1980

Uranium Development in the San Juan Basin Region: A Report on Environmental Issues

San Juan Regional Uranium Study

URANIUM DEVELOPMENT IN THE SAN JUAN BASIN REGION

FINAL REPORT

A REPORT ON ENVIRONMENTAL ISSUES

BY THE

SAN JUAN BASIN REGIONAL URANIUM STUDY

ALBUQUERQUE, NEW MEXICO

U.S. DEPARTMENT OF THE INTERIOR

SAN JUAN BASIN REGIONAL URANIUM STUDY

Figure I-1.--Headframe of Kerr-McGee mine at Ambrosia Lake, N.M. Source: Kerr-McGee Corp.

UNITED STATES DEPARTMENT OF THE INTERIOR

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A REPORT ON ENVIRONMENTAL ISSUES

Final Edition

Prepared by

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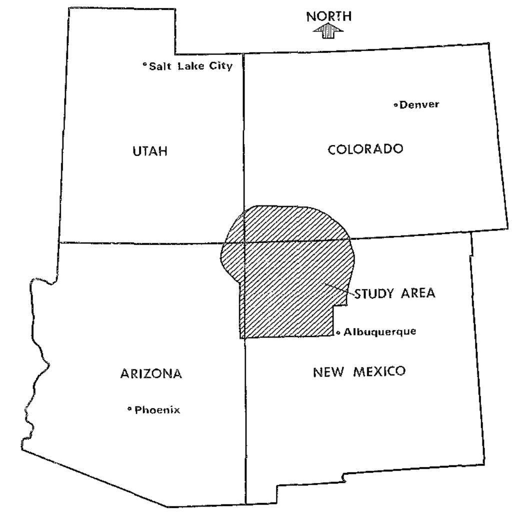
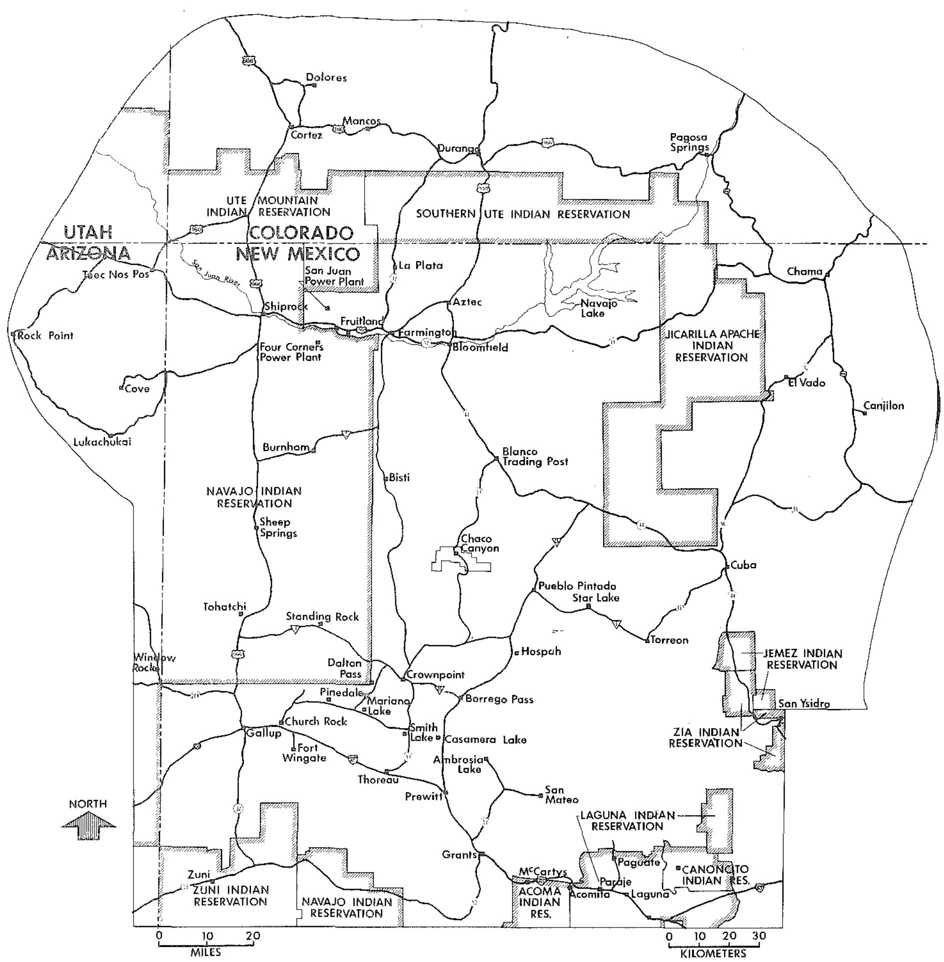
Fall 1980



