as rangeland for livestock. Cursory radiological data obtained averaged 12.0 μR/hr on this claim.

Unknown - Section 11, T15N, R13W. This is an additional claim investigated and is not listed on NAMLRD's known claims. There were no drill holes or mining related activities noted on this claim, however, an area measuring 325' L x 300' W showed signs of subsidence. The subsidence has occurred on a hillside and is due to a coal fire. This area is fenced and is being used as rangeland for livestock. Cursory radiological data obtained averaged 10.0 μR/hr on this claim.

THURSDAY - April 25, 1996:
Last Chance # 2 - SW¼ NE¼ NW¼ Section 2, T14N, R14W. There were several drill holes staked with plastic pipes located on this claim. There were no mining related activities noted on this claim. Disturbances and construction were limited to the access roads, drill pads, and numerous small and shallow dozer cuts. This claim is located in a fenced area and is being used as rangeland for livestock. The access road is fenced and the gate locked. Cursory radiological data obtained averaged 13.0 μR/hr on this claim.

Becenti - NW¼ Section 28, T15N, R17W. This is an additional claim investigated and is located outside the boundaries of two previious claims investigated on February 15, 1996. This claim has a small pit (PI) on it. Other associated features located on this site consisted of approximately 2,000 yd^3 of waste material (DPE) covering 0.17± acre and 25 linear feet of dangerous highwall (DH). Impacted area is approximately 0.36± acre. Cursory radiological data obtained ranged from 12.0 μR/hr to 320 μR/hr on this claim.

Unknown - Section 8, T16N, R16W. This is an additional claim investigated and is not listed on NAMLRD's known claims. There were several drill holes staked with plastic pipes located on this claim. There were no mining related activities noted on this claim. Disturbances and construction were limited to the access roads and drill pads. This claim is located in an open area and is being used as rangeland for livestock. Cursory radiological data obtained averaged 13.0 μR/hr on this claim.

Unknown - Section 2, T16N, R14W. This is also an additional claim investigated and is not listed on NAMLRD's known claims. There were several drill holes staked with plastic pipes located on this claim. There were no mining related activities noted on this claim. Disturbances and construction were limited to the access roads and drill pads. This claim is located in an open area and is being used as rangeland for livestock. Cursory radiological data obtained averaged 11.0 μR/hr on this claim.

A U.S.G.S 7.5 minute quadrangle map for the township, range and section where the claim is located is used to locate the section, center or quarter comer and pinpoint the claim area. Once a known point *is located, it is used as a reference point to insure that the right area where the claim is located is investigated. All the claims were traversed on foot or where feasible by vehicle.*

CONTACTS: No public contacts were made during this week.

James Benally

James Benally
Reclamation Specialist II

Rose M. Grey

Rose M. Grey
Reclamation Specialist II

SHIPROCK AML FIELD OFFICE

PUBLIC INVOLVEMENT / COMMUNITY MEETINGS
DOCUMENTATION

PROBLEM AREA: Eastern Navajo - Hosea Butte, Laguna Castillo Borrego Pass and Casamera Lake **DATE:** April 22 - 25, 1996

TYPE OF CONTACT:

(Indicate meeting type, contact person, (address / telephone number), problems/concerns encountered, how handled, outcome of meeting or contact).

Monday - April 22, 1996

Met with Thomasita Shorty, Environmental Specialist, of Navajo Department of Transportation Department. Ms. Shorty needed the AML Clearance on four project areas: Pinedale Senior Citizens Center site, Buffalo Spring Pre-school building site, Navajo Route 9000 Right-of-way to Red Lake Chapter and Lukachukai Pre-school site. We inquire with her our investigation and told her we will write a memorandum for her information.

RECOMMENDATIONS:

The project was also conducted by Mr. James Benally, Reclamation Specialist II.

SUBMITTED BY: Rose M. Grey
Rose M. Grey
Reclamation Specialist II

ACKNOWLEDGE: ____________
Perry H. Charley
Reclamation Specialist III

MINE SITE VISIT REPORT
NAVAJO AML RECLAMATION DEPARTMENT

DATE(S) OF VISIT: April 29 to May 3, 1996

MINE/PROJECT NAME: Eastern Navajo Agency Non-Coal Inventory

DURATION OF VISIT: Varied daily 9:30 a.m. - 3:30 p.m.

PURPOSE OF VISIT: Field investigation and inventory of known mining claims for possible non-coal mining activities, and to document the extent of mining activities and any physical hazards present on these mining claims. Ms. Rose Grey, Reclamation Specialist II, assisted with this task.

OBSERVATIONS: This week's field investigations and inventory were concentrated on in the community of Borrego Pass, Thoreau, and Baca. The following claims were investigated this week:

MONDAY - April 29, 1996:
Unknown - SW¼ Section 17, T15N, R10W. This claim has drill holes staked with plastic pipes on it. There are no mining related activities on this claim. Disturbances and construction were limited to the access roads and drill pads during exploration activities. The access road leading to the claim passes through a residential area and is fenced and the gates locked. Cursory radiological data obtained averaged 13.0 μR/hr on this claim.

South Pod Ore Body - SE¼ SE¼ Section 25, T15N, R13W. Drill holes staked with plastic pipes were noted on this claim. There were no mining related activities noted on this claim. Disturbances and construction were limited to the access roads, drill pads, and small shallow dozer cuts. This claim is located in an fenced area and is being used as rangeland for livestock. Cursory radiological data obtained averaged 11.0 μR/hr on this claim.

Tietjen-Lewis No. 1 - Section 8, T14N, R13W. There were no drill holes or mining related activities noted on this claim. This claim is located in an open and remote area and is being used as rangeland for livestock. Access to this claim is difficult and rugged. Cursory radiological data obtained averaged 14.0 μR/hr on this claim.

TUESDAY - April 30, 1996:
Alpha - SW¼ SW¼ SW¼ Section 12, T14N, R13W. This claim has drill holes staked with plastic pipes on it. There are no mining related activities on this claim. Disturbances and construction were limited to the access roads and drill pads during exploration activities. The access road leading to the claim is fenced and the gate locked. Cursory radiological data obtained averaged 13.0 μR/hr on this claim.

June - NE¼ NE¼ NE¼ Section 14, T14N, R13W. This claim has a collapsed portal (P) and three partially collapsed portals (P) on it. Portal 1 is completely collapsed and/or backfilled. Radiological readings at the portals were: 9 μR/hr @ 1 m and 9 μR/hr on contact. Portal 2 is partially collapsed with a 2½' H x 6½' W opening and the depth unknown. Radiological readings at the portal were: 16 μR/hr @ 1 m and 16 μR/hr on contact. Portal 3 is partially collapsed with a 1' H X 6½' W opening and the depth unknown. Radiological readings at the portal were: 12 μR/hr @ 1 m and 13 μR/hr on contact. Portal 4 is partially collapsed with a 7' H x 8' W opening. Radiological readings at the portal were: 15 μR/hr @ 1 m and 16 μR/hr on contact. Associated features includes: 325 linear feet of dangerous Page 2
Mine Site Visit Report

highwalls (DH), approximately 1,075 yd^3 of waste material (DPE) scattered over 0.30± acre, and a 300' L x 35' W bench (BE). The radiological readings on the waste material ranged from 11 to 20 μR/hr @ 1 m and 10 to 13 μR/hr on contact.

Largo - NW¼ NW¼ NW¼ Section 14, T14N, R13W. There are three claims within the same area at this site. This claim has a 325' L x 25' W shallow dozer cut on it. There were no other mining related activities noted on this claim. Disturbances and construction were limited to the access roads, drill pads, and this shallow dozer cut. This claim is located in an open area and is being used as rangeland for livestock. Cursory radiological data obtained averaged 11.0 μR/hr on this claim.

WEDNESDAY - May 1, 1996:

West Eagle 1-3 - SE¼ SW¼ NE¼ Section 24, T14N, R13W. This claim has a 30' L x 15' W shallow dozer cut and a 15' diameter x 5' deep pit on it. There were no other mining related activities noted on this claim. Several 15' diameter x 3' to 5' deep pits dug into limestone outside the claim area were also noted. Disturbances and construction were limited to the access roads, drill pads, this shallow dozer cut, and the small pit. This claim is located in an fenced area and is being used as rangeland for livestock. The access road to this claim is fenced and the gate locked. Cursory radiological data obtained averaged 11.0 μR/hr on this claim.

Eagle 1-6 - SW¼ SE¼ Section 18, T14N, R12W. This claim has a 1,500' L x 1,000' W limestone quarry located on it. There were no other mining related activities noted on this claim. Associated with the quarry are 1,150 linear feet of dangerous highwalls (DH). Several stockpiles of crushed limestone were noted on site. Disturbances were limited to the quarry. Approximately 35.0± acres have been disturbed by the quarry activities. This claim is located in an open area and the adjacent area(s) are being used as rangeland for livestock. Cursory radiological data obtained averaged 6.0 μR/hr on this claim.

Section 32 & 33 (Moe Mine) - SE¼ NE¼ NE¼ Section 32, T15N, R11W. This claim has a backfilled inclined shaft (VO) on it. Associated features includes: approximately 980 yd^3 of waste material (DPE) scattered over 0.17± acre and 0.01± acre of industrial/residential waste. Area of impact is approximately 3.80± acres. This claim is located in a fenced area with no access road to it. The radiological readings on the waste material ranged from 42 to 260 μR/hr @ 1 m and 42 to 200 μR/hr on contact.

FRIDAY - May 3, 1996:

Section 34 - SW¼ NE¼ NE¼ Section 34, T14N, R11W. This claim has a completely collapsed portal (P) and a 250' L x 15' to 10' W rimstrip on it. Associated features includes: 200 linear feet of dangerous highwall (DH) and 700 yd^3 of waste material (DPE) covering 0.14± acre. Approximately 1.00± acre has been impacted by the mining activities. This claim is surrounded by fenced private land. The access road passes through the Elkins Ranch and the gate is locked. The radiological readings on the waste material ranged from 12 to 30 μR/hr @ 1 m and 12 to 30 μR/hr on contact.

A U.S.G.S 7.5 minute quadrangle map for the township, range and section where the claim is located is used to locate the section, center or quarter corner and pinpoint the claim area. Once a known point *is located, it is used as a reference point to insure that the right area where the claim is located is investigated. All the claims were traversed on foot or where feasible by vehicle.*

CONTACTS: The following individuals were contacted for information on access to the mining claims and/or exploration and mining activities. Mr. Henry Andrews and Mr. Buddy Elkins, private land owners, and Sharon Wellito, Community Services Coordinator, Casamero Lake Chapter.

James Benally

James Benally
Reclamation Specialist II

Rose M. Grey

Rose M. Grey
Reclamation Specialist II

SHIPROCK AML FIELD OFFICE

PUBLIC INVOLVEMENT / COMMUNITY MEETINGS DOCUMENTATION

PROBLEM AREA: Eastern Navajo - Thoreau & Casamera Lake Goat Mountain **DATE:** April 29 - May 3, 1996

TYPE OF CONTACT:

(Indicate meeting type, contact person, (address / telephone number), problems/concerns encountered, how handled, outcome of meeting or contact).

Wednesday - May 1, 1996

Ms. Sharon Willeto is the Casamera Lake chapter co-ordinator. We spoke with her and told her we needed some information on the Haystack / Baca area. She informed us that Haystack and Baca community are combined and that Bobby Delgarito was their land board member. She also stated that most of the Indian allotments are fenced off and owners live in Gallup or at NHA housings. She also stated that Henry Andrew of Andrew Ranch might let us access his property to get to Section 34, T14N, R10W in the Goat Mountain area.

Friday - May 3, 1996

Mr. Henry Andrew is one of the ranchers in the area. He resides along side the main route between Casamera Lake and Interstate 40. Mr. Andrew said that the route to Section 34 can only be access from the east, Haystack and Baca area. He also stated that the route through his property is fenced off as you go further east. Property owners had installed gates throughout to prevent poaching and cattle rustling. Mr. Buddy Elkins resides about 2 miles south of Mr. Andrew. His property is fenced off and locked at all times. We managed to see him drive back to his home. We followed him to his house. We told him who we are and that we needed to get to a site east of his place. He did not opposed us using his route to access the section 34, T14N, R10W. He was very cooperative and said that his gate is usually open up to 5:00 pm daily when he is home.

RECOMMENDATIONS:

The project was also conducted by Mr. James Benally, Reclamation Specialist II.

SUBMITTED BY: Rose M. Grey
Rose M. Grey
Reclamation Specialist II

ACKNOWLEDGE: ____________________
Perry H. Charley
Reclamation Specialist III

MINE SITE VISIT REPORT
NAVAJO AML RECLAMATION DEPARTMENT

)ATE(S) OF VISIT: May 7, 1996

MINE/PROJECT NAME: Eastern Navajo Agency Non-Coal Inventory

DURATION OF VISIT: 9:30 a.m. - 3:30 p.m.

PURPOSE OF VISIT: Field investigation and inventory of known mining claims for possible non-coal mining activities, and to document the extent of mining activities and any physical hazards present on these mining claims. Ms. Rose Grey, Reclamation Specialist II, assisted with this task.

OBSERVATIONS: Today's field investigations and inventory was concentrated on in the community of Baca. The following claims were investigated today:

TUESDAY - May 7, 1996:

ection 4 - NE¼ & SE¼ Section 4, T14N, R10W. This claim has drill holes staked with plastic pipes on it. There were no mining related activities noted on this claim. Disturbances and construction were limited to the access roads and drill pads during exploration activities. This claim is surrounded by fenced private property. The access road leading to the claim passes through the Willcoxson Ranch property with several locked gates. Cursory radiological data obtained averaged 11.0 μR/hr on this claim.

ection 4 - NE¼ & SW¼ Section 4, T14N, R10W. Drill holes staked with plastic pipes were noted on this claim. There were no mining related activities noted on this claim. Disturbances and construction were limited to the access roads and drill pads. This claim is also surrounded by fenced private property. The access road leading to the claim also passes through the Willcoxson Ranch property with several locked gates. Cursory radiological data obtained averaged 12.0 μR/hr on this claim.

U.S.G.S 7.5 minute quadrangle map for the township, range and section where the claim is located is used to locate the section, center or quarter corner and pinpoint the claim area. Once a known point is located, it is used as a reference point to insure that the right area where the claim is located is investigated. All the claims were traversed on foot or where feasible by vehicle.

CONTACTS: The following individuals were contacted for information on access to the mining claims and/or exploration and mining activities. Ms. Helen Murphy, BIA Natural Resource Management.

James Benally
Reclamation Specialist II

Rose M. Grey
Reclamation Specialist II

SHIPROCK AML FIELD OFFICE

PUBLIC INVOLVEMENT / COMMUNITY MEETINGS DOCUMENTATION

PROBLEM AREA: Eastern Navajo - Goat Mountain **DATE:** May 7, 1996

TYPE OF CONTACT:

(Indicate meeting type, contact person, (address / telephone number), problems/concerns encountered, how handled, outcome of meeting or contact).

Tuesday - May 7, 1996

Ms. Helen Murphy works at the Natural Resource Department at the Crownpoint BIA building. We needed to talk to someone about the ownership of Section 4, T14N, R10W. She was the only one in the office at the time. The rest of the staff were on training in Albuquerque. She did mention that Mr. Bobby Delgarito is the person to talk to. He is the land board member of Baca/Haystack, Thoreau, Casamera Lake and Prewitt chapter. She called him and left a message. So she said she will let him know that Shiprock AML office needed his assistance. She also told us how we can contact Mr. Delgarito in the future at any of the five chapters.

RECOMMENDATIONS:

The project was also conducted by Mr. James Benally, Reclamation Specialist II.

SUBMITTED BY: Rose M. Grey
Rose M. Grey
Reclamation Specialist II

ACKNOWLEDGE: ______________________
Perry H. Charley
Reclamation Specialist III

MINE SITE VISIT REPORT
NAVAJO AML RECLAMATION DEPARTMENT

DATE(S) OF VISIT: May 13 & 14, 1996

MINE/PROJECT NAME: Eastern Navajo Agency Non-Coal Inventory

DURATION OF VISIT: Varied daily from 8:30 a.m. - 4:45 p.m.

PURPOSE OF VISIT: Field investigation and inventory of known mining claims for possible non-coal mining activities, and to document the extent of mining activities and any physical hazards present on these mining claims. Ms. Rose Grey, Reclamation Specialist II, assisted with this task.

OBSERVATIONS: This week's field investigations and inventory were concentrated on in the community of Canoncito. The following claims were investigated this week:

MONDAY - May 13, 1996:
Herrera Ranch - NE¼ Section 16, T11N, R2W. There is a shallow 30' L x 25' W dozer cut on this claim. There were no drill holes or other mining related activities noted on this claim. Disturbances were limited to the access roads and the shallow dozer cut. This claim is in an open area and is being used as rangeland for livestock. Cursory radiological data obtained averaged 10.0 μR/hr on this claim.

The reclaimed Canoncito and Ferre Coal Mines were also inspected for off-site features, access roads, fences, signs, permanent features, slopes, and diversion channels/ditches. The two reclaimed sites look sound and did not exhibit any major deficiencies.

TUESDAY - May 13, 1996:
Unknown - A vertical shaft depicted in the SW¼ of Section 32, T11N, R2W, was investigated for previous mining related activities. No exploration or mining related activities were noted at this site.

Unknown (Coal Mine) - SE¼ Section 16, T11N, R2W. This site has a portal (P) measuring 4' H x 4' W x depth unknown on it. An associated feature consists of a gob pile of approximately 275 yd^3 covering 0.07± acre. No other features were noted within the immediate vicinity of the portal other than a buming log west of the portal. This site is being used as a place to party. Impacted area is approximately 0.23± acre. No radiological data was obtained at this site.

Unknown (Uranium Mine) - SE¼ of Section 22, T10N, R3W. This site has a portal (P) measuring 4' H x 8' W x depth unknown on it. Other associated features includes: approximately 50 linear feet of dangerous highwall (DH) and 175 yd^3 of waste material (DPE) covering 0.02± acre. This site is located in an open area and is being used for rangeland for livestock. The access road leading to the site is impassable by 4-wheeled drive vehicles and the ATV. Approximately 2.58± acres have been impacted by the previous mining activities. Radiological data obtained were 70 μR/hr @ 1 m and 70 μR/hr on contact at the portal and 300 μR/hr @ 1 m and 440 on contact on the waste material.

Diamond 2 (Largo) - NE¼ Section 33, T15N, R17W. This site has three backfilled portals (P) on it. This site has been worked and regraded and revegetated by the previous operator(s). Approximately 4.65± has been regraded and revegetated. This site is fenced but livestock still get in and graze the area. Cursory radiological data obtained were 70 μR/hr @ 1 m and 70 μR/hr on contact in front of the portals and 180 μR/hr @ 1 m and 200 μR/hr on contact on the bench and regraded waste material.

A U.S.G.S 7.5 minute quadrangle map for the township, range and section where the claim is located is used to locate the section, center or quarter comer and pinpoint the claim area. Once a known point is located, it is used as a reference point to insure that the right area where the claim is located is investigated. All the claims were traversed on foot or where feasible by vehicle.

CONTACTS: The following individuals were contacted for information on access to the mining claims and/or exploration and mining activities. Mr. Curtis Chavez, Land Board Member, Canoncito Chapter.

James Benally

James Benally
Reclamation Specialist II

Rose M. Grey

Rose M. Grey
Reclamation Specialist II

SHIPROCK AML FIELD OFFICE

PUBLIC INVOLVEMENT / COMMUNITY MEETINGS DOCUMENTATION

PROBLEM AREA: Eastern Navajo - Canoncito & Herrera **DATE:** May 13 - 14, 1996

TYPE OF CONTACT:

(Indicate meeting type, contact person, (address / telephone number), problems/concerns encountered, how handled, outcome of meeting or contact).

Tuesday - May 14, 1996

Mr. Curtis Chavez is the land board member for the Canoncito community. We spoke with him and told who we are and our purpose for the visit. He was very helpful. He informed us that there are two more sites that we should look at. The sites were not on the listing. The coal site is in Section 16, T11N, R2W. Mr. Chavez mentioned that the community youth uses the place for social get togethers. The other site is located in Section 22, T10N, R2W. This site was very hard to find and there was no sign of frequent visitation. He also mentioned that the claim in Section 16, T11N, R2W, NE 1/4, has no physical mining activities. The previous reclaimed sites, Canoncito Mine and Ferre Mine, are not showing any failures. He was satisfied with the work. There was one site on the quad map that showed a vertical shaft. He did not knew of any opening.

RECOMMENDATIONS:

The project was also conducted by Mr. James Benally, Reclamation Specialist II.

SUBMITTED BY: Rose M. Grey
Rose M. Grey
Reclamation Specialist II

ACKNOWLEDGE: ____________________
Perry H. Charley
Reclamation Specialist III

MINE SITE VISIT REPORT
NAVAJO AML RECLAMATION DEPARTMENT

DATE(S) OF VISIT: May 30, 1996

MINE/PROJECT NAME: Eastern Navajo Agency Non-Coal Inventory

DURATION OF VISIT: 10:00 a.m. - 12:30 p.m.

PURPOSE OF VISIT: Accompany Peter J. Luthiger, Supervisor, Radiation Safety and Environmental Affairs, Quivira Mining Company, to perform preliminary site assessments at Section 23 (Grace Nuclear) mine site. Ms. Rose Grey, Reclamation Specialist II, assisted with this task.

OBSERVATIONS: Previous field investigations and inventory was conducted on this site on April 4, 1996, as part of the Eastern Navajo Agency's field investigations and inventory. Four retention ponds and six uncapped steel pipes had been located at that time.

Mr. Luthiger had a map of the area previously disturbed during the initial in situ mining activities. The map was used to located four additional steel pipes and two PVC pipes on the claim. A 300' Water Level Indicator, Model # 51453, manufactured by the Slope Indicator Company was used to measure the water level and the depth of the steel and PVC castings. Ten steel and two PVC castings were measured and water samples taken from the ones with water in them. The wells are numbered from G-1-1 through G-1-12. The following are the results of the measurements for the steel and PVC castings:

Well No. & Casting	Water Level	Depth of Casting	Water Sample Taken
G-1-1 (Steel)	@ 175.5'	> 300'	Yes
G-1-2 (Steel)	No Water	Plugged @ 24.5'	No
G-1-3 (Steel)	No Water	Plugged @ 2.5'	No
G-1-4 (Steel)	@ 15.5'	25.5'	Yes
G-1-5 (Steel)	@ 28.0'	> 300'	Yes
G-1-6 (Steel)	No Water	Plugged @ 1"	No
G-1-7 (Steel)	No Water	Plugged @ 1'	No
G-1-8 (Steel)	@ 7'	> 300'	Yes
G-1-9 (Steel)	@ 250.0'	> 300'	Yes
G-1-10 (PVC)	No Water	Plugged @ 19.5'	No
G-1-11 (PVC)	No Water	Plugged @ 151.0'	No
G-1-12 (Steel)	> 300'	> 300'	Yes

Mr. Luthiger will forward the results of the water samples to NAMLRD upon receiving the results from the lab.