LOCATION MAP

Map I-1



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TO THE READER

The San Juan Basin Regional Uranium Study was initiated in 1977 by the Secretary of the Interior in his role as trustee over Indian lands and manager of the public domain. The task force was formed from Department of the Interior agencies and the general scientific community. The project was undertaken in response to the need for information generated by the rapid upturn in uranium development in New Mexico in the early 1970's.

The Study's goal has been to provide a regional analysis of the effects of uranium development on the human and natural environment of northwest New Mexico from the present until the year 2000. It is hoped that this information will aid decision-makers, prove useful in environmental impact statement preparation, and inform the general public. The study area is shown in Maps I-1 and I-2.

Over the last three and one-half years, more than 150 social and natural scientists and staff have participated in the preparation of this volume and its 70 technical working papers, listed in the References. Working from the Study's projection of future exploration, mine, and mill sites, and tonnage of ore mined and milled, team members analyzed impacts at the regional, subregional and sometimes site-specific levels, depending on available data and methodology. Key impacts found are summarized in Chart XIII-1 (in pocket).

The reader is cautioned that uranium development is a "speculative" industry, subject to unpredictable upswings and downturns and consequently difficult to forecast with any assurance of accuracy. Three successive DOE forecasts (1977, 1978, 1980) have changed their predictions of tons of U_3O_8 to be produced by New Mexico in the year 2000 from 36,000 to 27,000, and finally down to 18,900.

How has this affected the accuracy of this Study? Impacts were calculated from uranium ore being mined and processed, not resultant tons of U_3O_8. A recent trend of reduction in ore grade mined in New Mexico has thus far nullified the effect of declining projected demand for U_3O_8. This allows for retaining the same basic level of projected impacts at the Study's Moderate level of development, minus 5 percent.

It should still be remembered that the pace and general magnitude of development are more important for broad regional impact analysis than exact years and discrete numbers of mines and mills. Thus, although the precise time frame and level of uranium development in the basin may eventually vary from the levels assumed for this study, this book can continue to be used as a general guide to environmental impacts from potentially large scale uranium development in the San Juan Basin region.

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PART 1

URANIUM DEVELOPMENT:

A Perspective

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URANIUM DEVELOPMENT

AND THE

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Chapter I

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Chapter I

Summary

Uranium, a heavy metal which is a key to atomic energy, is in demand to supply nuclear fuel to generate electricity. Up to half of the fuel sought for U.S. nuclear power plant operations over most of the next 20 years is expected to come from the San Juan Basin in northwest New Mexico.

In the three decades since uranium production in this area began, two national priorities have emerged:

1) Concern for the human environment;

2) A national energy problems described by the President as second in urgency only to that of world peace.

This study, ordered by the Secretary of the Interior, for the first time examines the environmental implications of uranium mining and milling in this region, within the context of other major activities.