CONTACTS: Mr. Harrison Livingston, individual allottee was contacted and informed of what NAMLRD personnel and Mr. Luthiger were doing at the mine site.

James Benally
Reclamation Specialist II

Rose M. Grey
Reclamation Specialist II

MINE SITE VISIT REPORT
NAVAJO AML RECLAMATION DEPARTMENT

DATE(S) OF VISIT: May 30, 1996

MINE/PROJECT NAME: Eastern Navajo Agency Non-Coal Inventory

DURATION OF VISIT: 10:00 a.m. - 12:30 p.m.

PURPOSE OF VISIT: Accompany Peter J. Luthiger, Supervisor, Radiation Safety and Environmental Affairs, Quivira Mining Company, to perform preliminary site assessments at Section 23 (Grace Nuclear) mine site. Ms. Rose Grey, Reclamation Specialist II, assisted with this task.

OBSERVATIONS: Previous field investigations and inventory was conducted on this site on April 4, 1996, as part of the Eastern Navajo Agency's field investigations and inventory. Four retention ponds and six uncapped steel pipes had been located at that time.

Mr. Luthiger had a map of the area previously disturbed during the initial in situ mining activities. The map was used to located four additional steel pipes and two PVC pipes on the claim. A 300' Water Level Indicator, Model # 51453, manufactured by the Slope Indicator Company was used to measure the water level and the depth of the steel and PVC castings. Ten steel and two PVC castings were measured and water samples taken from the ones with water in them. The wells are numbered from G-1-1 through G-1-12. The following are the results of the measurements for the steel and PVC castings:

Well No. & Casting	Water Level	Depth of Casting	Water Sample Taken
G-1-1 (Steel)	@ 175.5'	> 300'	Yes
G-1-2 (Steel)	No Water	Plugged @ 24.5'	No
G-1-3 (Steel)	No Water	Plugged @ 2.5'	No
G-1-4 (Steel)	@ 15.5'	25.5'	Yes
G-1-5 (Steel)	@ 28.0'	> 300'	Yes
G-1-6 (Steel)	No Water	Plugged @ 1"	No
G-1-7 (Steel)	No Water	Plugged @ 1'	No
G-1-8 (Steel)	@ 7'	> 300'	Yes
G-1-9 (Steel)	@ 250.0'	> 300'	Yes
G-1-10 (PVC)	No Water	Plugged @ 19.5'	No
G-1-11 (PVC)	No Water	Plugged @ 151.0'	No
G-1-12 (Steel)	> 300'	> 300'	Yes

Mr. Luthiger will forward the results of the water samples to NAMLRD upon receiving the results from the lab.

CONTACTS: Mr. Harrison Livingston, individual allottee was contacted and informed of what NAMLRD personnel and Mr. Luthiger were doing at the mine site.

James Benally
Reclamation Specialist II

Rose M. Grey
Reclamation Specialist II

OPEN FILE REPORT NUMBER 353

This report is preliminary and has not been edited or reviewed for conformity to New Mexico Bureau of Mines and Mineral Resources standards.

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES

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Uranium Mines and Deposits in the Grants district, Cibola and McKinley Counties, New Mexico

Virginia T. McLemore
and
William L. Chenoweth

New Mexico Bureau of Mines and Mineral Resources
Open-file Report 353

Revised December 1991

List of Maps

The purpose of this report is to present a series of maps showing the approximate outlines of uranium deposits and areas of significant mineralization. Mines and prospects are also shown on the maps. The data presented here are intended to supplement McLemore and Chenoweth (1989) and to aid exploration and mining companies in locating and developing these deposits. The data may also be useful for administrators in local, state, and federal government agencies who require this information for environmental studies, land-use decisions, and other planning actions. The data will be updated periodically and ultimately published by NMBMMR in the future and any updates and/or corrections will be greatly appreciated.

The approximate outlines of the uranium deposits were obtained from a variety of sources including published and unpublished reports. Most sources are referenced on each of the maps. In addition to published reports, mine and uranium deposit maps and other data were obtained from a number of mining companies and the files of the U.S. Atomic Energy Commission, Grand Junction (Colorado) Office. Several geologists from various companies review portions of the maps, including M. H. Alief (Chevron Resources Co.), J. Greenslade (retired, Phillips Petroleum Co.), D. C. Fitch and J. E. Motica (Hecla Mining Co.), J. H. Jackson (Santa Fe Mining, Inc.), and H. E. Whitacre (Quivira Mining Co., now Rio Algom Mining Corp.). George W. Hazlett (retired, United Nuclear Corp.) and Harlen K. Holen (retired, U.S. Department of Energy) reviewed all of the maps and assisted in plotting the oxidation-reduction interface in the Morrison Formation. Warren I. Finch (U.S. Geological Survey) and William Hatchell (New Mexico Department of Natural Resources) also reviewed all of the maps. However, the authors assume full responsibility for the data presented.

Production data for each mine are presented in Table 1 up through 1970. These data were obtained from the U.S. Atomic Energy Commission files. Production data for each mine from 1971 to 1988 are confidential and summarized in Table 2. Additional production data are presented in McLemore (1983a) and McLemore and Chenoweth (1989). Statistics on reserves are from various cited references, however reserve data are not available for most deposits.

The geologic setting, host rocks, size, geometry, and mineralogy of uranium deposits in the Grants district are summarized elsewhere and not repeated here. The reader is referred to McLemore and Chenoweth (1989), Turner-Peterson and others (1986), Rautman (1980), Hilpert (1969), and Kelley (1963) for more information.

References

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Anderson, O. J., 1980, Abandoned or inactive uranium mines in New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-file Report 148, 778 p., photos, maps.

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total ore vas received at the buying stations and mills. Ore g... present an avera... le total shipments ... lyses are incomplete; not all of the ore shipments ... assayed for V_2O_5
[1]Produce... unknown amount of uranium ore after 1970 (see table 2)... ne of the ore cre... Barbara J #1 may ... y have been produced from Barbara J #3.

Number	Mine Name	Tons Ore	Pounds U_3O_8	%U308	Pounds V_2O_5	%V_2O_5	Type of deposit	Host Rock[4]	Periods of Production/Shipper
					GRANTS URANIUM DISTRICT				
	Cibola County (formerly Valencia County)								
12N.9W.4.414	Blackhawk and Bunney (Sec. 4)	13,934	72,996	0.26	4,571	0.09	limestone	Jt	1952 - John Dorsett; 1954-M.W. Larsen; 1956-Cheyenne Contracting; 1958-1960, 1962-Sutton and Sutton; 1960-1962-Astro Enterprises; 1963-Sutton and Moe; 1965-1966-Mesa Mining Co. 1967-Bailey and Fife
11N.9W.20.414	Cedar (Yucca, Falcon)	3,199	13,631	0.21	6,461	0.10	limestone	Jt	1952 - Maddox and Teague; 1953-Maddox and Teague; 1954-1955-La Jara Mining Co.; 1955-Falc Uranium and Oil Co.;1955-1956-Yucca Uranium C 1956-1957-Florida Minerals; 1957-Utco Uranium Corp.
10N.3W.22.400	Chaves Lease	192	821	0.21	2,165	0.56	sandstone	Jmr	1955 - Calumet and Hecla
12N.9W.4.243	Christmas Day	2,624	9,373	0.18	5,621	0.10	limestone	Jt	1954-1956 - Colamer Corp.
8N.5W.8.113	Crackpot	3,214	8,396	0.13	21,348	0.33	limestone	Jt	1955 - Anaconda
12N.9W.33.444	[1]F-33 (Sec. 33)	48,686	304,871	0.31	31,306	0.12	limestone	Jt	1954-1959 - Anaconda
11N.5W.26,35	[1]Jackpile-Paguate	9,498,698	46,194,350	0.24	5,315,237	–	sandstone	Jmbj	1952-1970 - Anaconda
12N.9W.15.411	La Jara (Zia)	3,574	31,277	0.44	613	0.52	limestone	Jt,Je	1952 - J.M. Keeney; 1954-La Jara Mining Co.; 1956-Florida Minerals; 1957-1958-Zia Mining Co.; 1960-Chena Mining Co.
12N.9W.8.224	Last Chance	2,753	9,334	0.17	12,804	0.26	limestone	Jt	1951 - William Barlow; 1952-F.A. Sutton; 1953-T.J Skidmore; 1956-F.J. Broaddus
11N.9W.8.214	Lone Pine	392	983	0.13	3,309	0.42	limestone	Jt	1954-1955 - Lone Pine Mining Co.; 1955-Permian Basin Uranium Co.
8N.6W.16.124	Paisano	9	34	0.18	–	–	limestone	Jt	1957 - Good News Mining Ltd.
12N.9W.4	[1]Red Bluff-Gay Eagle						limestone	Jt	1952-1959 - Uranium Development Co.; 1953,1955 1957,1964-Moise Mirabel; 1953,1955-1957 - W.A. Martin; 1954, 1956 - Amuranium Corp; 1954 - M.J Larson; 1954 - E and M Mining Co.; 1954 - Willia and Russell; 1954, 1956 - McElvain Brothers; 1958 1958 - Sutton and Sutton; 1958 - Chena Uranium C 1959-1960 - L.O. Sutton; 1960 - Astro Enterprises; 1962-1953 - Homer Scriven; 1963, 1965-Mesa Min Co.
12N.9W.4.221	Red Bluff #2,4	2,756	10,157	0.18					
12N.9W.4.214	Red Bluff #3,5,9	457	1,350	0.15					
12N.9W.4.434	Red Bluff #7,8,10; Gay Eagle	41,914	168,560	0.20					
	TOTAL	45,127	180,067	0.20	49,831				
11N.4W.30.243	[1]St. Anthony (M-6, Hanosh)	78,722	320,942	0.20	100		sandstone	Jmbj	1951 - Hanosh Mines; 1957-1960-St. Anthony Uranium Co.; 1960-American Metal-Climax Corp. (now controlled by United Nuclear Corp.)
13N.8W.30.243	[1]San Mateo Mine	837,110	2,847,799	0.17	–		sandstone	Jmp	1959-1962 - Rare Metals Corp. of America; 1962-1967 - El Paso Natural Gas Co.; 1967-1970-United Nuclear Corp.
9N.5W.27.211	Sandy Mine	939	2,221	0.12	2,579	0.14	limestone	Jt,Je	1955 - Anaconda
12N.9W.9.120	Section 9	64,424	189,778	0.15	112,584	–	limestone	Jt	1950 - Fred Glover; 1953-1959-Anaconda; 1960-19 Farris Mines

Number	Mine Name	Tons Ore	Po[illegible]$_3$0$_8$	%U308	rounds V_20_5	$\%V_20_5$	[illegible]e of [illegible]posit	Host Rock[4]	Periods of Production/S...pp..
12N.9W.11.334	Taffy (Bonanza)	110	362	0.16	–	–	sandstone	Jmp	1961 - Lummus and Muriel
11N.9W.4.411	Tom 13	32	169	0.26	315	0.49	limestone	Jt	1954-1955 - Anaconda
12N.9W.4.442	UDC #5	927	3,091	0.17	1,375	0.07	limestone	Jt	1953-1954 - Uranium Development Co.
11N.5W.35.341	Watter	319	2,643	0.41	2,184	0.34	sandstone	Jmbj	1952-1953 - Anaconda
11N.5W.35.100	Windwhip	2,788	17,325	0.31	9,298	0.17	sandstone	Jmbj	1954 - Anaconda
11N.5W.36.443	Woodrow	5,326	134,014	1.26	4,895	0.05	breccia pipe	Jmj;Jmb	1953-1956 - Anaconda
	<u>McKinley County</u>								
14N.11W.5.313	Alta (Section 6)	3,330	27,212	0.40	13,719	0.35	sandstone	Jmw	1951-1957 - Anaconda; 1960-Farris Mines, Inc.; 1961-L.O. Sutton, Jr.; 1966-Henry Andrews
14N.9W.28.144	[1]Ann Lee (Section 28)	1,116,729	5,032,647	0.20	–	–	sandstone	Jmw	1958-1963 - Phillips; 1963-1970-United Nuclear
13N.9W.30.213	[2]Barbara J #1	8,691	52,631	0.26	14,830	0.11	limestone	Jt	1956-1957, 1960-1962 - Midcontinent Uranium; 1959-1960 - Dalco Uranium, Inc.
13N.9W.30.141	Barbara J #2	46,495	191,199	0.21			limestone	Jt	1957,1960-1964 - Midcontinent Uranium; 1959 - Dalco Uranium, Inc.
	[1]Whitecap	11,953	41,631	0.17					1959-1960 - Dalco Uranium Co.; 1966-1967 - Farr Mines, Inc.; 1967-1968 - Midcontinent Uranium C
	TOTAL	58,448	232,830	0.20					1966-1967-Farris Mines
13N.9W.30.221	Barbara J #3	102,128	485,719	0.23			limestone	Jt	1959-1963 - Midcontinent Uranium Co.
13N.9W.18.441	Beacon Hill-Gossett (Section 18)	39,354	166,065	0.21	22,671		sandstone	Jmp	1956 - Holly Mining Co.; 1957-Lea Exploration C 1958-1959-E.P. Moe; 1960-1961-KSN Co., Inc.; 1962-1963,1966-1967-Farris Mines
15N.17W.28.132	Becenti (NW1/4 Section 28, Eunice Becenti allotment)	846	3,350	0.20	2,266	0.14	sandstone	Kd	1952-1954 - Tucker, Hyde, Davenport 1953 - Hagens, Fitzhugh, Davenport 1956,1958-1959 - A.W. Tucker
15N.17W.28.344	Becenti (SW1/4 Section 28, Naomi Becenti allotment) mined through Diamond #2	8,536	42,499	0.25	20,847	0.13	sandstone	Kd	1958-1959 - Largo Uranium Co. 1964-1966 - A and 8 Mining Co. 1968-1969 - Shiprock Ltd.
14N.11W.19.220	[1]Billy the Kid (Section 19)	872	2,693	0.15	4,276		limestone	Jt	1952 - Warren McCormick; 1952-W.A. Greer; 1953-Maddox-Teague; 1954-Continental Divide; 19 H.E. Andrews; 1960-Don W. Wright
15N.13W.12.322	[1]Black Jack #1	1,439,432	6,440,419	0.22			sandstone	Jmw	1959-1961 - Lance Corp.; 1960-1961-Homestake Mining Co; 1961-Sabre-Pinon Corp.; 1962-1968-Homestake-Sapin Partners; 1969-1970-United Nuclear-Homestake Partners
15N.13W.18.223	[1]Black Jack #2	247,613	1,129,004	0.23	–	–	sandstone	Jmb	1959-1961 - Lance Corp.; 1961-Sabre Pinon Corp. 1962-1967-Homestake-Sapin Partners; 1968-1970-United Nuclear-Homestake Partners
13N.10W.24.234	Blue Peak	12,051	44,020	0.19	18,707	–	sandstone	Jmp	1951-1952-Blue Peak Mining; 1953-Shattuck Denn; 1955-Saint Michaels Foundation; 1956-Colohoma Uranium, Inc.; 1957-1958-Three Jacks Mining; 19 1960-Farris Mining Co.; 1960-1961-Lloyd O. Sutto 1964-Lee Garcia
13N.10W.24.144	Bob Cat	117	186	0.06	71	0.12	sandstone	Jmp	1956-Brown and Wallace

Number	Mine Name	Tons Ore	Pounds U_3O_8	%U308	Pounds V_2O_5	%V_2O_5	Type of Deposit	Host Rock[4]	Periods of Production/Shipper
14N.10W.14.414	[1]Buckey (Jeep)	161,635	770,893	0.24	241	–	sandstone	Jmw	1957-1958-Holly Minerals; 1958-1965-See Tee Mini Co.
16N.17W.35.411	C D and S	16	48	0.15	–	–	sandstone	Jmw	1957-C D and S Mining Co.
13N.9W.33.433	Charlotte (Section 33)	208	704	0.17	–	–	limestone	Jt	1958-Westvaco Minerals
16N.16W.17.212	[1]Church Rock (Section 17)	77,965	302,608	0.19	–	–	sandstone	Jmw,Jmb, Kd	1960-1961-Phillips Petroleum Co.; 1961-1962-Quint Corporation (now owned by United Nuclear Corp.)
14N.9W.35.332	[1]Cliffside - Section 36	7,074	6,046,780	0.41	–	–	sandstone	Jmw	1960-1963-Phillips Petroleum Co.; 1963-1968-Unite Nuclear; 1970-Kerr McGee
13N.9W.20.312	Davenport Incline	7,517	28,539	0.19	–	–	sandstone	Jmp	1957-1958-E.P. Moe; 1959-Black Rock Mining; 196 See Tee Mining Co.; 1966-Bailey and Fife
15N.17W.33.214	Diamond #2 (Largo #2, Mike Smith Lease)	47,181	202,440	0.21	65,450	–	sandstone	Kd	1952-Albert Smith; 1953-Adee Dodge Enterprises; 1953-1954-General Uranium Co.; 1954-1959-Largo Uranium Co.; 1964-1957- A and B Mining Co.; 197 Shiprock Ltd.
13N.9W.20.411	[1]Dog, Flea, and BG Group	244,177	906,235	0.19	–	–	sandstone	Jmp	1957-1970-Four Corners Exploration
13N.9W.21.324	[1]Doris-Section 21	31,950	118,052	0.18	–	–	sandstone	Jmp	1958-1959-Westvaco Minerals; 1959-1961-Phillips Petroleum Co.; 1961-KSN Co.
14N.10W.11.312	Dysart #1 (Section 11)	891,922	3,795,495	0.21	47,438	–	sandstone	Jmw	1956-1960-Rio de Oro; 1959-1960-Midcontinent Exploration Co.; 1961-1962-Homestake-Sapin
14N.10W.11.424	Dysart #2	237,602	894,642	0.18	–	–	sandstone	Jmw	1959-1961-Rio de Oro; 1959-Midcontinent Explorati Co.; 1961-1962-Homestake-Sapin
13N.9W.20.233	East Malpais Lease	30,333	139,818	0.23	–	–	sandstone	Jmp	1959-1960-Four Corners Exploration Co.
14N.12W.24.243	Elkins Group	59	151	0.13	231	0.20	limestone	Jt	1953-1954-Josephine Elkins
14N.11W.9.214	[1]Evelyn	10,743	49,584	0.23	23,539	0.48	sandstone	Jmb	1953-1956 - Anaconda Co.; 1966-1968-Farris Mines, Inc.; 1969-1970-Smith Development; 1970-Minerals Energy
13N.9W.29.141	Faith-Section 29	66,327	258,615	0.19	–	–	limestone	Jt	1958-1959 - Westvaco Minerals; 1960-Phillips Petroleum Co.; 1960–1964-KSN Co.; 1963-United Nuclear
13N.9W.30.442	Flat Top	49,663	216,486	0.22	66,126	0.11	limestone	Jt	1955-1957 - Holly Uranium Co.; 1957-1959-Flat To Mining Co.; 1963-1966-Bailey and Fife
15N.16W.4.111	Foutz #1	324	1,844	0.28	2,676	0.41	sandstone	Jmw	1953-1954-Foutz Mining Co.; 1953-Hanosh Mines, Inc.
15N.16W.31.444	Foutz #2	242	1,045	0.22	2,877	0.59	sandstone	Jmw	1953-1954 - Foutz Mining Co.
16N.16W.31.444	Foutz #3 (Yellow Jacket)	2,412	8,556	0.18	12,466	0.26	sandstone	Jmb	1953-1955 - Foutz Mining Co.
14N.11W.8.213	Francis	755	6,164	0.41	12,578	0.93	sandstone	Jmb	1953-1954 - Farris Mines, Inc.
	[1]Haystack								Haystack Mountain Development Corp.
13N.11W.13.312	SW1/4 sec. 13	1,162	2,830	0.12	–	–	limestone	Jt	1958,1961-Haystack Development Corp.
13N.11W.13.444	Sec. 13	3,736	16,701	0.22	–		limestone	Jt	1956,1958-1961-Art Bibo (mined in trespass)
13N.10W.19.110	Sec. 19 (Haystack No. 1)	137,310	562,267	0.20	165,454		limestone	Jt	1951-A.T.S.F.RR; 1952-1957,1959-1961, 1963-1965-Haystack Mountain Development Corp.
	TOTAL	142,208	581,798	0.20	165,494				
13N.9W.14.414	Hogan Mine (Section 14)	129,551	678,510	0.26	–	–	sandstone	Jmp	1959-1961 - Four Corners Exploration Co.; 1962-Homestake-Sapin