Chapter I

Uranium Development and the Role of the San Juan Basin

INTRODUCTION AND OVERVIEW

Uranium: A Key to Nuclear Energy

Uranium became a household word as the key that unlocked the atomic era at the end of World War II. Later crowded from the limelight by world and national events, this once obscure and useless metal has re-emerged into the public eye. This time, its prominence arises from its role in the energy dilemma, rather than in military strategy.

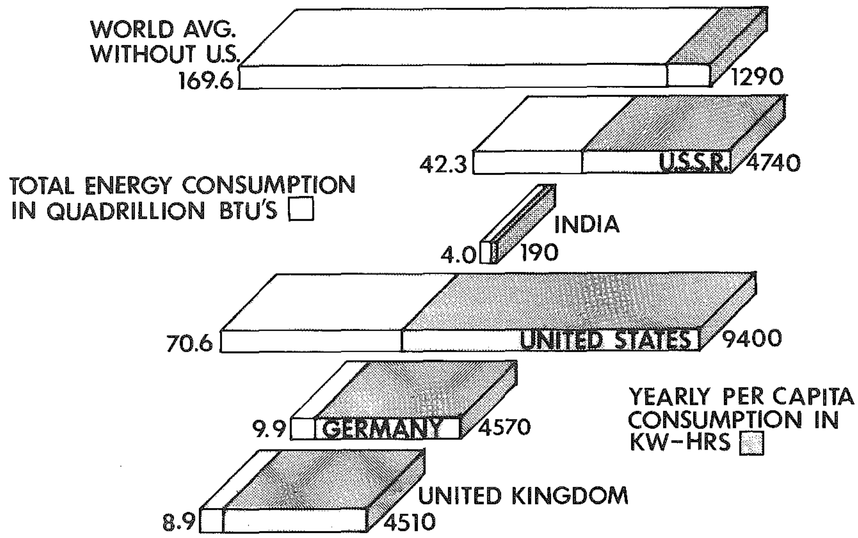
Uranium has proved to be indispensable for tapping the tremendous energy stored in the atom. This energy, like that from fossil fuels such as coal, oil, and gas, can serve many purposes. The primary use for which uranium is sought today is to fuel nuclear fission reactors that generate electricity.

U.S. Energy Situation. The market for uranium in this country is spurred by the fact that demands for energy are outrunning supplies from traditional sources. This fact contributes to a steady climb in prices of other fuels, tending to make nuclear-fueled power generation much more competitive in cost than formerly estimated.

The United States is the world's largest energy user. With less than 6 percent of the population, it consumes more than 30 percent of the energy used annually (Figure I-3). Americans' per capita use of energy has grown steadily--a trend which the administration's National Energy Plan proposes to retard through conservation steps.

Executive officials and members of Congress, among others, often express concern over the extent to which the United States depends on foreign countries for oil. Oil and natural gas supply about three-fourths of U.S. energy consumption. The potential impacts of dependency on foreign sources were demonstrated during the 1973 Mideast oil embargo and after political upheavals disrupted Iran's production in 1979.

The known domestic reserves of oil and gas, considered indispensable to such bulwarks of the economy as transportation and industry, are declining. Partly because of this, plentiful coal and comparatively plentiful uranium are increasingly relied upon to replace oil and gas in fueling electric power generating plants.



APPROXIMATE 1975 ENERGY CONSUMPTION
Based on U.N. & OECD Publications

Figure I-3.

Electricity from Nuclear Fission. The fuel most commonly used in today's nuclear power plants is uranium-235 (^{235}U), a naturally occurring isotope that makes up less than 1 percent (0.71%) of natural uranium. It can take a ton of uranium-bearing rock to obtain one-half ounce of uranium-235. In a nuclear reactor, the uranium-235 atoms split apart or fission in a chain reaction. The resulting heat is harnessed to create steam that drives a turbine to generate electricity. A piece of uranium fuel as big as a golf ball contains as much energy as 168,000 gallons (4,000 barrels) of oil. One pound of uranium contains the energy potential of 3.3 million pounds (1,650 tons) of coal.

The first U.S. nuclear power plant went into operation in 1957, and in the next two decades such plants multiplied to the point where 68 nuclear plants generated nearly 13 percent of the total U.S. electricity produced in 1977, when a strike cut coal production. However, estimates of future nuclear power plant growth have been scaled back repeatedly in recent years.

Expected Nuclear Power Growth. A U.S. Geological Survey report published in 1975, for example, said that according to trends and projections nuclear plants could be expected to provide 60 percent of all U.S. electrical power in the year 2000 (U.S. Department of the Interior, Geological Survey, 1975). Circumstances changed thereafter to such an extent that by 1977 a U.S. Department of Energy (DOE) estimate based on the proposed National Energy Plan projected that nuclear plants would account for 32 percent of U.S. generating capacity by 2000. While this was much less than earlier estimates, it still assumed the nuclear role would be the most rapidly growing aspect of power generation.

By 1979, prospects for the near future had further declined to the extent that the DOE projected the nuclear share of U.S. electricity generation at 25 percent by 1995. The rate of increase this involved indicated that the nuclear share would probably still fall short of 30 percent in 2000, though rising more rapidly thereafter. (U.S. Department of Energy, 1979b) The steady reductions in nuclear power estimates for the future have resulted in a corresponding falling-off of the predictable demand for uranium from the San Juan Basin and elsewhere, even during the course of this study. Although future trends remain upward, companies cut back on basin production in 1980 and closed several mines. As Figure I-4 indicates, these wide fluctuations in production are not unusual.

SOURCE: U.S. DEPARTMENT OF ENERGY

Figure I-4.--Recent production of uranium in San Juan Basin

With the downward trend persisting, the study team felt that assumed demand levels with which it originally worked might lean to the high side. Consequently, downward adjustments were made in preparing this report. Nevertheless, since technology, public sentiment, and political factors are subject to rapid changes, and nuclear power constitutes a key element in the volatile energy picture, the downward trend could either reverse or continue. The assumed production levels and resulting analyses, therefore, are necessarily imprecise. However, the study team deems them adequate for the purpose of acquainting decision-makers with a range of potential uranium development impacts--based on the assumption of specified activity levels--so that remedies can be planned and in some cases undertaken.

While the timing may be imprecise, depending as it does on future events, the association of certain kinds of impacts with various levels of uranium recovery can be foreseen with considerable assurance. (Further discussion of uranium projections and methodology is found in Chapter II.)

Estimates of uranium oxide (U_3O_8) requirements used here are based on the premise that developments in breeder or fusion reactors, solar, geothermal, or other longterm potential power generating options will not materially affect the picture within the next 20 years or so. Such long lead times between original concept and actual operation are common in the energy field. Meanwhile, coal is expected to dominate the electricity generating plant fuel scene. This has special significance in the San Juan Basin, where important coal and uranium ore deposits often lie near each other (Chapter VI). From 2000 to 2020, the DOE foresees a possibility of nuclear ascendancy in electricity generation, under certain conditions.

Uranium Country

Uranium ore is mined either underground or from surface mines and is milled to a yellowcake concentrate (U_3O_8)* having a uranium content of about 85 percent in various chemical forms, depending on the mill process. Close to half of the nation's uranium yellowcake production comes each year from a narrow strip across the southern part of the San Juan Basin (Maps I-1, I-2, I-3).

This is the Grants mineral belt. The known and potential deposits of uranium ore suggest that this area and parts of the basin farther north could account for up to half of the U.S. output of U_3O_8 annually until the mid-1990's and for a declining share thereafter.

The San Juan Basin and adjoining area comprising the uranium study area occupy northwest New Mexico and overlap into Colorado, Arizona, and Utah. This area is referred to in this study as the San Juan Basin region.

Because regional uranium development by 2000 is believed likely primarily in McKinley and Valencia counties in northwest New Mexico, this study focuses on that area.