Number	Mine Name	Tons Ore	Poun[redacted]	%U308	Pounds V_2O_5	$\%V_2O_5$	[redacted]f [redacted]osit	Host Rock[4]	Periods of Production/Shipper
15N.18W.12.244	Hogback #3-5	6,354	24,234	0.19	2,954	0.03	carbonaceous shale	Kd	1952-1954 - Tucker, Hyde, Davenport; 1955-1956-Hyde Uranium Co.; 1957-1958-Calumet and Hecla; 1958-Mathis and Mathis; 1959-See Tee Mining Co.; 1960-Windsor Mining Co.
13N.9W.7.221	[1]Isbella (Section 7)	76,748	237,060	0.15		—	sandstone	Jmp	1959-1961-Phillips Petroleum Co.; 1961-1962-KSN Mining Co.
14N.11W.35.120	Lost Mine	10	4	0.02	4	0.02	sandstone	Jmb	1954-Berryhill and Elkins
15N.14W.12.423	[1]Mac #1	60,109	289,125	0.24		—	sandstone	Jmb	1968-Homestake-Sapin; 1968-1970-United Nuclear-Homestake
15N.13W.18.442	Mac #2	31,194	109,009	0.14			sandstone	Jmb	1968-Homestake-Sapin; 1968-1970-United Nuclear-Homestake
13N.9W.20.144	Malpais Raise	42,070	198,492	0.24			sandstone	Jmp	1958-Holly Minerals; 1958-1961-See Tee Mining Group
13N.9W.23.233	Marquez Mine	712,911	3,724,047	0.26			sandstone	Jmp	1958-1964-Calumet and Hecla; 1965-1966-United Nuclear Corp.
14N.10W.11.112	Mary #1 (Dysart #3)	357,262	794,063	0.11			sandstone	Jmw	1959-1962-Boyles Brothers; 1962-Entrada Corp.; 1964-Stella Dysart; 1964-1965-Homestake-Sapin
13N.9W.20.321	Mesa Top Mine	108,261	512,965	0.24	144,610		sandstone	Jmp	1954-1957-Lea Exploration Co.; 1957-1958-Holly Minerals
13N.10W.4.244	Pat - Junior - Section 4 (Dakota Mine)	5,069	12,645	0.12	2,478		sandstone	Jmw,Kd	1952-1959-Dakota Mining Co.; 1962-1963-Farris Mines, Inc.
13N.9W.19.420	[1]Poison Canyon	217,066	1,004,574	0.23	338,094		sandstone	Jmp	1952-1959-Haystack Mountain Development Corp.; 1960-1962-Farris Mines Inc.
14N.11W.28.113	Red Cap Group (T Group)	195	497	0.13	951	0.24	limestone	Jt	1952-1953-Navajo Development Co.; 1953-Fitzhugh & Doerrie
13N.10W.16.134	Red Point Lode	482	1,223	0.13	746	0.07	limestone	Jt	1952-1955-R.M. Shaw
14N.11W.20.144	Red Top Mines	165	390	0.12	1,287	0.39	limestone	Jt	1955-Red Top Uranium Mining Co.
14N.9W.34.424	[1]Sandstone	1,034,255	3,540,829	0.17	—	—	sandstone	Jmw	1959-1963-Phillips Petroleum Co.; 1963-1970-United Nuclear Corp.
13N.9W.1.200	[1]Section 1 (13N-9W) mined through Cliffside	148,066	1,699,137	0.57	—		sandstone	Jmw	1967,1969-1970-Kerr McGee; 1969-1970-National Lead Co.
15N.16W.3.332	Section 3 (15N-16W) Santa Fe-Christensen (Rats Nest Mine)	324	1,836	0.28	404		carbonaceous sandstone (coal)	Kd	1957-George Christensen; 1957-1958-Rem Uranium Co.
13N.10W.5.144	Section 5 (13N-10W)	23	54	0.12	—		sandstone	Kd	1958-Westvaco
13N.9W.8.114	Section 8 (13N-9W) (Spencer Shaft)	47,808	165,319	0.17			sandstone	Jmp	1958-1960-United Western; 1961-Hyde and Casper; 1964-1966-W.D. Tripp; 1966-1967-James J. Goode
14N.10W.10.244	[1]Section 10 (14N-10W)	130,767	510,935	0.20			sandstone	Jmw	1957-1962-Kermac Nuclear; 1964-Homestake-Sapin
14N.10W.12.411	[1]Section 12 (14N-10)	74,975	211,873	0.14			sandstone	Jmw	1961-Anderson Development Corp.; 1962-1963-Stella Dysart
13N.9W.13.334	Section 13 (13N-9W) SW1/4 (mined through Rialto shaft)	1,689	6,312	0.19			sandstone	Jmp	1962-1963-Febco Mines, Inc.
14N.10W.15.441	[1]Section 15 (14N-10W)	1,213,814	3,625,924	0.15			sandstone	Jmw	1958-1968-Homestake-Sapin; 1961-1965-Rio de Oro; 1968-1970-United Nuclear-Homestake
14N.9W.17.323	[1]Section 17 (14N-9W)	544,164	2,315,182	0.21			sandstone	Jmw	1960-1964-Kermac Nuclear; 1965-1970-Kerr McGee

Number	Mine Name	Tons Ore	Pounds U308	%U308	Pounds V_2O_5	$\%V_2O_5$	Type of Deposit	Host Rock[4]	Periods of Production/Shipper
13N.10W.18.341	Section 18 (13N-10W) (Indian Allotment)	25,796	98,175	0.19	75,342	0.30	limestone	Jt	1952-F.A. Sitton; 1952-Thompson and Williams; 1952-1953-Glen Williams; 1955-1956-Santa Fe Uranium Co.; 1956-1959-Federal Uranium Corp.; 1963-1964-Mesa Mining Co.; 1966-Cibola Mining Co
14N.9W.18.400	[1]Section 18 (14N-9W) mined through Sec. 17	501,946	1,586,447	0.16			sandstone	Jmw	1962-1964-Kermac Nuclear; 1965-1970-Kerr McGee
14N.9W.20.114	[1]Section 20 (14N.9W) mined through Sec. 17	486,375	2,223,977	0.23			sandstone	Jmw	1962-Kermac Nuclear
14N.10W.22.223	[1]Section 22 (14N-10W) heap leach	2,189,051 —	11,605,672 38,105	0.18 —			sandstone	Jmw	1958-1964-Kermac Nuclear; 1965-1970-Kerr McGee
14N.10W.23.134	[1]Section 23 (14N-10W)	2,528,797	9,679,773	0.19	—	—	sandstone	Jmw	1959-1968-Homestake-Sapin; 1969-1970-Homestake-United Nuclear
13N.10W.23.444	Section 23 (13N-1OW)	21,826	138,541	0.32	10,256	0.06	limestone	Jt	1957-1965-Haystack Mountain Development Corp.; 1965-1966-Santa Fe Pacific
13N.9W.24.121	Section 24 (13N-9W) Chill Wills, Rialto	9,261	31,381	0.17	—	—	sandstone	Jmp	1960-1963-Febco Mines, Inc.
13N.9W.24.300	Section 24 (13N-9W) (Sl/2, East Marquez) mined through Marquez decline	10,120	33,800	0.17			sandstone	Jmp	1960-1962-Calumet and Hecla
13N.11W.24.222	Section 24 (13N-11W) (Nana-A-Bah Vandever Allotment)	24,638	115,075	0.22	85,545	0.18	limestone	Jt	1952-1954-Glen Williams; 1955-1956-Santa Fe Uranium Co.; 1956-1957-Federal Uranium Corp.
14N.10W.24.332	[1]Section 24 (14N-10W) Heap leach	1,904,582 —	7,071,564 579	0.19 —			sandstone	Jmw	1959-1964-Kerr-McGee Nuclear; 1965-1970-Kerr McGee
13N.10W.25.411	[1]Section 25 (13N-10W)	235,156	958,058	0.20	153,657	0.12	limestone	Jt	1951-AT and SFRR; 1955-1961-Haystack Mountain Development Corp.; 1962-1965-Santa Fe Pacific; 1963, 1965-1966-Farris Mines, Inc.; 1968-Homestake Mining Co.; 1969-1970-United Nuclear Corp.
14N.10W.25.144	[1]Section 25 (14N-10W)	1,791,048	6,444,889	0.18	—	—	sandstone	Jmw	1959-1969-Homestake-Sapin; 1969-1970-Homestake-United Nuclear
13N.10W.26.221	[1]Section 26 (13N-IOW) (Desidero Allotment)	11,110	83,752	0.38	17,518	0.08	limestone	Jt	1952-1957-Hanosh Hines
14N.10W.26.220	[1]Section 26 (14N-10W) mined through Section 24	362,110	1,198,696	0.17	—	—	sandstone	Jmw	1965-1970-Kerr-McGee
14N.9W.27.324	[1]Section 27 (14N-9W) mined through	553,732	2,442,855	0.22			sandstone	Jmw	1967-1970-United Nuclear
14N.9W.27.310	Ann Lee	285,057	1,275,695	0.22				Jmw	
	section total	838,789	3,718,550	0.22					
14N.9W.28.333	Section 28 mined through Sec. 30	23,648	94,333	0.20			sandstone	Jmw	1958-United Western
14N.9W.29.300	Section 29 (14N-9W) mined through Sec. 32 shaft	390,511	1,999,236	0.26			sandstone	Jmw	1961-1964-Kermac Nuclear; 1965-1970-Kerr McGee

Number	Mine Name	Tons Ore	Pou[illegible]O_8	%U308	Pounds V_2O_5	$\%V_2O_5$	[illegible] of [illegible]posit	Host Rock[4]	Periods of Production/Shipper
14N.9W.29.100	Section 29 mined through Sec. 30 shaft	318,361	1,401,003	0.22			sandstone	Jmw	1960-1970-Kerr-McGee
14N.9W.29.400	Section 29 mined through Sec. 33	641,918	1,936,819	0.15			sandstone	Jmw	1963-Kerr-McGee
13N.9W.30.333	Section 30 (13N-9W) Roundy Lease, Rimrock #3	91,513	464,810	0.25	76,565		limestone	Jt	1952-1956-F.O. Manot; 1956-1966-Rimrock Mining Co.; 1970-Bailey and Fife
14N.9W.30.232	[1]Section 30 (14N-9W)	2,855,164	15,064,056	0.26	--		sandstone	Jmw	1959-1964-Kermac Nuclear; 1965-1970-Kerr McGe
14N.9W.30.141	[1,3]Section 3OW (14N-9W)	68,895	282,714	0.21			sandstone	Jmw	1970-Kerr-McGee
14N.9W.31.200	Section 31 (14N-9W) mined through Sec. 32	3,469	17,999	0.26	--		sandstone	Jmw	1970-Kerr-McGee
13N.9W.31.120	Section 31 (13N-9W)	15,736	77,121	0.25	21,628	0.27	limestone	Jt	1953-1954, 1958, 1961-Haystack Mountain Development Corp.; 1962-Santa Fe Pacific
13N.9W.32.144	Section 32 (13N-9W) Moe #4	2,407	9,746	0.25	21,628	0.27	limestone	Jt	1963-Sutton and Moe
14N.9W.32.122	Section 32 (14N-9W)	488,031	1,927,388	0.20	—	—	sandstone	Jmw	1958-1961-Homestake-New Mexico; 1961-1968-Homestake-Sapin; 1968-1970-United Nuclear-Homestake
13N.9W.32.144	Section 32 (15N-11W) (NE1/4, D. Begay allotment) mined through Moe #5 decline	20,117	89,091	0.22			sandstone	Jmb	1960-1963-Kermac Nuclear; 1964-1968-E.P. Moe; 1968-1969-DeVilliers Nuclear
15N.11W.33.242	Section 33 (15N-11W) Moe #5, West Ranch Mine	4,243	21,149	0.25			sandstone	Jmb	1960,1962-1963-Kermac Nuclear 1964-E.P. Moe
14N.9W.33.213	[1]Section 33 (14N-9W)	960,007	3,222,939	0.16			sandstone	Jmw	1959-1961-Ambrosia Lake Uranium Co.; 1959-196 Phillips Petroleum Co.; 1962-1964-Kermac Nuclear; 1964-1965-United Nuclear Corp.; 1965-1970; Kerr McGee
	Branson heap leach		26,149		–				
	NOTE: Ambrosia Lake Uranium Co. consisted of Kerr-McGee, Anderson Development Co., Pacific Uranium Co., Phillips Petroleum Co., and Branson Estate								
13N.10W.36.224	Section 36 (13N-10W) Rimrock	1,435	3,770	0.13	2,698	0.19	limestone	Jt	1952-1953-Moses Mirabel; 1954-1955-Skult-Munsor 1958-Chena Mining Co.; 1962-Homer Scriven
14N.10W.36.222	Section 36 (14N-10W) Lease 60-167	5,249	53,349	0.51	45,950	0.43	sandstone	Jmb	1957-1958-V.C.A.; 1959-United Western
14N.12W.10.243	Silver Bit 1-18	293	3181	0.54	3,340	0.57	sandstone	Jmw,Jmb	1955-1956-G.W. Fields; 1957-Monitor Exploration; 1957-United Western Mining
14N.10W.31.334	Silver Spur Group	5,938	29,454	0.25	19,202	0.25	sandstone	Kd	1952-Chas Davis; 1952-1953-Silver Spur Mining Co 1955-Holly Uranium Co.; 1956-Holly Minerals; 195 1959-Febco Mines; 1958-Holly Corp.; 1966-Farris Mines
15N.16W.4.414	U Mine Christensen 1-20	2,560	8,460	0.17	4,075	0.09	carbonaceous sandstone	Kd	1953-1954-Williams and Reynolds; 1955-Frontier Uranium; 1957-George Christensen; 1957-Rem Uranium Co.;1958-W.C.T. Engineering Co

Number	Mine Name	Tons Ore	Poun[illegible]	%U308	Pounds V_2O_5	$\%V_2O_5$	[illegible]f [illegible]sit	Host Rock[4]	Periods of Production/Shipper
13N.9W.34.343	Vallejo Mine	6,458	21,733	0.17	394	—	limestone	Jt	1957-1959-Vallejo Uranium Mines; 1959-1960-Sams' Oil and Minerals; 1962-1963-Penta Mining Co.
15N.16W.2.442	Westwater #1	4,713	26,571	0.28	27,134	0.40	sandstone	Jmw	1957-1960-Westwater Uranium Corp.
	[1]Mine Water Recovery	—	893,787	—	—	—		Jmw	1963-1970-Kerr McGee, HomestakeSapin Partners, United Nuclear

NOTE: In November 1961, Homestake-Sapin Partners acquired Homestake-New Mexico Partners. In April 1962, United Nuclear Corp. merged with the Sabre-Pinon Corp. and United Nuclear became the surviving corporation and became United Nuclear Corp. In February 1963, United Nuclear Corp. acquired the uranium mines and mill of the Phillips Petroleum Co. In 1965, Kermac Nuclear Fuels Corp. was dissolved. The operating company became Kerr-McGee Oil Industries, Inc. Later it was the Kerr-McGee Corp. and the Kerr-McGee Nuclear Corp. In April 1968, Homestake-Sapin Partners became United Nuclear-Homestake Partners. See Chenoweth (1989) for a listing of Ambrosia Lake operations.

Table 2—Uranium mines in New Mexico that have produced from 1971 to 1991.

Occurrence number	Mine name	Production[1] class	Host[2] rock	Periods of production/Shipper
		GRANTS URANIUM DISTRICT		
Cibola County (formerly Valencia County)				
12N.9W.33.444	[3]F-33 (Section 33)	c	Jt	1971–1977 - Homestake
11N.5W.26,33	[3]Jackpile-Paguate	e	Jmj	1971–1982 - Anaconda
11N.5W.13.300	JJ #1	d	Jmj	1976–1981 - Sohio-Reserve
13N.8W.24.433	Mt. Taylor	d	Jmw	1980–1983 - Gulf, 1985–1990 - Chevron
12N.9W.4	[3]Red Bluff-Gay Eagle	b	Jt	1976 - Moises-Mirabel
11N.4W.19.300, 11N.4W.30.240, 11N.5W.24.411	[3]St. Anthony	b	Jmj	1976–1980 - United Nuclear
13N.8W.30.243	[3]San Mateo Mine	d	Jmp	1971 - United Nuclear
McKinley County				
14N.9W.28.144	[3]Ann Lee (Spider Rock)	d	Jmw	1971–1972, 1982 - United Nuclear; 1977–1982 - Spider Rock
13N.9W.30.221	[3]Barbara J #3 (White Cap)	c	Jt	1979–1980 - Todilto Exp. Dev. Co.
14N.11W.19.220	[3]Billy the Kid	a	Jt	1976 - Henry Andrews
15N.13W.12.322	[3]Black Jack #1	d	Jmw	1971 - United Nuclear-Homestake
14N.10W.14.414	[3]Buckey	c	Jmw	1972 - Hydro-Nuclear; 1978–1980, 1982 - Cobb
16N.16W.17.212	[3]Church Rock (Sec. 8, 17)	c	Jmw, Jmb, Kd	1976–1977, 1979–1982 - United Nuclear
14N.9W.36.332	[3]Cliffside-Section 36	d	Jmw	1971–1985 - Kerr McGee
13N.9W.20.411	[3]Dog, Flea, and BG Group	c	Jmp	1971–1975 - Four Corners Exp.; 1978–1980 - M&M Mining
13N.9W.21.324	[3]Doris-Section 21	b	Jmp	1978–1979 - Ranchers
14N.11W.9.214	[3]Evelyn	b	Jmb	1971 - Smith Dev.; 1971–1972 - Stevenson; 1972 - Oral Creek
13N.11W.13.314	[3]Haystack-Section 13	c	Jt	1975–1981 - Todilto Exp. and Dev.
13N.10W.19.110	Section 18 and 19	c		
13N.9W.19.323	Hope (Section 19)	b	Jt	1977–1981 - Ranchers
13N.9W.7.221	[3]Isabella	c	Jmp	1978–1980 - Koppin; 1980–United Nuclear
13N.8W.7,18	Johnny M (Sections 7, 18)	d	Jmw	1976–1982 - Ranchers

Occurrence number	Mine name	Production[1] class	Host[2] rock	Periods of production/Shipper
15N.14W.12.423	[3]Mac #1	c	Jmb	1976–1978, 1980 - United Nuclear-Homestake
15N.14W.12.134	Mariano Lake (Section 12)	d	Jmb	1977–1982 - Gulf
17N.16W.35.200	N.E. Church Rock (2 shafts)	d	Jmw	1972–1982 - United Nuclear
17N.16W.35.200	N.E. Church Rock #1	d	Jmw	1976–1985 - Kerr McGee
17N.16W.36.100	N.E. Church Rock #1-E	d	Jmw	1979–1985 - Kerr McGee
17N.16W.27.200	N.E. Church Rock #2	d	Jmw	1978–1982 - Kerr McGee
13N.9W.30.143	Piedra Trieste (Section 30)	a	Jt	1979–1981 - Todilto Exp. & Dev.
13N.9W.19.420	[3]Poiston Canyon	c	Jmp	1976–1978 - Reserve
15N.13W.21.142	Ruby #1 } mined through	d	Jmb	1976–1979 - Western Nuclear
15N.13W.25.224	Ruby #3 and #4 } same decline			1980–1982 - Western Nuclear
15N.13W.25.224	Ruby #3 and #4	d	Jmb	1980–1982, 1984–1985 - Western Nuclear
14N.9W.34.424	[3]Sandstone	d	Jmw	1974–1980 - United Nuclear
13N.9W.1.200	[3,4]Section 1 (13N–9W) mined through Cliffside	d	Jmw	1971–1982 - Kerr McGee
14N.10W.10.244	[3]Section 10 (14N–10W)	c	Jmw	1980 - Cobb
14N.10W.12.411	[3]Section 12 (14N–10W)	c	Jmw	1978–1982 - Cobb; 1980 - United Nuclear
14N.10W.13.413	Section 13 (14N–10W)	c	Jmw	1977–1981 - United Nuclear-Homestake; 1981 - Homestake
14N.10W.15.441	[3]Section 15 (14N–10W)	d	Jmw	1971–1981 - United Nuclear-Homestake; 1981 - Homestake
13N.9W.16.441	Section 16 (13N–9W) mined through Dog-Flea mines	b	Jmp	1973 - United Nuclear-Homestake
14N.9W.17.323	[3]Section 17 (14N–9W)	d	Jmw	1971–1985 - Kerr McGee
14N.9W.18.420	[3,4]Section 18 (14N–9W) mined through Section 17	d	Jmw	1971–1982 - Kerr McGee
14N.9W.19.411	Section 19 (14N-9W)	d	Jmw	1978–1985 - Kerr McGee
14N.9W.20.114	[3,4]Section 20 (14N–9W) mined through Section 17	d	Jmw	1971–1979 - Kerr McGee
14N.10W.22.223	[3]Section 22 (14N–10W)	d	Jmw	1971–1985 - Kerr McGee
14N.10W.23.134	[3]Section 23 (14N–10W)	d	Jmw	1971–1982 - United Nuclear-Homestake; 1981–1989 - Homestake
16N.17W.23.221	Section 23 (16N–17W)	a	Jmw	1975 - Grace Nuclear (in situ production)
14N.10W.24.332	[3]Section 24 (14N–10W)	d	Jmw	1971–1985 - Kerr McGee

Occurrence number	Mine name	Production[1] class	Host[2] rock	Periods of production/Shipper
13N.10W.25.411	[3]Section 25 (13N–10W)	c	Jt	1971, 1979 - United Nuclear; 1972–1973 - United Nuclear-Homestake; 1972–1973 - Bailey and Fife; 1980–1981 - Reserve
13N.9W.8.114	Section 8 (Spencer Shaft)	c	Jmp	1978–1979 - Koppin
14N.10W.25.144	[3]Section 25 (14N–10W)	d	Jmw	1971–1981 - United Nuclear-Homestake; 1981–1985 - Homestake
14N.9W.26	Section 26 (14N–9W) mined through Section 35 and sandstone	c	Jmw	1971–1972, 1977–1982 - Kerr McGee
14N.9W.26.430	[4]Section 26 (14N–10W)	c	Jmw	1971–1982 - Kerr McGee
14N.9W.27.310,324	[4]Section 27 E and W	d	Jmw	1971–1979 - United Nuclear
14N.9W.29	[3,4]Section 29 (14N–9W) mined through Sections 32 and 30	d	Jmw	1971–1982 - Kerr McGee
14N.9W.30.232	[3]Section 30 (14N–9W)	d,e	Jmw	1971–1985 - Kerr McGee
14N.9W.30.141	[3]Section 30W (14N–9W)	d,e	Jmw	1971–1985 - Kerr McGee
13N.9W.30.333	[3]Section 30 (13N–9W)	c	Jt	1971 - Bailey and Fife
14N.9W.31.200	[1,3]Section 31 (14N–9W)	c	Jmw	1971–1972, 1980–1981 - Kerr McGee
14N.9W.32.122	[3]Section 32 (14N–9W)	d	Jmw	1971–1981 - United Nuclear-Homestake; 1981–1982 - Homestake
14N.11W.32.224	[3]Section 32–33 (West Ranch)	c	Jmw	1972 - Hydro Nuclear; 1978 - Cobb
14N.9W.33.213	[3]Section 33 (14N–9W)	d	Jmw	1971–1985 - Kerr McGee
14N.9W.35.233	Section 35 (14N–9W) (Elizabeth Shaft)	d	Jmw	1971–1985 - Kerr McGee
Sandoval County				
12N.3W.18.141	Rio Puerco	a	Jmw	1979–1980 - Kerr McGee
Insitu Leaching Pilot Plant				
17N.13W.9.322, 17N.13W.16	Crownpoint	a	Jmw	1981–1987 - Mobil (Nufuels)

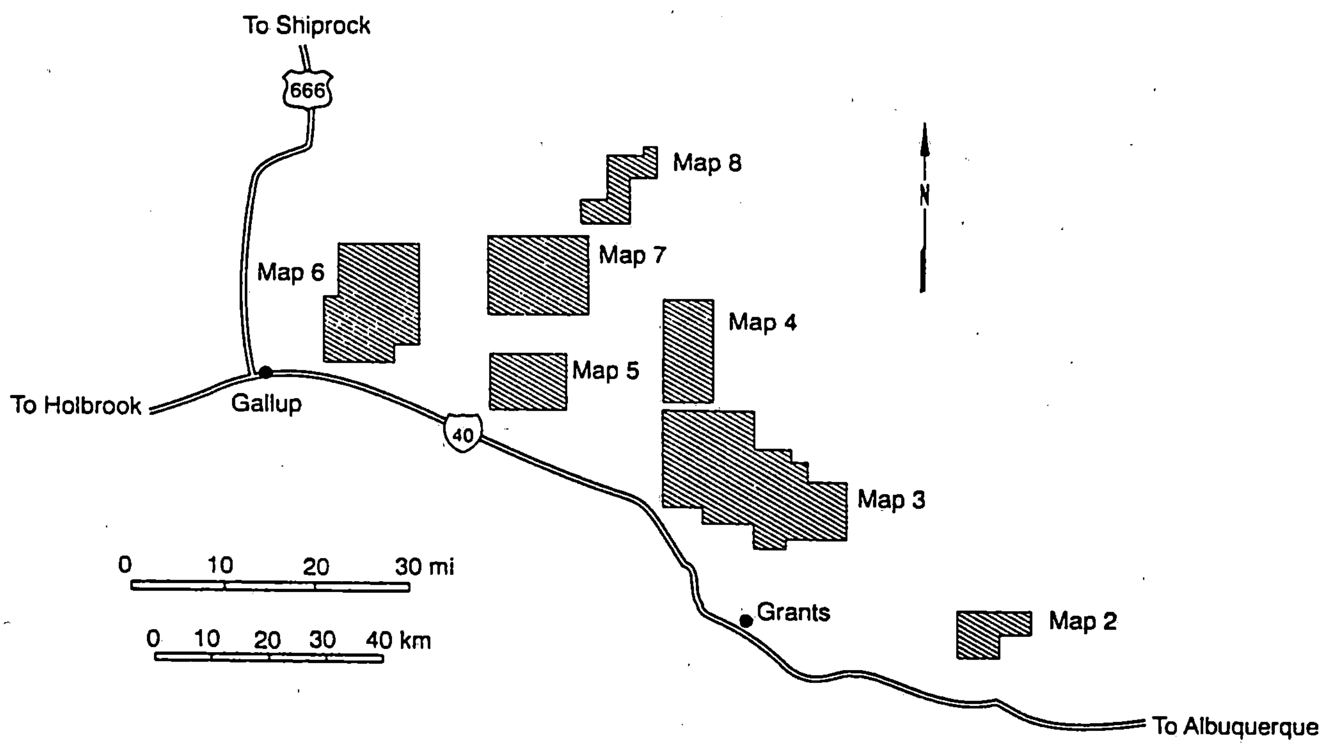
[1]Production Class: a - 0–20,000 lbs U_3O_8; b - 20,000–100,000 lbs U_3O_8; c - 200,000–2 million lbs U_3O_8; d - 2 million-20 million lbs U_3O_8; e - greater than 20 million lbs U_3O_8 (total production to date).

[2]Host rock: Jt - Todilto Limestone; Jmr - Recapture Member; Jmw - Westwater Canyon Member; Jmb - Brushy Basin Member; Jmp - Poison Canyon Sandstone; Jmj - Jackpile Sandstone; Jmj - Jackpile Sandstone; Kd - Dakota Formation.

[3]Produced prior to 1970, included Table 1. Production classification based on total production.

[4]Properties mined through adjacent shafts.

NOTE: In 1981, the United Nuclear-Homestake Partnership was dissolved. Homestake Mining Co. became the sole operator of the mill and the Sections 13, 15, 23, 25, and 32 mines. (All but Section 23 closed in 1981–1982, but Homestake continued to recover uranium from ine water until June 1990.) In 1983, Kerr McGee reorganized the uranium operations in New Mexico into the Quivira Mining Co. Quivira closed its mines in March 1985 but continued to recover uranium from mine water. In 1988, Kerr McGee sold the Quivira Mining Co. to Rio Algom Ltd. Rio Algom Mining Corp. (U.S. subsidiary) continues to recover uranium from mine water.



MAP 1 - LOCATION OF URANIUM ORE DEPOSIT MAPS OF THE GRANTS URANIUM DISTRICT, NEW MEXICO.

Uranium Resources of Northwestern New Mexico

By LOWELL S. HILPERT

GEOLOGICAL SURVEY PROFESSIONAL PAPER 603

Prepared on behalf of the U.S. Atomic Energy Commission

A description of the stratigraphic and structural relations of the various types of uranium deposits in one of the world's great uranium-producing regions

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1969

TABLE 4.—*Uranium deposits, by county, in northwestern New Mexico*—Continued

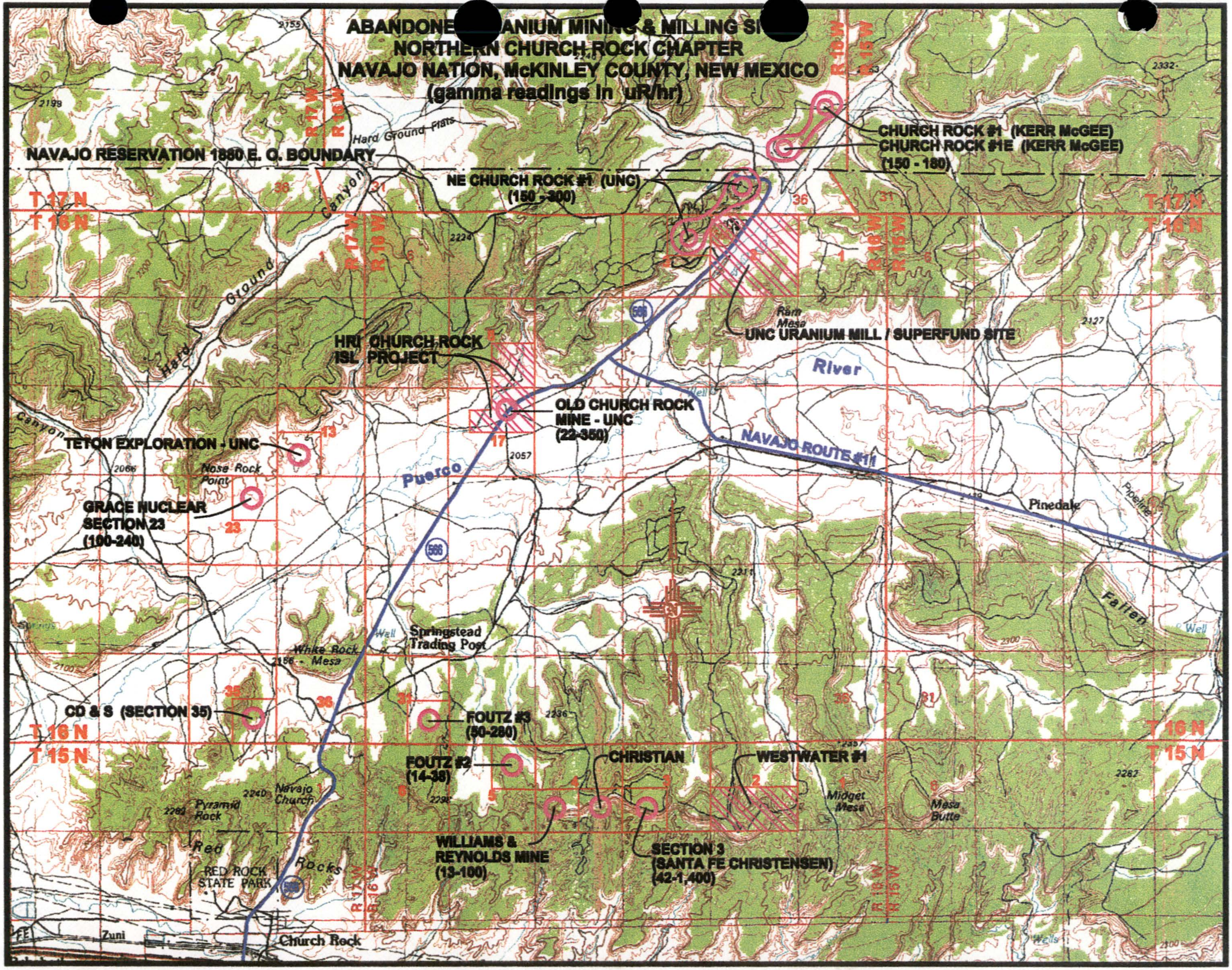
Name of deposit	Location Sec.	T.	R.	Description of deposit and sample	Source of data
				McKinley County—Continued	
T 2 (*45*)	W½NW¼SW¼ 28.	14 N.	11 W.	Small deposit in upper part of Todilto Limestone. Ore mined from open pit, 1952.	AEC.
T 10 (*46*)	W½NW¼SW¼ 28.	14 N.	11 W.	Probably an extension of T 2 deposit into T 10 claim. Deposit mined from open pit, 1952.	Do.
Silver Bit 7 (*95*)	N½NE¼ 10	14 N.	12 W.	Deposit at top of Jmw. Deposit probably worked as small opencut, 1955–57.	C. K. Presley (WC, 1955).
Silver Bit 15 (*96*)	SW¼NE¼ 10	14 N.	12 W.	One or more deposits at top of Jmw. Ore worked as opencuts, 1955–57.	Do.
Silver Bit 18 (*97*)	SE¼NE¼ 10	14 N.	12 W.	One or more deposits probably at top of Jmb and possibly in base of Dakota Sandstone. Ore probably mined from opencut, 1955–57.	Do.
Unnamed	10–11	14 N.	12 W.	Yellow uranium minerals in sandstone near top of Jmr.	Earl Arlin (OC, 1957).
Eagle	SW¼ 18	14 N.	12 W.	Small deposit in Todilto Limestone	AEC.
Lawrence Elkins (*20*).	SE¼NE¼ 24	14 N.	12 W.	Small deposit in Todilto Limestone. Some ore possibly mined in 1954.	Do.
Tom Elkins (*48*)	NW¼SE¼ 24	14 N.	12 W.	Small deposit in Todilto Limestone. Deposit mined in 1954–55.	Do.
Largo	N½NW¼ 14	14 N.	13 W.	Yellow uranium mineral shows in spots in bedding along outcrop of Todilto Limestone.	R. H. Olson, and J. P. Hadfield, Jr. (WC, 1957).
Last Chance 2	NW¼ 2	14 N.	14 W.	Spotty, yellow uranium minerals show in sandstone near top of Jmr. Channel sample, 0.02 percent eU_3O_8.	J. P. Hadfield and R. H. Olson (WC, 1951).
Section 27	W½SE¼ 27	15 N.	11 W.	Deposit in sandstone in Jmb	Pacific Uranium Mines Co., DH, November 1956.
Sections 32–33 (West Ranch) (*90*).	NE¼ 32 and NW¼ 13.	15 N.	11 W.	Geology unknown. Deposit 260 ft below surface, probably in Jmw. Deposit mined through inclined shaft, 1960–64.	AEC.
Section 35	NE¼ 35	15 N.	11 W.	Deposit or cluster of deposits in Morrison Formation	Phillips Petroleum Co., DH, November 1957.
Section 23	NE¼NE¼ 23	15 N.	12 W.	Deposit in sandstone in Jmb	Tidewater Oil Co., DH, October 1958.
Black Jack 1 (*8*)	N½S½ 12	15 N.	13 W.	A very large, V-shaped, complex deposit in upper part of Jmw. North arm of V trends east, is about 150 ft wide and 3,600 ft long, apparently follows sedimentary structures, and is prefault. From apex of V at east end of north arm, other arm extends southward about 3,000 ft and is about 200 ft wide. It is relatively thick and apparently is postfault, as it is oxidized and controlled, at least in part, by north- and northeast-trending fractures. Deposit mined through vertical shaft, 1959–64.	MacRae (1963); AEC.
Section 13	NE¼NE¼	15 N	13 W.	Deposit in sandstone in Jmw	Tidewater Oil Co., DH, October 1958.
Do	N½SE¼ 13	15 N.	13 W.	do	Do.
Black Jack 2 (*9*)	N½ 18	15 N.	13 W.	Several large irregularly shaped ore bodies in sandstone 18–60 ft thick near base of Jmb. Best ore occurs where sandstone is gray, crossbedded, and coarse grained; it contains mudstone splits and finely disseminated carbonaceous material. Ore pods are unoxidized (and probably prefault) and controlled by sedimentary structures, which trend southeastward. Main ore cluster is about 200–800 ft wide and 3,000 ft long. Small mineralized pods occur along same trend southeast and northwest of main deposits. Mined through vertical shaft, 1959–64.	Hoskins (1963); AEC.
Section 21	W½NW¼ 21	15 N.	13 W.	Deposit in sandstone in lower part of Jmb	Tidewater Oil Co., DH, October 1958.
Nicholson-Brown	S½ 26	15 N.	14 W.	Deposit in Jmw	AEC, DH.
Santa Fe Christ (*4*).	SW¼ 3	15 N.	16 W.	Deposit in carbonaceous shale at base of Dakota Sandstone. Ore mined in 1957–58.	AEC.

TABLE 4.—*Uranium deposits, by county, in northwestern New Mexico*—Continued

Name of deposit	Location Sec.	T.	R.	Description of deposit and sample	Source of data
				McKinley County—Continued	
Unnamed	NE¼ 32	16 N.	12 W.	Radioactive zone at the top of 3-ft coal bed at top of Crevasse Canyon Formation and immediately beneath Hosta Tongue of Point Lookout Sandstone. Channel sample of upper foot of coal bed 0.019 percent U.	G. O. Bachman, E. H. Baltz, and R. B. O'Sullivan (WC, 1953).
Section 21	SW¼ 21	16 N.	15 W.	Deposit in sandstone in Jmb	Tidewater Oil Co., DH, October 1958.
Section 8	SE¼ 8	16 N.	16 W.	Deposits in lower part of Jmb and upper part of Jmw	Phillips Petroleum Co., DH, January 1959.
Section 9	SE¼ 9	16 N.	16 W.	Probably similar to Section 8 (above)	Do.
Section 16	N½NW¼ 16	16 N.	16 W.	Deposits in Jmb or upper part of Jmw	Tidewater Oil Co., DH, December 1958.
Do	NW¼SW¼ 16	16 N.	16 W.	Deposit in upper part of Jmw	Do.
Church Rock (*20*)	NE¼ 17	16 N.	16 W.	Cluster of deposits in Jmb and Jmw. Deposits mined through vertical shaft, 1960–62.	Phillips Petroleum Co., DH, January 1959.
Section 17	W½ 17	16 N.	16 W.	Deposit at top of Jmw	Do.
Section 18	NW¼ 18	16 N.	16 W.	Deposit probably in upper part of Jmw	Do.
Do	SW¼ 18	16 N.	16 W.	Deposit at top of Jmw	Do.
Section 19	NW¼ 19	16 N.	16 W.	Deposit probably similar to those in adjoining sec. 18 (above).	Do.
Section 20	20	16 N.	16 W.	Deposit, or cluster of deposits, probably in Jmw	Unknown.
Section 22	22	16 N.	16 W.	Deposit, probably in Jmw	Unknown, DH.
Section 23	NW¼NE¼ 23	16 N.	16 W.	No information available	Phillips Petroleum Co., DH, January 1959.
Foutz 3 (Yellow Jacket; 3YJ) (*37*).	SE¼SE¼ 31	16 N.	16 W.	Tabular, elongate deposit near and at outcrop of 25-ft-thick sandstone in Jmb. The deposit is about 250 ft long, 10–100 ft wide, and averages about 3 ft in thickness. It was controlled in part by set of near-vertical fractures that trend about N. 30° W. Host sandstone is bounded by claystone units, is poorly sorted, crossbedded, clayey, and lacks any obvious carbonaceous material. Except for local spots of canary yellow oxide, uranium minerals are inconspicuous. Ore body was within a light-brown limonite-stained zone which in turn was within a purple hematitic envelope. These zones all within light-gray sandstone. U:V ratio about 1:1. Workings consist of four interconnected adits and two small stopes, the floors of which are about 20 ft apart vertically. Deposit was mined where fractures were concentrated, 1954–55.	FN, September 1954, October 1955.
Prospect 2	34	16 N.	16 W.	Radioactive zone in 3-ft-thick sandstone in upper part of Jmr. Sandstone is fractured and contains much carbonized plant debris. Grab sample, 0.08 percent eU_3O_8.	D. E. Mathewson and F. R. Fincher (WC, 1953).
Section 13	S½ 13	16 N.	17 W.	Deposits in Jmw	Phillips Petroleum Co., DH, January 1959.
Section 14	NW¼ 14	16 N.	17 W.	No information available	Do.
Section 24	NE¼ 24	16 N.	17 W.	Deposit probably in Jmw	AEC, DH.
CD and S (Section 35) (*13*).	SE¼ 35	16 N.	17 W.	Deposit in Jmw. Ore mined at outcrop, 1957	Do.
Delter	NW¼ 36	16 N.	17 W.	Carnotite impregnates lowermost 2-ft-thick sandstone of Dakota Sandstone. The bed constitutes basal part of a sandstone, shale, and conglomerate sequence that fills stream channel scoured in Jmw. Channel is 200 ft wide and 30 ft deep and trends N. 30° E. Host bed is carbonaceous and capped by lens of carbonaceous shale.	Gabelman (1956a, p. 316, and fig. 104).
Car-Ball 13	NE¼ 26	16 N.	18 W.	Radioactive zone about 1.5 ft thick in carbonaceous shale near base of Crevasse Canyon Formation. Channel sample 4 in. thick, 0.21 percent eU_3O_8.	P. E. Melancon and E. B. Butts (WC, 1953).
Dalton Pass	*28	17 N.	14 W.	Radioactive impure coal bed about 3 in. thick at top of Crevasse Canyon Formation and immediately beneath Hosta Tongue of Point Lookout Sandstone. Sample 0.2 ft thick, 0.025 percent U.	G. O. Bachman, E. H. Baltz, and R. B. O'Sullivan (WC, March 1953).

TABLE 4.—*Uranium deposits, by county, in northwestern New Mexico*—Continued

Name of deposit	Location Sec.	T.	R.	Description of deposit and sample	Source of data
				McKinley County—Continued	
Christian (U mine) (*2*).	SE¼ 4	15 N.	16 W.	This cluster of deposits occurs in Christian 9 and 16 claims in carbonaceous zone about 15–20 ft above base of Dakota Sandstone and, as indicated by Mirsky (1953, fig. 3), in a scour-filled channel. Zone is composed of fine-grained crenulated limonite-stained gray sandstone that contains thin seams of carbonaceous shale and macerated carbonized plant debris. Tyuyamunite identified where uranium is more concentrated, and the concentration shows a direct relation to the abundance of carbonaceous material. Principal working is 500-ft adit driven northeastward in Christian 16 claim. In adit near face, mineralized zone is 3–5 ft thick. Deposits mined in 1953–55 from Christian 16 and in 1957–58 from Christian 9.	Mirsky (1953); FN, October 1955; U.S. Bur. Mines amenability test report no. 437; R. K. Pitman (OC, 1965).
Foutz 1 (*35*)	NW¼NW¼ 4	15 N.	16 W.	Deposit in sandstone in Jmw. Ore mined from shallow pit at outcrop, 1953.	FN, October 1955; Sharp (1955, p. 9).
Foutz 2 (*36*)	NE¼NE¼ 5	15 N.	16 W.	Deposit in sandstone in Jmw. Deposit mined from south-trending adit, 1953.	FN, October 1955.
Westwater 1 (*100*)	S½ 2	15 N.	16 W.	Deposit in upper part of Jmw. Ore mined in 1957–58	AEC.
Becenti (*1*)	NW¼ 28	15 N.	17 W.	Deposit occurs in upper part of 10- to 15-ft thick sandstone at base of Dakota Sandstone and overlain by lens of carbonaceous shale. Host sandstone makes up scour-filled channel in which crossbeds dip about N. 30° E. Sandstone is limonite stained and contains seams and small pockets of carbonized plant material. Yellow uranium minerals including meta-autunite, metatyuyamunite, and uranophane (Gruner and others, 1954) are disseminated in sandstone as well as along joint and bedding surfaces. Joint sets trend N. 50° E. and N. 15° W. Ore mined from an open pit, 1952–58.	FN, October 1955; and Gabelman (1956a, p. 315–316).
Diamond 2 (Largo 2) (*3*).	NW¼NE¼ 33	15 N.	17 W.	Two medium to large deposits and several satellites, mostly in basal medium- to coarse-grained sandstone unit of Dakota Sandstone. Unit fills channel or channels scoured in Jmw. Is overlain by carbonaceous shale and interbedded fine-grained sandstone. Beds strike N. 30° W., dip about 30° SW. Two main deposits about 750 ft apart along strike. Strike length of north body about 300 ft and south body about 500 ft. Bodies pinch out along 500 level about 275 ft vertically below mine entry at outcrop. Ore occurred in podlike masses, generally crudely elongate with dip of beds and crudely parallel to axes of cross folds and to plunge of slumplike structures in host sandstone. Ore minerals uraninite, possibly coffinite, metatyuyamunite, probably tyuyamunite, and carnotite, associated with corvusite, limonite, jarosite, and a little marcasite and closely associated with carbonaceous debris. In south body much oxidation above 450 level and some between 450 and 500 level. Mine yielded about 50,000 tons of ore, 1953–64, that had U:V ratio of 3:1 and lime content of 0.5 percent.	Mirsky, 1953; Gruner and others, 1954, p. 37; FN, October 1954; Gabelman, 1956a, p. 312–316; Four Corners Uranium Corp., January 1959; Chico, 1959.
Hogback 3 (*2*) and 4 (*3*).	NE¼ 12	15 N.	18 W.	Deposit occurs in a carbonaceous coaly shale of Dakota Sandstone. Shale is lenticular and locally several feet thick and occupies same stratigraphic position as shale that overlies Becenti and Diamond 2 deposits (above). No uranium minerals are apparent except in spots in underlying sandstone which under the deposit ranges from 4 to 11 ft in thickness. Deposit apparently is related to thick part of carbonaceous shale, which thins away from vicinity of deposit, and possibly to underlying channel-type sandstone (Mirsky, 1953, p. 15). Deposit was mined, 1952–60, from open pit and prospected at southern end by 400-ft incline shaft.	FN, October 1954; Gabelman (1956a, p. 307–308); Mirsky (1953).