New Bustle of Activity. Northwest New Mexico was for centuries remote and until the mid-20th century was left untouched by civilization in many places. Sparsely settled, largely by Indians who wrested a subsistence from a semiarid region while adhering to old traditions and ways of life, much of the San Juan Basin region was long an out-back domain of vast distances and sweeping vistas.

This has been changing in recent decades. The entire area near Four Corners--where Colorado, New Mexico, Arizona, and Utah meet--is alive with exploration and other activities, largely related to energy development.

Uranium mining and milling constitutes part of this activity. However, the basin is also rich in low sulfur coal and natural gas. (Map I-4) To a lesser extent, oil and helium are produced. A known geothermal resource area lies near the eastern border of the area.

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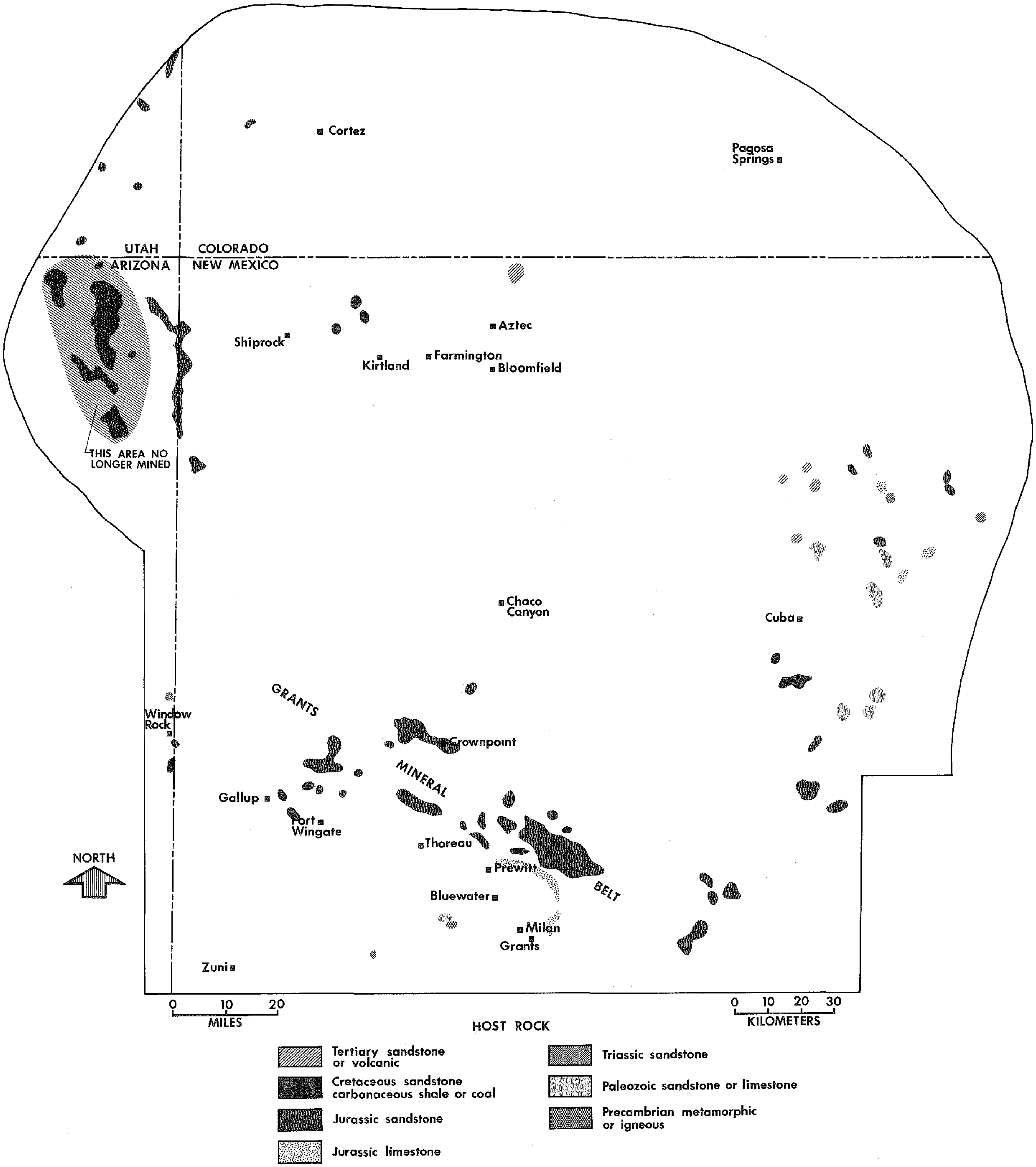
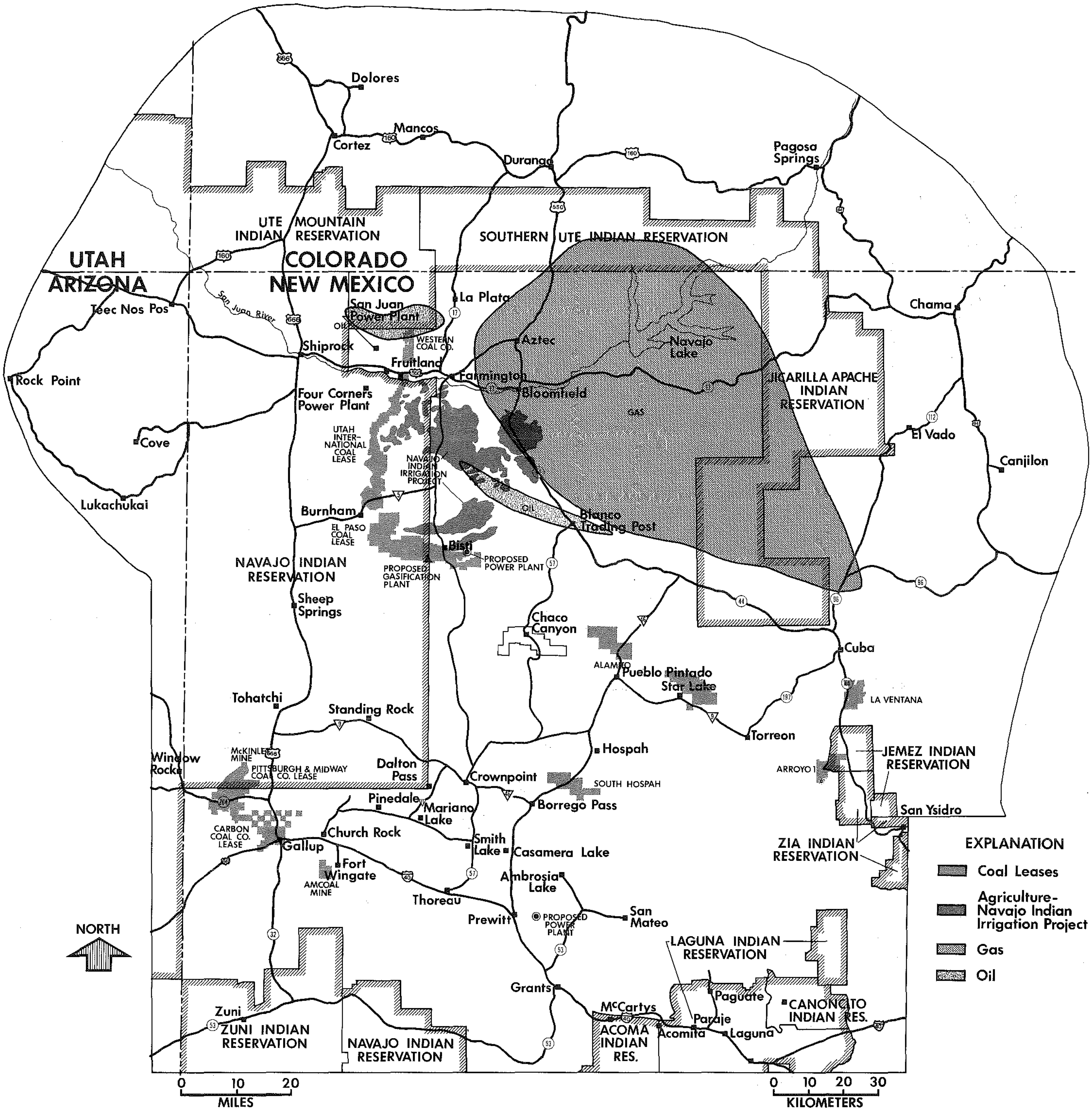
*Most yellowcake is not U_3O_8. Often it is in the form of sodium or ammonium diuranate. However, the DOE practice of using U_3O_8 to indicate the various mill concentrates will be followed here (U.S. Department of Energy, 1979a).