ABANDONE ANIUM MINING & MILLING SI
NORTHERN CHURCH ROCK CHAPTER
NAVAJO NATION, McKINLEY COUNTY, NEW MEXICO
(gamma readings in uR/hr)
NAVAJO RESERVATION 1880 E. O. BOUNDARY
CHURCH ROCK #1 (KERR McGEE)
CHURCH ROCK #1E (KERR McGEE)
(150 - 180)
NE CHURCH ROCK #1 (UNC)
(150 - 300)
UNC URANIUM MILL / SUPERFUND SITE
HRI CHURCH ROCK
ISL PROJECT
OLD CHURCH ROCK
MINE - UNC
(22-350)
TETON EXPLORATION - UNC
GRACE NUCLEAR
SECTION 23
(100-240)
NAVAJO ROUTE #11
CD & S (SECTION 35)
FOUTZ #3
(50-280)
FOUTZ #2
(14-38)
CHRISTIAN
WESTWATER #1
WILLIAMS &
REYNOLDS MINE
(13-100)
SECTION 3
(SANTA FE CHRISTENSEN)
(42-1,400)
T 17 N
T 16 N
T 15 N
R 17 W
R 16 W
R 15 W
Hard Ground Flats
Hard Ground Canyon
Puerco River
Ram Mesa
Nose Rock Point
Pinedale
Pipeline
Fallen
Springstead
Trading Post
White Rock Mesa
Navajo Church
Pyramid Rock
Red Rocks
RED ROCK
STATE PARK
Midget Mesa
Mesa Butte
Zuni
Church Rock
Well

RADIONUCLIDE CONCENTRATIONS AND DOSES RESULTING FROM THE UNITED NUCLEAR URANIUM MILL TAILINGS SPILL AT CHURCH ROCK, NEW MEXICO

JERE MILLARD, THOMAS BUHL
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SURVEILLANCE AND FIELD OPERATIONS SECTION
RADIATION PROTECTION BUREAU
ENVIRONMENTAL IMPROVEMENT DIVISION
NEW MEXICO HEALTH AND ENVIRONMENT DEPARTMENT

Draft Report
April 1982

Table 2.6 Mean 1979 Radionuclide Concentrations in Rio Puerco Sediments from Main Channel Terraces, Concentrated Areas and Precipitated Raffinate Salts as Compared to Upper Bank Background Soils.

SAMPLE TYPE	MEAN RADIONCULIDE CONCENTRATION (pCi/g + SEM)			
	U 238(n)	Th 230(n)	Ra 226(n)	Pb 210(n)
Background	2.44 ± 0.50(17)	0.75 ± 1.28(78)	1.29 ± 0.27(60)	1.70 ± 0.13(78)
All Terraces	3.24 ± 0.27(116)	27.49 ± 0.96(657)	0.49 ± 0.14(579)	2.78 ± 0.09(657)
1. Stake 0-109	-0.04 ± 0.16(37)	23.18 ± 2.18(135)	0.20 ± 0.37(130)	3.90 ± 0.34(135)
2. Stake 111-329	4.24 ± 0.29(46)	33.67 ± 1.43(318)	0.85 ± 0.23(275)	2.61 ± 0.09(318)
3. Stake 331-491	5.54 ± 0.39(33)	20.70 ± 1.43(204)	0.13 ± 0.17(174)	2.31 ± 0.11(204)
Concentrated Areas	5.93 ± 1.00(35)	55.30 ± 3.48(205)	0.77 ± 0.44(171)	5.43 ± 0.37(205)
Salts	3.14 + 1.35(4)	83.12 + 17.84(20)	-0.60 + 1.4(19)	8.23 + 2.25(20)

TABLE 2.7 Mean 1979 Rio Puerco Sedimont Concentrations Comp~~os~~ared To 1980 Values.

YEAR	SAMPLE TYPE	MEAN RADIONUCLIDE CONCENTRATION (pCi/g ± SEM)			
		U 238	Th 230	Ra 226	Pb 210
1979	Concentrated Areas	5.9 ± 1.0	55 ± 3	0.8 ± 0.4	5.4 ± 0.4
1979	Main Channel Terraces	3.2 ± 0.3	27 ± 1	0.5 ± 0.1	2.8 ± 0.1
1980	Main Channel [a] Terraces	2.2 ± 0.1	8.4 ± 0.5	0.9 ± 0.1	1.6 ± 0.1
1980	Side Channel Terraces	1.8 ± 0.1	8.7 ± 0.9	0.9 ± 0.1	1.6 ± 0.1

(a) Mean 1980 terrace concentrations from main and side channels were obtained from samples of the first half of the stream to stake 250.

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PNL-4122

Survey of Radionuclide Distributions Resulting from the Church Rock, New Mexico, Uranium Mill Tailings Pond Dam Failure

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ABSTRACT

An intensive site survey and on-site analysis program were conducted to evaluate the distribution of four radionuclides in the general vicinity of Gallup, New Mexico, subsequent to the accidental breach of a uranium mill tailings pond dam and the release of a large quantity of tailings pond materials. The objective of this work was to determine the distribution and concentration levels of ^{210}Pb, ^{226}Ra, ^{230}Th, and ^{238}U in the arroyo that is immediately adjacent to the uranium tailings pond (pipeline arroyo) and in the Rio Puerco arroyo into which the pipeline arroyo drains. An intensive survey between the United Nuclear Corporation (UNC) Church Rock Mill site and the New Mexico-Arizona state border was performed. Sampling locations were established at approximately 500-ft intervals along the arroyo. During the weeks of September 24 through October 5, 1979, a series of samples was collected from alternate sampling locations along the arroyo. The purpose of this collection of samples and their subsequent analysis was to provide an immediate evaluation of the extent and the levels of radioactive contamination. The data obtained from this extensive survey were then compared to action levels which had been proposed by the Nuclear Regulatory Commission and were adapted by the New Mexico Environmental Improvement Division (NMEID) for ^{230}Th and ^{226}Ra concentrations that would require site cleanup.

The Pacific Northwest Laboratory/Nuclear Regulatory Commission mobile laboratory van was on-site at the UNC Church Rock Mill from September 22, 1979, through December 13, 1979, and was manned by one or more PNL personnel for all but four weeks of this time period. Approximately 1200 samples associated with the Rio Puerco survey were analyzed in the laboratory. An additional 1200 samples related to the Rio Puerco cleanup operations which the United Nuclear Corporation was conducting were analyzed on-site in the mobile laboratory. The purpose of these analyses was to determine the effectiveness of the cleanup operations that were ongoing and to evaluate what additional cleanup would be required. This on-site analysis of radioactive contamination constituted the principal task of this project, with the identification of those portions of the arroyo exceeding the NMEID proposed cleanup criteria being the

major output. Additional tasks included an evaluation of the initial soil sampling scheme (letter from T. Wolff [NMEID] to J. Abiss [UNC], dated September 25, 1979) and the proposed NMEID verification sampling scheme (letter from T. Buhl [NMEID] to H. Miller [NRC], dated April 23, 1980).

EXECUTIVE SUMMARY

On July 16, 1979, a break in the tailings pond dam of the United Nuclear Corporation's Church Rock, New Mexico, mill occurred. Approximately 94 million gallons of the tailings liquid which had been impounded behind this dam were released into an adjacent arroyo along with an estimated 1,100 tons of tailings solids. The spilled solution traveled down the so-called "pipeline arroyo" and into the north branch of the Rio Puerco arroyo. Beyond this point it continued past the location where the north and south branches of the Rio Puerco join immediately northeast of Gallup, New Mexico, continued across the remainder of the state of New Mexico, and extended into the state of Arizona for ~20 to 25 miles, where the flow of the Rio Puerco terminates.

In September, 1979, Pacific Northwest Laboratory (PNL) responded to a request from the New Mexico Environmental Improvement Division and the U.S. Nuclear Regulatory Commission (NRC) to provide immediate on-site sampling and radionuclide analysis capability. The principal objective of PNL's work on-site at the United Nuclear Corporation mill was to provide capabilities for immediate analyses of samples which had been collected from the Rio Puerco environment. The conditions for sample preparation and sample analysis were optimized so that the total amount of time required from the time the sample was collected until the data regarding radionuclide concentrations for that sample were available could be less than 48 hours. The concentrations of ^{210}Pb, ^{226}Ra, ^{230}Th, and ^{238}U were determined in ~2400 samples from a survey of the Rio Puerco contamination and from subsequent cleanup operations initiated by the United Nuclear Corporation. The purpose of these later analyses was to determine the effectiveness of the cleanup operations that were ongoing and to evaluate what additional cleanup would be required. This on-site analysis of radioactive contamination constituted the principal task of this project, with the identification of those portions of the arroyo exceeding the NMEID proposed cleanup criteria being the major output.

The following conclusions have been drawn as a result of the investigation of the Church Rock uranium mill tailings pond dam failure:

1. On-site use of planar intrinsic germanium detectors provides adequate sensitivity and short analysis times for quantitation of ^{210}Pb, ^{226}Ra, ^{230}Th, and ^{238}U in sediments/soils.

2. The original sampling plan, which consisted of collecting surface soil/sediment samples at 1000-ft intervals, was adequate to determine those areas which were contaminated and required cleanup.

3. Clustering of samples within arroyo reaches defined by physical (morphological) features would provide a better estimation of the radionuclide spatial variability than did the sampling pattern which was used and which was based on equal distance increments.

4. The revised Rio Puerco cleanup criteria proposed by the NMEID are statistically adequate.

5. Concentrations of ^{210}Pb, ^{226}Ra, and ^{238}U in samples throughout the length of the arroyo are not distinguishable from natural background concentrations.

6. Concentrations of ^{230}Th range from background levels to levels elevated considerably greater than background. Plots of ^{230}Th concentrations versus distance from the tailings pond show high variability. Therefore, a statistical smoothing function was applied to the data to facilitate interpretation.

7. Sediment samples from two site-variability studies indicate that there is considerable ^{230}Th concentration variability within even limited areas of the arroyo (i.e, 5-ft square grids and 25-ft square grids).

8. The concentrations of ^{230}Th in the Rio Puerco show an apparent periodicity as a functon of distance. This period is ~2.5 km.

9. The estimated total inventory of ^{230}Th in the Rio Puerco from sampling stake 0-491 is 26.8 Ci, based on data from the upper two feet of the core samples. The inventory based on data from the first-terrace and second-terrace samples (upper two inches) is 4.9 Ci. The

total inventory of ^{230}Th background in the upper two inches of arroyo sediment is estimated to be 0.30 Ci.

10. Present inability to differentiate between natural background ^{230}Th and contamination-derived ^{230}Th prohibits a clear definition of the ^{230}Th inventory from the tailings pond solution.

11. Sediment samples from the Grand Canyon National Park show no radionuclide levels in excess of normal background.

RADIONUCLIDE LEVELS IN CATTLE RAISED NEAR URANIUM MINES AND MILLS IN NORTHWEST NEW MEXICO

BY

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EXECUTIVE SUMMARY

Evidence from two separate studies conducted in New Mexico in 1978-1979 indicated that livestock raised near uranium mines and mills have elevated radionuclide levels, compared with controls. New Mexico's Grants Mineral Belt region covers 4,000 square kilometers and is rich in underground uranium. This area has been heavily mined for 30 years. The problem of potential livestock contamination from the uranium industry is, therefore, of great concern to the New Mexico Environmental Improvement Division (NMEID).

In 1982, the New Mexico Legislature appropriated over $90,000 to investigate this potential problem. The present investigation was conducted to determine whether cattle grazing in areas with uranium mining and milling activity have higher levels of U-238 decay chain radionuclides than controls, and to assess the potential public health risk to humans from eating cattle raised in these areas.

Ambrosia Lake and Church Rock, NM, were chosen as areas for the study. Ambrosia Lake has been the site of extensive underground uranium mining for about 30 years and two large uranium mill tailings piles are located there. Church Rock was chosen because of concerns generated by a study conducted in this community following an accidental spill of mill tailings effluent in 1978. Crownpoint, an area 40 kilometers northwest of Ambrosia Lake, has not been developed for uranium mining or milling and was chosen as a suitable control site.

Cattle were purchased from the above study areas. Five cattle were purchased from one owner in Ambrosia Lake (ALG1); five from another owner (ALG2); seven from Church Rock (CR); and ten from Crownpoint (CP). On the basis of previous studies by the NMEID of the uranium mining and milling activities in these areas, it was determined that the cattle's potential for ingestion of radio nuclides was highest in Ambrosia Lake, followed by CR. The CP animals were not exposed to the uranium activities and were used as a comparison group.

The twenty-seven cattle were slaughtered in October, 1983. Muscle, liver, kidney, and femur were analyzed for uranium-238 (U-238), uranium-234 (U-234), thorium-230 (Th-230), radium-226 (Ra-226), lead-210 (Pb-210), and polonium-210 (Po-210) by Eberline Laboratory, Albuquerque, NM. Duplicate tissues for 20% of the cattle muscle, liver, and kidney samples were analyzed by the USEPA Las Vegas radiochemistry laboratory. In addition, samples of vegetation, soil, and water collected from each of the four groups were analyzed by Eberline for the same radionuclides. The mean radionuclide levels for the four groups were compared statistically using analysis of variance and nonparametric tests.

The laboratory analyses were completed on March 15, 1985. The mean radionuclide concentrations were highest in the ALG1 cattle followed by ALG2 and Church Rock cattle, in that order. Radionuclide levels were lowest among the control cattle.

Radium-226 and Po-210 concentrations in muscle tissue from ALG1 were higher than those in controls. Many of the radionuclide concentrations in the liver, kidneys, and femurs of AGL1 cattle were statistically higher than controls. Liver and kidney tissues from ALG1 cattle were particularly elevated in Ra-226 and Po-210. Environmental sampling of ALG1 revealed soil radionuclide levels that were all statistically higher than controls. Vegetation from ALG1 contained significantly higher levels of Th-230 and Ra-226 than controls. Water samples contained higher levels of U-238 and U-234 than controls.

Cattle from ALG2 also had elevated radionuclide levels compared with controls. Liver was elevated in uranium and kidney was elevated in all radionuclides except Po-210. Vegetation from ALG2 contained higher levels of Th-230 and Ra-226 than controls. Mean radionuclide concentrations in soil from ALG2 were several times higher than those of controls but the differences did not attain statistical significance. Radionuclide concentrations in water samples from ALG2 were similar to those of controls except that one sample from the outflow of an ion exchange facility was elevated in uranium.

Church Rock cattle had statistically higher levels than controls of U-238 (liver and femur), U-234 (muscle, liver, and femur), and Ra-226 (femur). Soil samples from CR were higher than controls for all radionuclides tested, but the differences did not attain statistical significance. Water from CR contained concentrations of U-238 and U-234 that were statistically higher than controls.

The mean concentrations of radionuclides in muscle, liver, and kidney from each of the four groups were used to calculate 50 year radiation dose commitments and cancer risks incurred from regularly eating tissues for one year according to the following scenarios:

scenario 1 — 74 kg muscle, 2.7 kg liver and 1.3 kg kidney (consumption of 78 kg of meat per year, the U.S. per capita annual average meat consumption, and muscle, liver, and kidney in proportion to the organ's percentage weight in edible beef).

scenario 2. — 78 kg of muscle and no liver or kidney

scenario 3. — 62.3 kg muscle, 13.1 kg liver, and 2.6 kg kidney (a "worst case" scenario calculated using a recent dietary survey of New Mexicans (24)).

Calculations revealed that for scenario 1, radiation doses from eating cattle tissues were similar for the CR and CP groups. Consumption of ALG2 cattle resulted in radiation doses approximately twice those incurred from eating control cattle tissues. The dose to kidney from eating ALG1 cattle was higher than the CP control by about 100 millirem. The increased lifetime risk of dying from a radiation-induced cancer from consuming ALG1 cattle for one year was one chance in 280,000.

Worst case estimates as described in scenario 3 predicted much higher doses, especially from eating ALG1 cattle. Worst case cancer risk estimates were one chance in 630,000 for control beef, one chance in 120,000 for ALG1, one chance in 400,000 for ALG2 and one chance in 670,000 for Church Rock.

Although the study has the limitations of small sample sizes and potential inaccuracies inherent to laboratory measurements of tissue radionuclide levels, it is apparent that there were elevated radionuclide concentrations in cattle tissue from all of the exposed groups. Results of environmental sampling support the conclusion that the levels of radionuclides increased as the level of exposure to the products of the uranium mining and milling industry increased.

The magnitude of the public health risk from eating this tissue is directly proportional to the amount of tissue consumed and the duration of the exposure. Eating liver and kidney incurs higher internal radiation doses than eating muscle tissue. Since few individuals would continually consume cattle raised in these areas, the risk to the general public is minimal unless an individual buys and slaughters a cow from ALG1, freezes it, and consumes large quantities of this meat.

Ranchers who raise and regularly consume these cattle (especially ALG1 cattle) may be receiving radiation doses that are excessive. The International Commission on Radiological Protection has recommended that the acceptable limit for excess deaths in a population is below one death per 100,000 exposed individuals (22). The cancer risk for a hypothetical rancher who eats ALG1 cattle for 20 years is one death per 14,000 exposed persons using scenario 1 assumptions. Thus, under these circumstances persons eating ALG1 cattle would receive an excess amount of radiation. For comparison, it was estimated by the Environmental Protection Agency that an individual who lived continuously next to some uranium mill tailings piles may have an excess lifetime cancer risk as high as 4 chances in a hundred (28). A person not exposed to uranium mining or milling activities in any way except by eating ALG1 beef for life (60 years) is subject to an additional lifetime cancer risk of about 1 in 4500, assuming scenario 1 conditions.

In conclusion, cattle from Ambrosia Lake and Church Rock had higher tissue radionuclide concentrations than controls. Evidence indicates that this resulted from exposure to radionuclides released by the uranium mining and milling industry. The public health risk from eating exposed cattle is minimal unless large amounts of this tissue, especially liver and kidney, are ingested. Radionuclide levels in ALG1 cattle were particularly high, which raises concerns about the future use of this pasture for grazing cattle.

ENVIRONMENTAL IMPROVEMENT DIVISION

RECOMMENDATIONS RESULTING FROM THE REPORT

"RADIONUCLIDE LEVELS IN CATTLE RAISED NEAR URANIUM MINES AND MILLS IN NORTHWEST NEW MEXICO"*

1) The Radiation Protection Bureau will take two actions to notify interested parties. First, the cattle owners will be notified and briefed by Radiation Protection Bureau personnel as to the scientific findings of the study and the practical ramifications prior to discussion with any other interested individuals or parties. Second, the Environmental Improvement Division will invite representatives from both Federal and State agencies, interested legislators, and the press, to a meeting to discuss the findings of the study.

   From a practical standpoint it is important that the owners fully understand the increased risk, which is regarded as being minimal, unless large amounts of the cattle tissue, especially liver and kidney are ingested. Individuals consuming ALG1 cattle have the potential for the highest exposure.

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*These recommendations, made by the EID, are based on findings in the cited report and are intended to be guidelines for the protection of public health. These recommendations do not necessarily represent the position of the specific authors cited, whose role was to collect, report, and analyze scientific data.

2) The Radiation Protection Bureau will inventory other areas in the state impacted by uranium decay chain radionuclides released into the environment, utilizing existing information from state and federal agencies. The Bureau will notify livestock owners and ranchers in these areas of the potential for human food chain contamination. If requested, technical expertise will be provided by EID to assist these individuals in pursuing their own testing to ascertain if increased site-specific risks exist.

3) To minimize the risks incurred from eating the ALG1 cattle the EID advises that the owner be encouraged to permanently discontinue use as pasture of all ALG1 acreage affected by mine dewatering effluent or, should the owner choose to continue utilizing said pasture, then the following steps should be observed:

   a) The liver and kidneys should **not** be consumed at any time; and

   b) The cattle should **not** be used as the sole source of meat for any length of time.

   The owner is advised to follow these recommendations based on the results of past use of the ALG1 pasture for grazing. Since it is not known what effects future use for grazing might have, the same recommendations should apply. The effects resulting from consumption of domestic vegetables irrigated with uranium mine dewatering effluent are unknown. This report however, documents the transfer of radionuclides through the food chain so that caution should be exercised.

4) The cattle owners from ALG2 and Church Rock will be alerted to these findings and it is advised that they follow the recommendations outlined in #3.

Although the study found that risks to individuals consuming meat from cattle raised in ALG2 and Church Rock areas were less than from ALG1, it is important that people understand how they can take steps to avoid increasing their risk, however small it might be.

5) To minimize the potential risk to consumers, ranchers grazing cattle in any of the areas to be identified in the inventory (See #2) who choose to sell their meat for public consumption, should coordinate with the New Mexico Livestock Board to ensure that cattle that have been grazed on contaminated pastures have the kidney and liver removed.

By ensuring that the above mentioned steps are carried out, the New Mexico Livestock Board will effectively be in a position to reduce the potential for exposure to the public.

6) It is recommended that the NRC enforce their regulation that requires control of wind-blown tailings from uranium milling facilities. If it is demonstrated that present control technology is ineffective, an effective control should be required to prevent tailings from leaving the restricted area. If existing contamination is unacceptable outside the restricted area (i.e., soil concentrations of Ra-226 are greater than 5pCi/g), then a zone of restricted use to prohibit livestock grazing should be established.

Clean up of contaminated soils, as required under NRC regulations for long-term stabilization and reclamation, should be accomplished and meet the 5pCi/g standard for Ra-226 and NRC should monitor vicinity properties to ensure this.

The study showed an increased risk resulting from ingestion of cattle exposed to dewatering effluent. Exposure to soils and vegetation contaminated by windblown tailings and mine spoils are also an important contributor to the overall radionuclide levels observed in cattle tissues.

7) A more restrictive level for uranium in mine discharges should be developed and adopted. Because the present NRC limits on uranium are based on chemical toxicity, because recent data indicates that the radiological toxicity of uranium may pose a greater risk to human health, and because the authority is divided between separate federal agencies, a determination should be made as to which legal mechanism(s) is most appropriate in establishing a lower numerical limit for uranium.

Levels lower than existing standards are currently being achieved. This recommendation is being made because the resulting dose to human target organs would be unacceptable if uranium were discharged at existing maximum permissible concentrations, as currently allowed by Federal and State Radiation Protection regulations. The Governor's Working Group made a similar recommendation in their 1985 report due to concern that the limits for uranium were too high to adequately protect public health.

8) A lower numerical effluent limitation for Pb-210 and Po-210 should be adopted. Because radiation, water quality, and air quality protection statutes and regulations could potentially be applied to control this problem, a determination should be made as to which legal mechanism(s) is most appropriate in establishing these lower limits.

Lower standards of Pb-210 and Po-210 are needed since the study shows that existing standards allow an unacceptable dose to an individual consuming ALGI beef. Substantial existing data indicate that levels lower than existing standards are presently being achieved.

9) The US EPA should revise its Environmental Radiation Protection Standards for Uranium Recovery Facilities (40 CFR 190) to include Pb-210 and Po-210 in annual dose commitment calculations and retain the exemption for the short-lived radon daughters (Po-218, Pb-214, Bi-214, and Po-214). This regulation limits the annual dose commitment to an individual member of the public to 25 mrem.

Lead-210 and Po-210 are presently exempt from Federal Regulations and Part 3 of the New Mexico Radiation Protection Regulations. Findings of this study identify Pb-210 and Po-210 as being the major dose contributors to man. If the Pb-210 and Po-210 levels documented in this study are included in annual dose commitment calculations, the regulatory limit of 25 mrem is exceeded.

10) Additional research needs to be conducted into the degree and long-term potential effects of radionuclide contamination of grazing lands resulting from the application of uranium mine liquid and atmospheric releases.

The report documents radionuclide contamination of the ALG1 pasture. Too little scientific data are available to evaluate the long-term environmental effects of radionuclides left unmanaged in such an area. More research needs to be conducted to determine the degree of the problem and the possible need, ultimately, for controls on land use or clean-up of the soils.

HEALTH
& ENVIRONMENT

department

Radionuclide Levels In Sheep and Cattle Grazing
Near Uranium Mining and Milling At Church Rock, NM.

Dr. JERE B. MILLARD

Dr. SANDRA C. LAPHAM

PAUL HAHN

OCTOBER 1986

NEW MEXICO ENVIRONMENTAL IMPROVEMENT DIVISION

P. O. Box 968

Santa Fe, New Mexico 87504-0968

EXECUTIVE SUMMARY

On July 16, 1979 an earthern dam holding a uranium mill tailings pond near Church Rock, New Mexico was breached, releasing 94 million gallons of acidified liquids and 1100 tons of solids. Concerns about adverse helath effects to nearby human populations consuming local grazing animals, prompted an investigation by the New Mexico Environmental Improvement Division, Navaho Area Indian Health Service and the Environmental Protection Agency Office of Radiation Programs in Las Vegas, Nevada (EPA-LV).

Muscle, liver and kidney samples were collected from 10 sheep and seven cattle grazing in the Church Rock area. In addition, tissues were collected from 10 sheep and 10 cattle grazing in a control location near Crownpoint, New Mexico. Environmental samples of water, soil and vegetation were also collected from the control and Church Rock grazing areas. Sheep and cattle tissues were sent for radiochemical analyses of U-238, U-234, Th-230, Pb-210, and Po-210 at EPA Las Vegas and Eberline respectively.

Radionuclide concentrations in sheep and cattle were found to be statisticall higher than control animal concentrations for U-234 and U-238 in most tissues sampled. This finding corresponded to higher observed levels of U-234 and U-238 in water samples from the Church Rock area as compared to control samples. Other radionuclides sampled from Church Rock tissues showed concentratoins similar to control tissue concentrations.

Fifty-year radiation dose commitments were calculated for a hypothetical individual consuming exposed and control animal tissues. Despite elevated U-234 and U-238 tissue levels, the resulting dose commitments for Church Rock tissue consumption were very similar to those calculated for consumption of control tissues. Excess cancer risks attributable to eating exposed animal tissues from the Church Rock area were found to be negligible and below the limit of one excess cancer death per 100,000 individuals established by the International Commission on Radiological Protection.

February 16, 1999

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD PANEL

Before Administrative Judge Peter B. Bloch

In the Matter of	)	
	)	
HYDRO RESOURCES, INC. 2929 Coors Road Suite 101 Albuquerque, NM 87120	)	Docket No. 40-8968-ML ASLBP No. 95-706-01-ML

WRITTEN TESTIMONY OF DOUGLAS M. BRUGGE, Ph.D., M.S.

On behalf of Eastern Navajo Diné Against Uranium Mining ("ENDAUM") and Southwest Research and Information Center ("SRIC"), Dr. Douglas M. Brugge submits the following testimony regarding the amended application of Hydro Resources Inc .("HRI") for a source materials license to conduct in situ leach ("ISL") uranium mining at three proposed sites in McKinley County, New Mexico.

Q.1. Please state your name and qualifications.

A.1. My name is Douglas M. Brugge. I am an assistant professor in the Department of Family Medicine and Community Health at Tufts University School of Medicine in Boston, Massachusetts. I have a Ph.D. in biology from Harvard University in

Cambridge, Massachusetts, and a Masters of Science in industrial hygiene from the Harvard School of Public Health in Boston, Massachusetts.

Q2. Do you have other relevant professional affiliations?

A.2. Yes I do. I am the director of the Navajo Uranium Miner Oral History and Photography Project. I am on the technical expert panel for the Uranium Education Center at Diné College in Shiprock, New Mexico. I am on the board of directors of the Childhood Cancer Research Institute in Worcester, Massachusetts. I also have been a consultant to Nuclear Risk Management for Native Communities, a program of the Center for Environment, Technology and Development of Clark University in Worcester, Massachusetts. I am a member of the American Public Health Association and the Massachusetts Public Health Association. A copy of my curriculum vitae, with a list of my publications, is appended to this testimony as **Exhibit A**.

Q.3. Please describe your professional experience and training in the areas of uranium mining impacts, environmental health and toxicology, and environmental impact assessment.

A.3. I have extensive professional experience in studying and reporting on the impacts of uranium mining. In this context, I have reviewed the historical literature on the development of scientific understanding of the radiological hazards associated with underground uranium mining. I have reviewed and studied the literature pertinent to the current state of scientific knowledge about the toxicology and epidemiology of occupational and environmental exposures among uranium miners and millers and the toxicology and epidemiology of the individual heavy metal and radiological elements commonly found in uranium ore. I have advised attorneys for the Navajo Tribe in their effort to amend the Radiation Exposure Compensation Act ("RECA") of 1990 to expand the universe of uranium workers potentially eligible for compensation payments and to ease current eligibility standards for former uranium miners and the survivors of deceased miners. I am the author of monographs on exposure pathways and health effects of uranium, radium and tritium, all of which were prepared for Nuclear Risk Management for Native Communities. I am currently completing a toxicological and epidemiological review document for thorium. I have reviewed EPA Region IX's draft site assessment for the King Tutt uranium mining area near Shiprock, New Mexico. Using interview transcripts derived from work carried out by myself and several colleagues associated with the Navajo Uranium Miner Oral History and Photography Project, I am completing an assessment of putative lifestyle activities that could have put Navajo uranium miners and their families at risk for exposure to uranium ore toxins. This work is expected to result in the publication of several academic papers that explore different aspects of the history of uranium mining in Navajo communities in the Four Corners Area, including a study that will shed light on exposure pathways for Navajos living near uranium mines and mills. In carrying out much of this work, I have had occasions to visit abandoned uranium mining sites in Navajo communities in the Four Corners Area. I have also reviewed in depth and critiqued the U.S. Nuclear Regulatory Commission's ("NRC's") and U.S. Environmental Protection Agency's ("EPA's") decommissioning documents for the Sequoyah Fuels Corporation uranium fuel-fabrication plant in Gore, Oklahoma.

Q.4. What is the purpose of your testimony?

A.4. The purposes of my testimony are to render my professional opinions that (1) NRC's assessment of cumulative impacts of the HRI project is deficient because of the agency's failure to describe and assess the full toxicity of the heavy metal and radiological contaminants found in uranium ore, including in HRI's ores, and that are likely to be in wastes present at abandoned uranium mine sites in the Church Rock area, and that (2) NRC's proposed 0.44 milligram per liter ("mg/L") uranium standard for groundwater restoration is inadequate to protect human health. In particular I will present information that indicates the potential for these toxins to affect health at low levels of exposure.

Q.5. What materials did you review in preparing this testimony.

A.5. I reviewed relevant portions of the NRC's Final Environmental Impact Statement ("FEIS"),[1] selections from HRI's 1988 Church Rock Environmental Report,[2] and the testimony of NRC's Christepher A. McKenney in regard to the NRC Staff's basis for the

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[1] Final Environmental Impact Statement to Construct and Operate the Crownpoint Uranium Solution Mining Project, McKinley County, New Mexico. NUREG-1508. U.S. Nuclear Regulatory Commission (Washington, D.C.) (February 1997).

[2] Hydro Resources, Inc. Church Rock Environmental Report (April 1988) (ACN 8805200344), transmitted by letter from M. Pelizza, HRI, to D. Smith, NRC (April 13, 1988) (ACN 8805200332).

0.44 mg/L uranium restoration standard.[3] I also reviewed the written testimony of Dr. Richard Abitz ("Abitz's Testimony") with respect to groundwater chemistry concerns, given in support of ENDAUM's and SRIC's written presentation of groundwater issues, and that portion of Dr. Christine J. Benally's testimony ("Benally Testimony") concerning the known environmental impacts of existing, abandoned uranium mines in the Church Rock area, given in support of ENDAUM's and SRIC's written presentations on environmental justice and cumulative impacts. I also reviewed technical reports on radionuclide accumulation in the edible tissues and organs of livestock which grazed in the Church Rock area in the 1980s, portions of which are attached to Dr. Benally's testimony as Exhibits U and V. As a general matter, I have studied and summarized in previous works findings from several of the federal government's toxicological profiles for specific contaminants found in uranium ore and wastes and certain of the National Research Council's reports on the biological effects of ionizing radiation. Finally, I reviewed recent public health literature on research methods and investigation techniques designed to address environmental impacts in "environmental justice populations," which the Navajo communities of Church Rock and Crownpoint certainly are. A list of literature I have reviewed to give this testimony is appended as **Exhibit B**.

Q.6. Please describe your understanding of the range of radiological and chemical contaminants in uranium ore and the underlying technical data that is the basis for your understanding.

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[3] Affidavit of Christepher`A. McKenney, Staff Exhibit 10 to NRC Staff's Response to Motion for Stay, Request for Hearing, and Request for Temporary Stay (February 20, 1998).

A.6. Uranium ore, and by extension, the solid wastes resulting from uranium mining, contain a wide range of naturally occurring radioactive materials associated with the uranium-238 decay series and an equally wide range of trace elements that are also indigenous to the host rocks. I base my understanding in this regard on my review of actual environmental monitoring data for an abandoned uranium mining area on the Navajo Nation in northwestern New Mexico, and on published technical literature. Allow me to explain.

Over the past several years, the U.S. Environmental Protection Agency ("EPA") in conjunction with various agencies of the Navajo Nation has carried out an extensive environmental monitoring and assessment program at the King Tutt uranium mining area near Shiprock, New Mexico. The results of that program were described in a June 1997 draft report,[4] which I have reviewed in detail and will refer to as "King Tutt Draft Assessment." To my knowledge, the EPA's King Tutt Mesa project is one of the few comprehensive environmental assessments of an abandoned uranium mining area anywhere in Navajo country. The area is located in the extreme northwestern corner of New Mexico along the Arizona state line in Township 29 North, Range 21 West. At least 17 different mines in the area produced uranium ore from the early 1940s through mid 1960s. King Tutt Draft Assessment, Table 2-1; included in **Exhibit C** attached hereto.

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4 See, Draft Integrated Assessment, Navajo Uranium Mines — King Tutt Mesa Study Area,, Red Valley Chapter, Navajo Nation, Oak Spring, New Mexico. U.S. Environmental Protection Agency Region IX Superfund Division (San Francisco, Calif.), Site EPA ID Number NND 986667434 (June 1997).

The assessment program involved the collection and analyses of hundreds of soil, sediment, surface water, and ground water samples from throughout the area. Id., Tables 6-1 through 6-12. Indoor radon gas and gamma radiation measurements were taken in and around homes in the mining area (id., Table 6-13), and gamma radiation surveys were conducted at most of the individual mine sites (id., Tables 7-1 and 7-2; included in **Exhibit C** attached hereto).

Since the analytical data from the sampling and monitoring program cover hundreds of pages of the draft assessment document, I summarized the maximum levels of various contaminants found in soils, sediments, surface water, groundwater and in homes in Table One, which is included in **Exhibit D** attached hereto. Maximum levels detected in the King Tutt Mesa area are given for radon, radium, uranium, thorium, gamma radiation, arsenic, beryllium, manganese and vanadium, and are compared with applicable federal environmental, drinking water, occupational and public-health standards. The radioactive elements in the list (radon, radium, uranium, thorium, and low LET ionizing radiation) are all expected from the uranium decay series, which is depicted in **Exhibit E** attached to my testimony.

Maximum levels of most of the contaminants listed in Table One exceeded their respective environmental standards or other thresholds in soils and sediments at the King Tutt sites. Additionally, maximum gamma radiation level shown in Table One exceeded the maximum background gamma level detected in aerial reconnaissance by more than 10 times. Table 7-1 of the draft assessment report, which I have included in **Exhibit C,** shows background gamma readings ranging from 12 to 33 microRoengtens per hour ("μR/hr") and gamma readings at locations within the mining sites ranging from 60 to 380 μR/hr.

Based on my review of these data, my professional opinion is that residual environmental contamination at mine sites in the King Tutt Mesa area is extensive and may pose a public health risk to surrounding residents.

Q.7. Are the radiological and chemical characteristics of the King Tutt locations comparable to those one can expect at the HRI sites?

A.7. I believe that they would be. I base that conclusion on my review of HRI's "Report of Analysis" of ore from monitor well CR-3 at the Church Rock ISL site, which appeared as Figure 6.6-2 in HRI's April 1988 Church Rock Environmental Report. I have attached to my testimony a copy of that data as **Exhibit F**. The concentrations of uranium, radium, vanadium, manganese, and arsenic in the HRI core sample all approach or exceed the maximum concentrations of those contaminants detected in environmental samples at the King Tutt sites. For example, the radium concentration of 610 picoCuries per gram ("pCi/g") in the Church Rock core sample exceeds the maximum radium-in-soil concentration detected at the King Tutt sites of 455 pCi/g. See Table One, included in **Exhibit D** attached hereto.

Q.8. Would it be reasonable to expect to observe the same mix of radiological and chemical contaminants in environmental media at abandoned uranium mining sites in the Church Rock area, if a similar level of environmental

assessment were conducted?

A.8. Yes it would be. From my inspection of documents attached to Dr. Benally's testimony, including her preliminary inventory of uranium mines, processing sites and exploration sites, I observe a range of gamma radiation readings at the Church Rock-area mines that are similar to those measured in the King Tutt area. I would also expect that to find a similar range of trace metals at those sites. I agree with Dr. Benally, therefore, that additional environmental assessment of the Church Rock-area mine sites is needed to determine the extent of radiological and trace element contamination of soils, sediments, surface water and groundwater at those sites. I also agree with her conclusion that both outdoor and indoor monitoring of ambient radon is needed to ascertain exposures and resulting doses to residents who live in the northern portion of Church Rock Chapter.

Q.9. Have you reviewed toxicological information on these contaminants to know what their carcinogenic affects may be?

A.9. Yes I have, and I have summarized that information in Table Two, which is included in **Exhibit D** attached hereto. Table Two shows the cancers known or suspected to be associated with each of the contaminants listed in Table One. The basis for the information in Table Two, including the values for "Cancer Effect Levels" ("CELs"), is my knowledge and study of the toxicological literature over the past the past five years. CELs have been established as a result of studies of animals and humans exposed to the toxins in laboratory studies and epidemiological studies.

For those contaminants for which a CEL has been calculated, it is included in parentheses in the table under the column "Known or probable cancers" and is expressed in a concentration of the contaminant per unit of tissue mass. The CEL is the minimum exposure found to cause cancer.

Based in this summary of the minimum cancer effect levels for each of the listed contaminants in Table Two, I conclude that the cancers most likely to be associated with exposure to uranium ore contaminants are lung cancer, bone cancer, leukemia, cancer of the mastoid air cells and nasal sinuses, and skin cancer. Stomach cancer and breast cancer could be added to the list if exposures to low LET[5] radiation are substantial.

Q.10. Have you reviewed toxicological information on these contaminants to know what their non-cancer affects may be?

A.10. Yes I have, and I have summarized those non-cancer effects in Table Three, which is included in **Exhibit D** attached hereto. Table Three shows the non-cancer health outcomes known to be associated with each of the contaminants present in elevated amounts in the King Tutt Mesa sites. For each of those health outcomes, a Lowest Observed Adverse Effect Level ("LOAEL") or a No Observed Adverse Effect Level ("NOAEL") is listed. The LOAEL is the lowest dose of the element at which the health effect of interest was observed. The NOAEL is the highest dose at which the health effect was not observed.

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5 "LET" stands for "linear energy transfer." Low LET radiation includes gamma radiation and most beta radiation, both of which have tissue penetrating powers and therefore develop low amounts of electrical energy to surrounding the tissues they pass through. By comparison, high LET radiation delivers high amounts of electrical energy to surrounding tissue because the radioactive particles (i.e., alpha particles) are large in atomic.

LOAELs and NOAELs are generally, but not always, reported in units of milligrams of toxin taken in by the animal or human per kilogram body weight per day ("mg/kg/d"). In cases of inhalation exposure the units are usually milligrams toxin per cubic meter in the air which is breathed ("mg/m^3").

As with the CELs, these LOAELs and NOAELs are based on laboratory and epidemiological studies in animals and humans. The summaries of health effects in Tables Two and Three are based on my review of the 38 scientific sources listed in the references included in **Exhibit B** attached to my testimony. These sources are primarily review articles and may very well miss some less well-documented health outcomes associated with heavy metal or radiation sources present in uranium ore. In addition, my review found virtually no scientific study of interactions between the various contaminants. I believe it is reasonable to suspect that in cases where two or more contaminants affect the same organ system alone, that they might have greater effects in combination. For the purposes of this testimony, however, I will assume no interaction between toxins, which is a conservative assumption of health risk associated with exposure.

Based on the LOAEL and NOAEL reported in Table Three, the non-cancer health effects of greatest likelihood for someone exposed to uranium ore would be damage to the kidneys, reproductive system (which would be manifested in birth defects), central nervous system, lungs, skin, liver, the cardiovascular system.

Q.11. Given your analysis of the radiological and chemical characteristics of uranium ores and uranium mine wastes, do you think that NRC's assessment of impacts of the CUP was adequate?

A.11. It was not. Clearly, NRC's analysis of cumulative effects of the HRI project did not address the impacts of trace metals in HRI's uranium ore or the trace elements that are likely to be in wastes at the 13 mining sites within the Church Rock area in the vicinity of the HRI site. I conclude, therefore, that the FEIS was deficient in its assessment of cumulative effects with respect to the impacts of existing and future mining activities in the Church Rock area.

Q.12. Based on your review of the relevant literature and on the information you have presented in Tables Two and Three, do you have an opinion with respect to the toxicity of uranium and the adequacy of the NRC's proposed uranium restoration standard for the CUP?

A.12. Yes I do. As can be seen in Table Two, uranium is a possible carcinogen for a variety of cancers. However, uranium's documented health effects are associated more with its chemical toxicity than its radioactivity, as shown in Table Three. This is especially the case for uranium's well-documented adverse effects on the kidneys. The uranium LOAEL for kidney damage in experimental animals is 1.1 mg/kg/d. EPA based its 1991 proposed drinking water standard for uranium of 0.02 mg/L on a Reference Dose ("RfD") of 0.003 mg-U/kg/d, which corresponds to a LOAEL of 2.8 mg/kg/d — a concentration that is more than twice the lowest level of effect observed in the animal studies. This means that the EPA standard does not make the most protection assumptions possible.

Nonetheless, EPA's proposed drinking water standard of 0.02 mg/L was based on observed health effects of uranium as a chemical toxicant.[6] It was not based on uranium's radiological properties because uranium has a very low specific activity. This standard is in contrast to NRC's proposed uranium restoration standard of 0.44 mg/L, which, according to the testimony of Mr. McKenney, is based on NRC's 10 CFR Part 20 Appendix B maximum concentration limits for radionuclides. Mr. McKenney represented that the 0.44 mg/L standard is health-based because it is derived from the NRC's calculation of concentrations that equate to a maximum radiation dose of 100 millirems per year. His analysis is misleading, however, because NRC's maximum levels for radioactive materials ignore the chemical toxicities of those materials. Since uranium is primarily a chemical toxin, a standard as important as the groundwater restoration standard for the CUP should be based on uranium's chemical toxicity, or at least a combination of both.

In my opinion, therefore, the toxicology and epidemiology of uranium is consistent with the EPA standard and inconsistent with proposed NRC restoration standard. For that reason, I conclude that NRC's proposed 0.44 mg/L standard is not protective of public health and should be at least one order of magnitude or lower to

[6] I note here that the EPA finds that the 0.02 mg/L standard also restricts cancer risk due to radioactivity to around one chance in ten thousand.

reflect a health-based approach.[7]

Q.13. Does that conclude your testimony?

A.13. Yes.

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[7] I should note that even at a concentration of 0.044 mg/L, which as Dr. Abitz notes is consistent with the EPA standard for groundwater cleanup at abandoned uranium mill tailings sites, or of 0.02 mg/L, which is the proposed EPA drinking water standard, uranium levels in restored groundwater would still be 10 to 20 times what they are in the Crownpoint water system, as shown in Table 3.12 of the FEIS. (There, the uranium concentrations in four samples range from 0.001 mg/L to 0.007 mg/L, for an average of 0.0025 mg/L.)

AFFIRMATION

I declare on this 16 day of February, 1999, at Boston, Massachusetts, under of perjury that the foregoing is true and correct to the best of my knowledge, and the opinions expressed herein are based on my best professional judgment.

Douglas M. Brugge

Douglas M. Brugge

Sworn and subscribed before me, the undersigned, a Notary Public in and for the State of Massachusetts, on this 16 day of January, 1999, at Boston, Massachusetts.

My Commission expires on 6/18/05.

Joseph M. Callery

Notary Public

Curriculum Vitae

Douglas M. Brugge, PhD, MS

Current Title: Assistant Professor

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Education

1988 S.M. in Industrial Hygiene, Harvard School of Public Health, Department of Environmental Science and Physiology.

1987 Ph.D. in Biology, November, Harvard University, Department of Cellular and Developmental Biology.

1982 B.A. cum laude, June, Washington University, double major in Biology and Chemistry.

Employment and Academic Appointments

1998-present	Assistant Professor, Department of Family Medicine and Community Health, Tufts University School of Medicine.
1994 - 1998	Lecturer, Department of Family Medicine and Community Health, Tufts University School of Medicine.
1988 - 1994	Labor Educator/Industrial Hygienist, Massachusetts Coalition for Occupational Safety and Health.
1987	Lecturer, Roxbury Community College
1983 & 1985	Teaching Fellow, Harvard University

Current Memberships

American & Massachusetts Public Health Associations
International Society for Exposure Assessment
Massachusetts Environmental Justice Network
Coalition to Protect Chinatown (Steering Committee)
Uranium Education Center (Advisory Board)
Childhood Cancer Research Institute (Board of Directors)

Awards and honors

Certificate of merit, Alternatives for Community and Environment, 1997
Certificate of Appreciation, Boston Hispanic Sub-Parents Advisory Council, 1996
Graduate fellowship, Harvard School of Public Health, 1987-88
National Science Foundation graduate fellowship, 1982-87
Alternate, International Science Fair, 1978
Honorable mention, Westinghouse Science Talent Search, 1978

Publications

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Curricula

Brugge, D., Editor, C. Slatin, and K. Durand, Assistant Editors. 1994. Hazardous Waste Site Workers' Basic Health and Safety Course, Second Edition, The New England Consortium, University of Massachusetts, Lowell, MA.

Brugge, D. 1991. Health and Safety Manual for Lead Abatement Workers, Chapters 1, 2, 3, and 4. United Brotherhood of Carpenters, Washington, DC.

Brugge, D. 1990. Health and Safety Manual for Vocational Education Instructors. Massachusetts Department of Education, Quincy, MA.

Chapters in Books

Brugge, D., T. Benally, P. Harrison, M. Austin-Garrison, L. Fasthorse-Begay, C. Stilwell, M. K. Bomboy-Marshall, M. Elsner and H. Johnson. The Navajo uranium miner oral history and photography project (in press, Navajo Nation Historic Preservation Department).

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Brugge, D. 1995. Pulling Up the Ladder: The Anti-Immigrant Backlash. In: Eyes Right! Challenging the Right Wing Backlash. Berlet, C., ed. South End Press, Boston, MA: 191-209.

Brugge, D. 1989. Ecological Interactions. In: McGraw-Hill Yearbook of Science and Technology: 109-110.

Recent Conference Abstracts

Brugge, D., A. Leong and FM Cheung. November, 1998. A community-based study of the impact of traffic and development on health and safety in Boston Chinatown. American Public Health Association Conference (accepted).

Hynes, P., D. Brugge, D. Mahoney, J. Watts, J. Lolly and R. Lopez. November, 1998. Public health in public housing: An evaluation and analysis of the indoor environment with community participation. American Public Health Association Conference.

Brugge, D., T. Benally, P. Harrison, E. Yazzie, M. Austin-Garrison and L. Fasthorse-Begay. August, 1998. Use of oral histories to examine historical and contemporary exposures of Navajos to byproducts of uranium mining. International Society of Environmental Epidemiology/International Society of Exposure Assessment Joint Conference, Boston, MA.

Brugge, D., A. Leong and FM Cheung. August, 1998. Traffic and development in Boston Chinatown: An analysis of police accident report data and a cross sectional survey of residents. International Society of Environmental Epidemiology/International Society of Exposure Assessment Joint Conference, Boston, MA.

Hynes, P., D. Brugge, D. Mahoney, J. Watts, J. Lolly and R. Lopez. August, 1998. Public health in public housing: An evaluation and analysis of the indoor environment with community participation. International Society of Environmental Epidemiology/International Society of Exposure Assessment Joint Conference, Boston, MA.

Brugge, D. and J. Hyde. November, 1997. Lessons in exploring approaches to partnerships between communities and environmental health researchers. American Public Health Association Conference, Indianapolis, IN.

Brugge, D., T. Benally, P. Harrison, M. Austin-Garrison and L. Fasthorse-Begay. November, 1997. Oral histories provide insights into historical and contemporary exposures of Navajo Indians to byproducts of uranium mining. American Public Health Association Conference, Indianapolis, IN.

Selected Popular Articles and Interviews

Profile and article by B. Morgan. Winter, 1998. Adrift in the Rain and the Wind. *Tufts Medicine*. 58 (1): inside cover and 28-35.

Brugge, D. March 13, 1998. Smoking and compromize. *Boston Phoenix*: 5.

Interview by Cider, M. February, 1998. Local author [Brugge] describes the horrors of radiation. *Somerville Community News*: 5.

Brugge, D. Fall, 1997. Reform the Radiation Exposure Act. *Navajo Uranium Worker Oral History and Photography Newsletter*. 6.

Brugge, D. January 28, 1995. Apology is Due. *Gallup Independent*: 4.

Brugge, D. and the Chinese Progressive Association Workers' Center. August 19, 1994. Protecting your right to a safe and healthy job. *Sampan*: 8.

Brugge, D. September 6, 1992. In lead-paint dispute, industry largely untouched. Letter to the editor. *The Boston Globe*: A26.

Brugge, D. April 15, 1991. Hazardous jobs no longer off-limits to women: Supreme Court ruling fixes part of the imbalance. *Unity:* 1-4.

Brugge, D. August 31, 1990. English only discriminates: Tolerance, respect provide unity. *MTA Today*: 4.

Major Projects and Research Areas

Conducted (with Jim Hyde) an evaluation of the policies and practices of Massachusetts HMOs with respect to prevention of asthma (1998-9)

Conducted (with Andrew Leong) the first cross sectional survey of environmental health concerns of Boston Chinatown residents for the Coalition to Protect Chinatown (1997-9).

Directed the Navajo Uranium Miner Oral History and Photography Project. Included collection of oral interviews, taking photographs, designing and self-publishing monograph ("Memories Come to Us in the Rain and the Wind: Oral Histories and Photographs of Navajo Uranium Miners and Their Families"), assembling exhibit, dissemination of monograph, national tour of the exhibit, publishing a project newsletter and presenting lectures (1997-9).

Directed a study of attitudes, knowledge and beliefs of recent Asian immigrants about environmental tobacco smoke that utilized focus group methodology (1997-9).

Conducted (with Pat Hynes) a cross sectional, community participatory survey of tenants of West Broadway public housing in South Boston for indoor environment and safety problems. The project is being extended to other public housing developments in Boston and has generated a follow-up program at the local community health center (1996-9).

Directed an educational project for parents about the indoor environment and schools that included presenting workshops and conferences, writing fact sheets, interpretation of technical documents and conducting visual inspections of school buildings (1996-8).

Directed a study of traffic impacts in Boston Chinatown using Boston Police Department traffic accident data and video tapes of intersections for the Coalition to protect Chinatown. Included writing the proposal, directing the research of graduate students, and integrating community recommendations. Data analysis included GIS mapping (1996-8).

Preparation of toxicological profiles, fact sheets and curricula and presentation of training sessions on radiological and chemical hazards at Laguna Pueblo in New Mexico and in communities adjacent to the Sequoyah Fuels uranium processing plant in Oklahoma for the Childhood Cancer Research Institute's project Nuclear Risk Management for Native Communities (1996-8).

Directed an educational project for school administrators and business agents about indoor environmental problems in school buildings (1995-6).

Community & University Service and Technical Consultation

Data analysis and interpretation of a survey of teachers for indoor environmental problems at Kennett High School in New Hampshire (1998).

Co-developed a policy on community collaborations for the Department of Family Medicine and Community Health, Tufts School of Medicine (1998).

Developed and implemented an initiative to expand the diversity of teaching and research faculty for the Department of Family Medicine and Community Health, Tufts School of Medicine (1997-8).

Community representative, Institutional Biosafety Committee, Millennium Pharmaceuticals Inc. (1996-8).

Technical advisor to the Uranium Education Center, Dine College, Shiprock, NM (1997-8).

Consulted for Xavier University and a consortium of 10 Native American Tribes on developing a video documentary on the environmental impacts of US Department of Energy programs of Indian Tribes (1997-8).

Served as technical counsel for parents of the Agassiz School in Jamaica Plain, Boston. Did walk throughs of the building, conducted health surveys, prepared reports, reviewed consultant reports, wrote scopes of work, attended the school's indoor air quality committee, and made public presentations. Pro bono assignment through the Massachusetts Environmental Justice Network (1995-8).

Provided technical assistance to parents and administration of the Peabody High School with respect to indoor air quality problems (1996 and 1998).

Member, twentieth anniversary banquet committee, Chinese Progressive Association (1997).

Data analysis (with Aviva Must) of an environmental health survey of Navajo Indians living near coal strip mines on Black Mesa in Arizona, for the Dineh Alliance, Window Rock, Arizona (1997).

Technical guidance for the Boston Chinatown Central Artery/Tunnel Task Force on impacts of traffic and construction related to the construction of the new central artery (1996-7).

Development of a proposal to do a comparative study of two products that test free chlorine concentrations in swimming pools for Environment Testing Systems, Inc. (1996-7).

Evaluation of a hazardous waste site basic health and safety worker training program for the United Brotherhood of Carpenters (1996).

Technical expert for production of an interactive worker training CD ROM video on personal protective equipment for Interactive Media Communications, Inc. (1995).

Inspection and report for general health and safety for the Teamsters Union at a metals shop in Woburn, Massachusetts. Included a plan for prioritizing hazards to be addressed by joint labor-management committee (1994).

Member, Massachusetts Attorney General's Committee on Residential Lead Paint Removal as a labor/workplace expert (1993-4).

Machine guarding inspection and report at a corrugate factory in South Boston following a serious machine related injury at the request of the Teamsters Union and management (1993).

Survey of teachers for symptoms of indoor air problems in six buildings of Dracut Public Schools with analysis of the results for the Dracut Teachers Association (1993).

Inspection and report for general health and safety in the Ames Envelope factory in Somerville, Massachusetts. Particular attention to issues of largely Latino immigrant work-force (1992).

Multiple inspections and reports for radiation, chemical and biological exposures in hospital trash room and pharmacy of Boston City Hospital at the request of the American Federation of State, County and Municipal Employees (1988-92).

Inspection, report and consultation on indoor air quality in a machine shop at Boston University at the request of the Union, UAW District 65 (1990-1).

Complete inspection and measurement of airborne exposure to metals and silica in the Komtek foundry in Worcester at the request of both management and the Steel Workers Union (1990).

Inspection for indoor air quality in two homeless shelters in Boston (1990 & 1993).

Teaching

Assistant course director, Patient, Doctor, Society, a class for first year medical students, Tufts School of Medicine Co-facilitated of a discussion sections in 1995-6, 1997-8 and 1998-9.

Developed and presented a lecture on occupational and environmental health. Developed a lecture on cultural issues and medicine (1997-9).

Coordinator, rotations for 3rd and 4th year medical students of rotations with the Indian Health Service (1997-9).

Co-directed a field placement for 3rd and 4th year MD/MPH students at the Boston Public Health Commission, Office of Environmental Health (1997-8).

Co-directed a field placement for 3rd and 4th year MD/MPH students for an asthma program at the Josiah Quincy Elementary School (1997-8).

Director of a course for third and fourth year medical students on "Occupational and Environmental Health: Issues in Preventive Medicine" at Tufts School of Medicine (1995 and 1997).

Co-director (with Elizabeth Barbeau) of a course for third and forth year medical students on "Socio-Political Forces in Occupational Health and Safety" at Tufts School of Medicine (1996).

Facilitator for problem based learning seminars for first year medical students, Tufts School of Medicine (1994 and 1996).

Developed and taught a course on basic industrial hygiene for Jobs for Youth, an inner-city job training program at the Franklin Institute in Boston (1995).

Developed and taught professional development course on participatory worker education methods at the American Industrial Hygiene Conference and Exposition (1994 & 1995).

Lead trainer for the hazardous waste site (OSHA 40 hours) and emergency responder (OSHA operations level) courses for the New England Consortium and the United Brotherhood of Carpenters (1988-94).

Trainer for a hazardous materials awareness course for George Meany Center for Labor Studies (railroad workers), Service Employees International Union (DPW Workers), New Hampshire Safety Council and for EMS Personnel (19910.

Industrial hygienist for an asbestos abatement health and safety course for the Sheet Metal Workers joint union-contractor training fund (1988-90).

Instructor, freshman biology course in cellular and biochemical biology, Roxbury Community College (1987).

Instructor, freshman biology course in organismal biology, Roxbury Community College (1987).

Teaching fellow, freshman biology, Harvard University (1983 and 1985).

Teaching fellow, cellular biology, Harvard University (1983 and 1985).

Selected Public Presentations

Presentations on results of a survey of environmental conditions and health in Boston Public Housing to the US EPA Region One Workgroup on IAQ, the BUSPH Department of Environmental Health and the HSPH Department of Environmental Health (1998).

Spoke on a panel on research ethics in the Navajo Nation at the Navajo Studies Conference (1998).

Presented lectures on the Navajo experience with uranium mining at the Colloquium on Qualitative Research in Health at Harvard Medical School, at Utah State University, Logan, UT (with Kathleen Tsosie-Blackie), at Dine' College in Tsaile, AZ (eight lectures), and to a forum held by the Fletcher School at Tufts University (1998).

Presentations about indoor air quality in schools to parents in Montpilleir and Derby Line Vermont (1998).

Testimony before the Marlboro Board of Health and the Barnstable Board of Health about ventilation and ETS in restaurants (1998).

Presented a workshop on the nature of radiation and chemical hazards to health for community groups in Amarrilo, TX (1998).

Departmental seminar at Tufts School of Medicine on the impact of traffic on safety in Boston Chinatown, presented jointly with Andrew Leong (1998).

Presented the oral history method used in the Navajo uranium miner oral history and photography project to a consortium of Indian Tribes in Richmond, WA (1998).

Lead a community workshop on the process of decommissioning the uranium hexaflouride plant in Gore, OK (1998).

Guest lecture on indoor air quality for two classes on the urban environment (taught by Pat Hynes) at the Boston University School of Public Health (twice in 1997 and once in 1998).

Guest host for a course on occupational and environmental health (taught by Barry Levy) (1996, 1997 and 1998).

Guest lecture on Navajo uranium miners to a course in the History Department, Tufts College (1997).

Guest lectures on Navajo uranium miners, science course, University of Massachusetts at Boston (1996 and 1997).

Guest expert on indoor air quality for a broadcast of Neighborhood Network News, Boston Cable TV (1996).

Organized and hosted Indoor Air Quality in Schools: A Conference for Parents, Tufts School of Medicine and US EPA, Region One (1996).

Presentation (with Timothy Benally) on the Navajo uranium miner oral history project as an example of participatory, community based research to the "Meeting Community Needs Conference," Clark University (1996).

Slide show of photos of Navajo uranium miners, to the photography collective of Community Change (1996).

Invited testimony, Commission on Risk Assessment and Risk Management, Environmental Protection Agency, Region One (1996).

Presentation (with Andrew Leong) on the impact of traffic on air quality in Boston Chinatown to the "Making the Connection: Urban Air Toxics and Public Health" Conference of NESCAUM (1996).

Lectures (with Jim Hyde and Elizabeth Barbeau) on options for controlling environmental tobacco smoke for the Connecticut Department of Public Health and the Massachusetts Department of Mental Retardation (1996).

Lecture on Navajo Indians and uranium mining presented as a multimedia presentation, departmental seminar, Tufts School of Medicine (1996).

Workshops on indoor air quality in schools for the Massachusetts Association of School Superintendents, the New Hampshire Association of School Administrators and the Rhode Island Association of School Administrators (1996).

Workshop on indoor air quality in schools for a conference of the New England School Development Council (1995).

Lecture on aerosols for a course teaching industrial hygiene to non industrial hygienists, Harvard Educational Resource Center (1995).

Lecture on non ionizing radiation for a graduate class in physical agents (taught by Rafael Moore) at the Work Environment Department, University of Massachusetts at Lowell (1995).

Lecture on Navajo Indian uranium miners for public health survey course (taught by Mark Boyer), Tufts School of Medicine (1995).

Workshop on adult education methods for the New England Lead Coordinating Committee Conference (1994).

Speech on occupational exposure to lead paint at an Environmental Diversity Forum Conference (1993).

Testimony on the impact of building a garage on Parcel C in Boston Chinatown on pollution and noise, Massachusetts Environmental Protection Act hearing (1993).

Chemical safety training for mostly non-English speaking workers at HLA Laundry in Dorchester, Massachusetts following an occupational death (1993).

Testimony on the evidence for health effects of extremely low frequency EMF at a hearing of the Massachusetts State Legislature.

Presentation on occupational health for the Center for Law and Education, Vocational Education Project, national conference, Cambridge, MA (1992 and 1993).

Train-the-trainer workshops for joint labor-management safety committee at Pneumatic Scale factory in Quincy, MA. Committee was trained to provide training for the rest of the work-force (1992).

Panel member for workshop on the hazards of working with computers, New England Conference on Computers and Social Change (1991).

Workshops on cancer, vehicle maintenance, and air quality for City of Boston joint labor-management committees (1991).

Guest, WBZ AM 1030, Workers' Memorial Day program on occupational hazards (1991).

Guest expert on the program, Greenwatch, WLVI, Channel 56, for a program on EMF hazards (1990).

Basic occupational health and safety workshop for trainers of immigrant workers, Coalition for a Better Acre, Lowell, MA (1990).

Testimony in favor of a bill granting presumption of occupational causes of certain cancers for fire fighters at a hearing of the Massachusetts State Legislature (1990).

Chair, round table discussion on electromagnetic fields and cancer for Mass COSH and communication workers union (1990).

LITERATURE REVIEWED

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ATSDR: Toxicological Profile for Beryllium. Report to Agency for Toxic Substances and Disease Registry in collaboration with U. S. Environmental Protection Agency. Atlanta, Georgia: Syracuse Research Corp., 1993.

ATSDR: Toxicological Profile for Ionizing Radiation, Draft. Report to Agency for Toxic Substances and Disease Registry in collaboration with U. S. Environmental Protection Agency. Atlanta, Georgia: Research Triangle Institute, 1997.

ATSDR: Toxicological Profile for Manganese, Draft. Report to Agency for Toxic Substances and Disease Registry in collaboration with U. S. Environmental Protection Agency. Atlanta, Georgia: Research Triangle Institute, 1997.

ATSDR: Toxicological Profile for Radon. Report to Agency for Toxic Substances and Disease Registry in collaboration with U. S. Environmental Protection Agency. Atlanta, Georgia: Clement International Corp., 1990.

ATSDR: Toxicological Profile for Thorium. Report to Agency for Toxic Substances and Disease Registry in collaboration with U. S. Environmental Protection Agency. Atlanta, Georgia: Clement Associates, Inc., 1990.

ATSDR: Toxicological Profile for Uranium. Report to Agency for Toxic Substances and Disease Registry in collaboration with U. S. Environmental Protection Agency. Atlanta, Georgia: Clement Associates, Inc., 1990.

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Brugge, Douglas. Uranium: Exposure Pathways and Health Effects. Produced by The Nuclear Risk Management for Native Communities (NRMNC) Project and the Center for Technology , Environment, and Development, Clark University. Worcester, MA: NRMNC, 1997.

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1067.

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Edition). New York: McGraw-Hill, 1996.

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Meyer, K. C. *Beryllium and Lung Disease.* Chest, Vol. 106. 1994 September. pp. 942-946.

Nechay, B. R. *Mechanisms of Action of Vanadium.* Annual Review of Pharmacology & Toxicology, Vol. 24. 1984. pp. 501-524.

Newman, L. S. and J. Lloyd, E. Daniloff. *The Natural History of Beryllium Sensitization and Chronic Beryllium Disease.* Environmental Health Perspectives, Vol. 104 (Suppl. 5). 1996 October. pp. 937-943.

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Ribera, D. and F. Labrot, G. Tisnerat, J. F. Narbonne. *Uranium in the Environment: Occurrence, Transfer, and Biological Effects*. Reviews of Environmental Contamination & Toxicology, Vol. 146. 1996. pp. 53-89.

Sources and Effects of Ionizing Radiation: United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 1994 Report to the General Assembly. New York: United Nations Publication, 1994.

Stebbings, J. H. *Radium and Leukemia: Is Current Dogma Valid?* Health Physics, Vol. 74. 1998 April. pp. 486-488.

Taylor, D. M. and S. K. Taylor. *Environmental Uranium and Human Health*. Review on Environmental Health, Vol. 12. 1997 July-September. pp. 147-157.

Travis, L. B. and R. L. Kathren, J. D. Boice Jr. *Cancer Risk Following Exposure to Thorotrast: Overview in Relation to a Case Report*. Health Physics, Vol. 63. 1992 July. pp. 89-97.

Valberg, P. A., et al. *Issues in Setting Health-based Cleanup Levels for Arsenic in Soil.* Regulatory Toxicology &Pharmacologyg, Vol. 26. 1997 October. pp. 219-229.

Wong, S. T. and H. L. Chan, S. K. Teo. *The Spectrum of Cutaneous and Internal Malignancies in Chronic Arsenic Toxicity*. Singapore Medical Journal

U.S. Environmental Protection Agency Region IX
Superfund Division

Integrated Assessment

Draft for Comment
June 1997

Navajo Uranium Mines - King Tutt Mesa Study Area
Red Valley Chapter, Navajo Nation
Oak Spring, New Mexico 87420

Site EPA ID Number: NND 986667434

TABLE 2-1
LIST OF MINING CLAIMS IN THE STUDY AREA

CLAIM	*Tons Ore*	*Pounds U_3O_8*	*Pounds V_2O_5*	*Estimated Volume of Mining Debris*	*Years of Production/Operators*
Salt Canyon Mines	93	331	4,473	2,058 yd^3	1950 - Cato Sells 1953 - Shorty & Tutt 1954 - H. Begat 1955 - Kennedy & McGee
Tent Claim	1,198	5,303	54,156	712.2 yd^3	1955 - Texas Mining Co. 1956-57 - E. Tapahonso 1963 - H. Bryant
King Tutt #1	290	1,060	8,257	623.4 yd^3	1951, 53 - Shorty & Tutt 1956 - Sylvania Mining Co. 1958 - C. Pickens
Junction Claim	18	38	153	80.6 yd^3	1953 - W. Duncan
King Tutt Point (VCA #2)	294 *	1,900 *	15,222 *	293.4 yd^3	1942, 1948-50 - VCA 1950 - J. Joe, R. Marshall, L Pettigrew 1951 - C. Thomas 1953, 1956 - VCA
Salt Rock Aggregate (VCA #6, Upper & Lower Salt Rock Claims)	107	358	4,122	671.4 yd^3	1949 - VCA 1950-51 - E. Tapahanso 1961-62 - Davis Mining Co.
Alongo Claim (Canyon View)	27	76	76	38.9 yd^3	1956 - E.J. Alongo
Begay #1	3,921	16,491	127,499	10,500 yd^3	1953-54 - W. Duncan, Jr. 1966-67 - VCA
Begay #2	4,515	18,450	190,638	800 yd^3	1962 - Davis Mining Co. 1963-64 - H. Davis 1965-66 - Fritz-Ericson Co. 1967 - VCA
Begay Incline	655	3,475	38,215	544.5 yd^3	1955-56 - Texas Mining Co.
Carrizo #1	828	3,426	21,917	952 yd^3	1956-58 - Spafford & Sons
Red Wash Point (VCA #1)	300 *	2,206 *	17,786 *	1,222.3 yd^3	1942, 1948-50 - VCA 1951-52 - S. Harvey 1952 - H. Russell
VCA #3 (Sunnyside, Lookout Point, Lookout Point Incline, Shadyside, Shadyside 2, Shadyside Incline, & Nelson Point)	8,283 *	47,428 *	559,600 *	4,600 yd^3	1942-43, 1948-50 - VCA 1950-58, 1961 - P. Shorty 1950-54 - Billy, Peterson, Shorty, Russell, Tutt, Tanner 1951, 1953-56, 1959 - VCA 1960-61 - W. George 1964-67 - VCA
Williams Point (VCA #4)	NA *	NA *	NA *	1,481.6 yd^3	1949 - VCA

TABLE 2-1 (cont.)
LIST OF MINING CLAIMS IN THE STUDY AREA

CLAIM	*Tons Ore*	*Pounds U_3O_8*	*Pounds V_2O_5*	*Estimated Volume of Mining Debris*	*Years of Production/Operators*
VCA #7	3,870 *	21,014 *	171,268 *	3,454 yd^3	1943-44, 1948-50 - VCA 1950 - E. Tapahanso 1950-52 - H. Begay 1951 - T. Jones, Jr. 1954-57, 1961-64 - VCA 1955-59 - Kennedy & McGee 1960 - C.H. Corey, Jr. 1961 - W. George
Syracuse	See	footnote	1		1942-1943, Wade, Curran, & Co.
Oak Springs (Gravel Top & VCA #10)	7,091	32,678	344,820	NA	1949- 50, 1954-59 - Cato Sells 1955-57 - VCA 1957-58 - Tanner & Thomas 1962, 1966 - W.D. Tripp

* Early production (1942-1948) shipped as East Reservation Lease. Therefore, actual numbers are higher.
Table adapted from New Mexico Bureau of Mines and Mineral Resources, Open-file Report No. 193, Table 1, Chenoweth, March 1984.
(1) From July 1942 to August 1943, 966 tons of ore, averaging 4.37 percent V2O5 were shipped from the Syracuse and Sunnyside Mines (Sunnyside is in the western Carrizos).

TABLE 7-1
COMPARISON OF HAND-HELD LUDLUM READINGS AT SELECTED DEBRIS PILE AREAS TO AERIAL GAMMA SURVEY MEASUREMENTS

Ludlum Measurement Identification	*Ludlum Measurement Location(a)*	*Ludlum Reading (µR/hr)*	*Vicinity Aerial Survey Contour (µR/hr)*
	Gravel Top Claim		
LR-3	(SS-3)	170	22
LR-4	(SS-4)	220	14/12
LR-5	(SS-5)	140	14
	Loading Area, Gravel Top Claim		
LR-8	(SS-8)	380	12
	Northern VCA Claim # 7		
LR-9	(SS-9)	120	12
LR-10	(SS-10)	100	12
	Southeastern VCA Claim # 7		
LR-11	(SS-11)	325	17
LR-12	(SS-12)	280	27
LR-13	(SS-13)	130	33
	Salt Canyon Claim		
LR-15	(SS-15)	130	14/12
	Northern VCA Claim # 3		
LR-16	(SS-17),	290	17
LR-17	(SS-18)	60	22
LR-18	(SS-19)	250	22
	Southern VCA Claim # 3		
LR-19	(SS-20)	120	14
	King Tutt Mesa Claim		
LR-20	(SS-21)	250	22
	Begay Claim # 1		
LR-21	(SS-22)	180	14
LR-22	(SS-23)	180	14
	Canyon View Claim		
LR-25	(SS-26)	175	14
LR-26	(SS-27)	120	14

(a) Sample identification numbers in parentheses are those of debris pile samples collected for chemical analysis.

TABLE 7-2

GROUND-BASED GAMMA RADIATION READINGS AT VARIOUS DISTANCES FROM DEBRIS PILES

Distance From Debris Pile (Feet)	*Gamma Radiation Readings Debris Pile 1 (μR/hr)*	*Predicted Gamma Radiation Readings $1/r^2$ (μR/hr)*	*Gamma Radiation Readings Debris Pile 2 (μR/hr)*	*Predicted Gamma Radiation Readings $1/r^2$ (μR/hr)*
0	220	-	140	-
1	180	220	115	140
2	160	55	95	35
3	140	24	60	15.6
5	100	8.8	50	5.6
10	85	2.2	29	1.4
20	45	0.55	20	0.7
30	34	0.24	18	0.16

Tab One:
Basis for Including Uranium Ore Contaminants in the Health Analysis

Contaminant	Applicable Standards	EPA threshold (media)	Other threshhold (source)	Maximum levels measured, King Tutt Mines (media)
Radon	20 pCi/m2/sec over background (uranium sites) (US NRC)	4 pCi/L (in homes)	4.0 WLM/yr (OSHA/MSHA) 1 WLM/yr (NIOSH)	1.5 pCi/L (home) Levels above mine sites not measured
Radium (all isotopes)	5 pCi/g (sediment and soil) (US NRC)	5 pCi/L (water)	2.7 pCi/L (WHO)	2.9 pCi/L (Surface and ground water) 40 pCi/g (sediment) 455 pCi/g (soil)
Uranium (all isotopes)		0.03 mg/L (prop. MCL for water)	0.05 mgm3 (OSHA) 15 pCi/L (AZ) 1.5 ug/m3 (AZ) 5 mg/L (NM)	35 pCi/L (surface water) 18 pCi/g (sediment) 827 pCi/g (soil)
Thorium (all isotopes)		15 pCi/L total alpha		low in water/sediment 390 pCi/g (soil)
Low LET ionizing radiation (i.e. Gamma radiation)	0.1 rem/yr above background (US NRC)		5 rem/yr (EPA, occup.) 25 mrem/yr (EPA, nuclear power)	380 uR/hr (handheld) 33 uR/hr (arial survey)
Arsenic	2.2 mg/Kg (sediment and soil) (US EPA)	0.05 mg/L (MCL for water)	0.01 mg/m3 (OSHA)	low in water 6.6 mg/Kg (sediment) 118 mg/Kg (soil)
Beryllium	0.14 mg/Kg (sediment and soil) (US EPA)		0.002 mg/m3 (OSHA) 0.0005 mg/m3 (NIOSH)	low in water 0.28 mg/Kg (sediment) 7.9 mg/Kg (soil)
Manganese	380 mg/Kg (sediment and soil) (US EPA)	0.05 mg/L (MCL for water)	1 mg/L (WHO) 0.1 mg/m3 (OSHA)	low in water 402 mg/Kg (sediment) 341 mg/Kg (soil)
Vanadium	540 mg/Kg (sediment and soil) (US EPA)		0.001 mg/m3 (WHO) 0.1 mg/m3 (OSHA)	low in water/sediment 5,100 mg/Kg (soil)

Revised D. Brugge Feb. 1999

Tal Two:

Cancer Hazards from Contaminants [Cancer Effect Level (CEL) in mg/kg/d unless noted (o=oral, i = inhalation; a = animal)]

Contaminant	EPA Reference Dose	Known or probable Cancers	Possible Cancers
Radon		Lung (1.5 pCi/L)	
Radium		Bone (1 uCi/Kg) nasal sinuses and mastoid air cells leukemia	Eye Breast Liver Kidney Nervous system
Uranium			Lung (5.1 mg/m3 i (a)) bone stomach brain skin
Thorium		(Liver, leukemia, bone??)[1]	Pancreas Lymph Hematopoitic system Lung
Low LET radiation (gamma and beta)	0.1 rem/yr above background	Acute leukemia Chronic myelogenous leukemia Stomach Lung Breast	Thyroid Bladder Brain and CNS Skin Oesophagus Colon Liver Bone
Arsenic	0.0004 mg/kg/d	Lung (0.02 o; 0.01 mg/m3 i) skin (0.009 o)	liver (0.03 o) bladder (0.02 o) kidney
Beryllium	0.005 mg/kg/d	Lung (0.006 i)	
Manganese	0.005 mg/kg/d		
Vanadium	0.009 mg/kg/d		

[1] Cancers caused by injection of "thorotrast" a coloidal suspension of thorium that is likely to differ substancially from exposure to thorium via inhalation or ingestion of non-coloidal thorium.

Table Three:
Non-cancer Hazards from Contaminants

Contaminant and MRL, Minimal Risk Level (mg/kg/d)	Systems affected	Type of effect/symptoms	LOAEL/NOAEL (mg/kg/day) Oral unless noted (h) = in humans (a) = in animals
Radon	Lungs	Fibrosis	LOAEL = 550,000 pCi/L
		Metaplasia	LOAEL = 420,000 pCi/L
Radium	Bone	Bone degeneration	NA (very high doses)
	Blood	Anemia	NA (high doses)
	Eyes	Cateracts	NA
	Liver	??	NA
	Immune sys	Altered function	NA
Uranium	Kidneys	Incr. plasma proteins	LOAEL = 1.1 (a)
		Protienurea, incr. brsulf. ret.	0.13 mg/m3 (inh) (a)
	Fetus	Developmental defects: cleft palate, kidney, embryolethality	LOAEL = 3 (a)
	Skin	Skin irritation	LOAEL = 47 (a)
	Whole body	Weight loss	LOAEL = 23 (a)
	Blood	Anemia	LOAEL = 33 (a)
		incr. hemocrit, hemogl, erythro.	LOAEL = 9 (a)
	Lungs	Fibrosis	LOAEL = 5.1 mg/m^3 (inh) (a)
			LOAEL = 4.5 (a)
	Liver	Congestion, incr bl. glcs, enzymes	LOAEL = 0.4 mg/m3 (inh) (a)
		Focal necrosis	LOAEL = 11.2
			LOAEL = 11
	Reproductive	Reduced sperm count	
	Nervous sys	Tremor, other effects	
Thorium	Lungs	Chirrosis	NOAEL = 5 mg/m3 (inh) (a)
			NOAEL = 0.9 mg/m3 (inh) (a)
	Blood	Decreased and abnormal RBC	NOAEL = 5 mg/m3 (inh) (a)
	Liver	Elevated enzyme levels	
Gamma radiation	Fetus	Birth defects	Low doses
	Poisoning		High doses

Arse (MRL = 0.0003 mg/kg/d)	CNS/PNS	Neuro[illegible] to the center[illegible] id periferal nerv[illegible] syste[illegible]sory change[illegible], [illegible]ngling, numbne[illegible] extrem[illegible]es, muscle weakness)	NOAEL = 0.01 (h) LOAEL = 0.01 (h)
	Liver	Causes liver damage (jaundice)	LOAEL = 0.05 (h)
	Heart	Altered myocardial depolarization Cardiac arrhythmias	LOAEL = 0.014 (h)
	Vascular sys	Periferal vascular disease (Raynaud's and Blackfoot diseases) Thickening, occlusion of blood vessels	LOAEL = 0.02 (h) 0.05 mg/m^3 (inh) (h)
	Blood	Anemia and leukopenia	LOAEL = 0.05 (h)
	Skin	Hyperpigmentation and hyperkeratosis of the skin	LOAEL = 0.01 (h) NOAEL = 0.0008 (h)
	Fetus	Low birth weight/neural tube defects	LOAEL = 23 (a)
	Genetic	Chromosomal aberrhations	LOAEL = 4 (a)
	GI	Nausea, vomiting, diarrhea, abdominal pain	LOAEL = 0.02 (h) NOAEL = 0.01 (h)
	Respiratory	Irritation	LOAEL = 8 (h)
Beryllium	Lungs	Acute chemical pneumonitis and chronic granulomous disease (Berylliosis)	LOAEL aprox. = 0.001 mg/m3 (inh) (h)
	Skin	Contact dermatitis; hypersensitivity can develop	0.019 mg
	Immune system	Increased T-cell activity	LOAEL = 0.0012 mg/m3 (inh)
	Kidney	Glucosurea	LOAEL = 0.7 (a)
Manganese	Lungs	"Manganese pneumonitis"	LOAEL = 0.97 mg/m3 (inh) (h)
	CNS	Neuropsychiatric disorder (irritability, Decreased reaction time Can lead to a Parkinson-like syndrome.	LOAEL = 0.06 NOAEL = 0.005
	Reproductive	Decreased male fertility	LOAEL = 0.97 mg/m3 (inh) (h)
	Liver	Cirrhosis.	LOAEL = 0.14 mg/m3 (inh) (h)
Vanadium	Lungs	Bronchial irritation.	LOAEL = 0.06 mg/m3 (inh) (h)
	Skin	Irritation.	?
	Eye	Irritation	?
	GI	Distress???	?
	Enzyme activity	Inhibits Na/K ATPase, Ca/Mg ATPase, and other such enzymes	?
	Heart	Cardiac palpitation	?
	CNS	Tremor, CNS depression, (manic depression?)	
	Kidney	Hemorrhagic foci, vascular infiltration	LOAEL = 0.57 (a)
	Fetus	Various developmental defects	LOAEL = 2.1 (a)

Key to Abbreviations:

UNITS of MEASUREMENT
g = gram
mg = milligram (one thousandth of a gram)
Kg = Kilogram (one thousand grams)
mg/kg = mg toxin per kg soil
d = day
mg/kg/d = one mg toxin per kg human or animal per day
pCi = pico Curie (one billionth of a curie)
L = Liter of water
mg/L = mg toxin per L of water
pCi/L pCi radioactivity per L of water
pCi/g = pCi radioactivity per gram of soil
m3 = Cubic meter of air
mg/m3 = mg toxin per cubic meter of air

ABBREVIATIONS

EPA = US Environmental Protection Agency
OSHA = US Occuaptional Safety and Health Administration
NIOSH = US National Institute of Safety and Health
WHO = World Health Organization
MSHA = US Mine Safety and Health Administration
MRL = Minimum Risk Level (dose below which no risk to humans is expected)
CEL = Cancer effect level (dose above which cancer was seen in studies)
MCL = Maximum Contamination Level (standard for contamination of drinking water)
CNS = Central nervous system (i.e. brain and spinal cord)
PNS = Periferal nervous system (i.e. nerves in the hands and feet)
LOAEL = Lowest Observed Adverse Effect Level (lowest dose at which a health effect was seen)
NOAEL = No Observed Adverse Effect Level (dose at which no health effect was seen)
LET = Linear Energy Transfer (low LET ionizing radiation can deliver an external dose)

EPA 520/1-83-008-1

Final
Environmental Impact Statement
for
Standards for the Control
of
Byproduct Materials from
Uranium Ore Processing
(40 CFR 192)

Volume I

September 1983

Office of Radiation Programs
U.S. Environmental Protection Agency
Washington, D.C. 20460

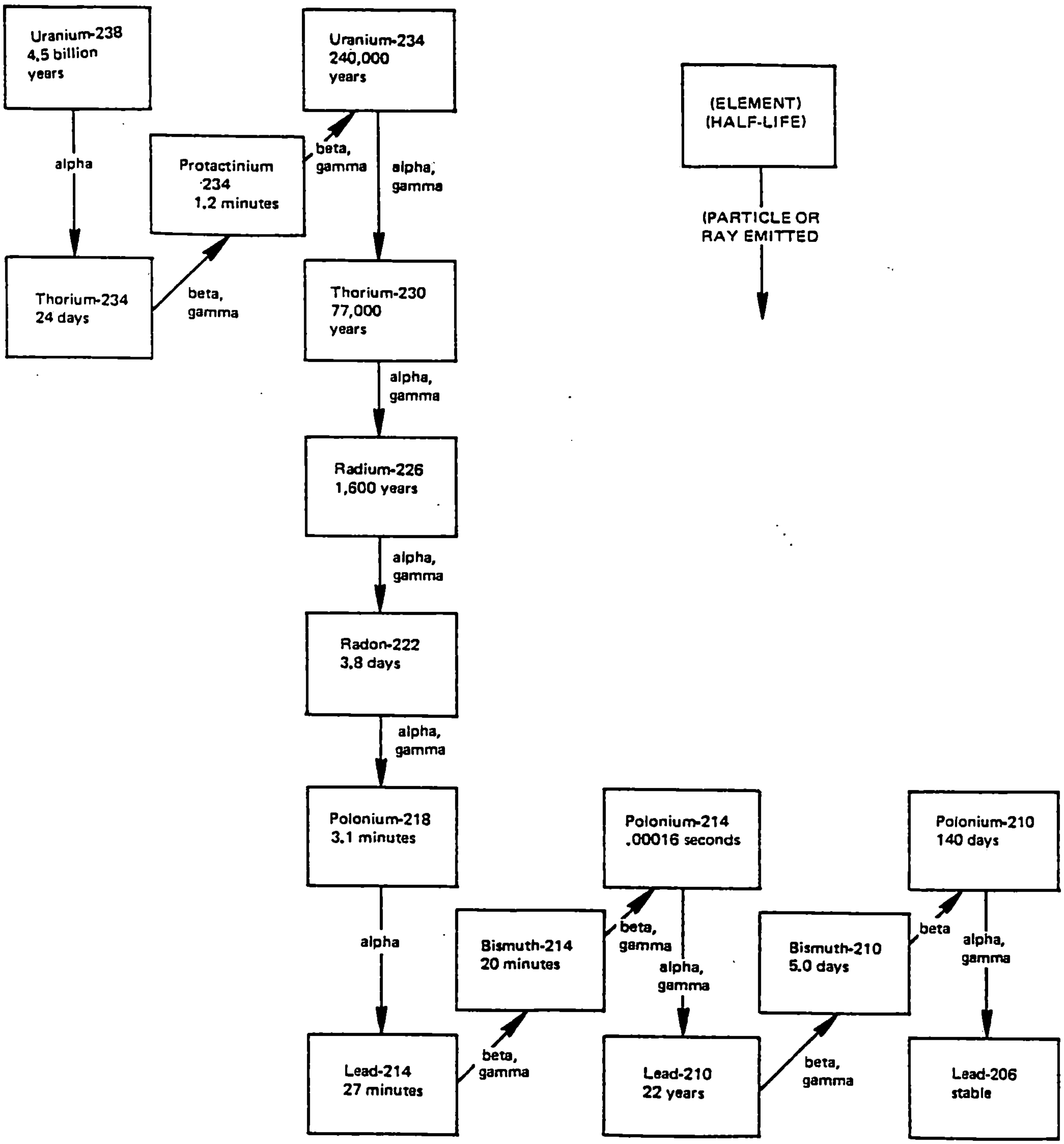

Figure 3-1. The Uranium-238 Decay Series.

HO-8968

I

HYDRO RESOURCES, INC.

CHURCHROCK PROJECT

ENVIRONMENTAL REPORT

TO SUPPLEMENT THE NEW MEXICO
ENVIRONMENTAL IMPROVEMENT DIVISION
DISCHARGE PLAN APPLICATION AND
NUCLEAR REGULATORY COMMISSION
SOURCE MATERIALS LICENSE APPLICATION

APRIL 1988

88-0694

6.6 RESTORATION DEMONSTRATION

6.6.1 Purpose and Scope

A series of leach studies were conducted on core material which was taken from the ore horizon at the Churchrock property. The purpose of these studies was to demonstrate the leachability of the uranium, determine what the expected leach chemistry would be and finally demonstrate that the groundwater could be restored to premining conditions.

Tests were conducted on core material from wells CR-3, CR-4, CR-5 and CR-6. These wells are situated at extreme positions within the orebody, thereby assuring representative leach/restoration characteristics for the entire orebody. Batch tests were conducted for all wells to predict which ions and trace metals would be elevated a a result of leach solution contact, for different points in the ore body. Two column leach studies were conducted on CR-3 core; one which is still in progress, at a rate that simulated actual leach solution flowrate in the field, and one accelerated leach study to meet the timing requirements of this application.

6.6.2 Core Handling

All core material was sampled in one foot sections (Figure 6.6-1), and analyzed for uranium and TOC. The uranium determination was used to select the interval(s) to be used in the leach study. TOC was used internally to predict oxygen consumption during the study.

Based on the information gleaned from the well logs and laboratory analysis, the appropriate sections of core were selected from CR-3. The core material was ground and a sample sent to Hagen Research for mineralogical analysis. The result of the core analysis is presented as Figure 6.6-2. Specific information on the core material is within Table 6.6-1. The material was then packed into two, three-inch diameter columns and sealed. The cores were than set up as shown in figure 6.6-3 for the leach study.

6.6.3 Leaching Phase

Leach solution was prepared using water from the Westwater Formation at the UNC mill site, and fortifying it with sodium bicarbonate to 800 mg/l. Baseline water quality is shown on Figure 6.6-4. This solution was forced through the column under pressure of 125 psi. Initially, pressure was provided by bottled nitrogen in order to extract the preoxidized uranium. Oxident was introduced to the system at pore volume 6.3 through two sources, bottled O2 at 125 psi and 118 ppm hydrogen peroxide in the barren lixiviant.

Figure 6.6-2

Hazen Research, Inc.
4601 Indiana St. • Golden, Colo. 80403
Tel: (303) 279-4501 • Telex 45-860

DATE February 9, 1988
HRI PROJECT 009-173
HRI SERIES NO. 37588-B
DATE RECD. 12/21/87
CUST P.O.#

Uranium Resources, Inc.
Mr. Sergio C. Garza
Post Office Box 186
Bruni, Texas 78344-0186

REPORT OF ANALYSIS

SAMPLE NO. 37588-1
SAMPLE IDENTIFICATION: CR-3

Uranium as U3O8, %	0.202
Uranium as U3O8, % (Replicate)	0.213
Uranium as U3O8, % (Replicate)	0.209
Gross Gamma (Radium Equivalent), pCi/g	510
Radium 226 (+-Precision*), pCi/g	610(+-30)
Vanadium, %	0.02
Selenium, ppm	0.3
Carbonate as C, %	0.04
Total Carbon, %	0.25
Organic Carbon (calculated), %	0.21
Manganese, %	0.011
Arsenic, ppm	3
Calcium, %	0.208
Zinc, %	0.002
Iron, %	0.804
Ferrous Iron, %	0.48
Magnesium, %	0.147
Molybdenum, %	<0.001
Sulfide, %	<0.01
Copper, %	<0.001
Lead, %	0.003

By: Robert Rostad
Laboratory Manager

*Variability of the radioactive disintegration process (counting error) at the 95% confidence level, 1.96 x sigma.

Exchangeable Cations, Cation Exchange Capacity and Exchangeable Sodium Percentage results to follow.

Table 6.6-1

CR-3 Fast Leach

Core Information

1. SAMPLE CORE

- Core designation	: Churchrock #2
- Well number	: CR-3
- Ore used on leach from core depth	: 786 to 793 feet and 796 to 799 feet

2. LEACH ORE SAMPLE

- Mass of ore	: 8635.5 grams
- Volume of ore	: 4401.3 CM^3
- Porosity (Core Services)	: 25%
- Pore Volume	: 1100 CM^3
- Moisture	: 10.7% (average)
-Mass of Dry Core	: 7711.5 grams
- Percentage U_3O_8 (by Hazen)	: 0.208% (average)
- Mass U_3O_8	: 16.040 grams