PRINCIPAL AREAS OF KNOWN URANIUM OCCURRENCES, PROSPECTS, MINES, AND UNDEVELOPED DEPOSITS

Map I-3



AREAS OF COAL, GAS AND OIL DEVELOPMENT

Map I-4

Developments include coal burning electric power plants that supply New Mexico, Arizona and Southern California, some large coal strip mines, and the 110,000 acre Navajo Indian Irrigation Project, about 15 to 20 percent of the way along toward completion as one of the largest single irrigation projects in the world. Power lines and pipelines are much in evidence, and paved roads are gradually extending their reach. These developments have brought thousands of people into one of the least populated areas in the United States.

Expected Uranium Growth. Under the 1979 DOE demand figures settled upon here as a likely level of development, the San Juan Basin's share of the increasing national uranium demand would entail near doubling of its 1978 production of U_3O_8 by 1990. Almost a threefold increase over the 1978 baseline figure would be needed by 2000. By comparison, the highest uranium demand assumed as being within the realm of possibility (from Edison Electric Institute, 1976) would require an increase of more than fourfold in the basin's 1978 production by 1990 and of nearly sixfold by 2000 (Boyle, 1978, No. 3, with revision).

In short, if nuclear power expands up to a quite conceivable level, the San Juan Basin's U_3O_8 production may reach twice its 1978 level by 1990 and three times the 1978 figure by 2000.

Environmental Concerns

This prospect thus emerges: A significant jump in uranium exploration, mining, and milling in a region which until the World War II era was almost undeveloped in many places and today experiences impacts from large and growing activity in coal mining, natural gas production, power plants, and other fields. Present indications are that this increase in uranium activity might be felt most strongly from the mid-1980's on.

Growing Awareness of Impacts. The growing probability of renewed uranium development of significant proportions, as well as increased coal mining and burning, produced rising awareness in responsible circles of the possibilities for combined impacts upon the environment from these many varied activities. This stemmed partly from the ample evidence that, although the uranium production industry is more than a quarter century old with limited exceptions, official concern for possible environmental impacts dates back less than half a dozen years. A scrambled land status contributes to important regulatory problems (Chapters XI and XII).

The Environmental Improvement Agency (EIA) of the State of New Mexico prepared in 1976 its first broad study of uranium related environmental matters (N.M. Environmental Improvement Agency, 1976). Four months later, an internal Department of the Interior memorandum reviewed the problems and issues in the Grants uranium belt. It took note, with evident agreement, of this statement by a New Mexico environmental official: "State and federal controls are non-existent or totally inadequate." (U.S. Department of the Interior, 1976, internal memorandum)

A considerable list of concerns was headed by questions relating to impacts on water resources, the management of huge piles of radioactive

tailings, the exposure to radiation, and the effects of the influx of significant numbers of people into the area.

Scattered Information. Overshadowing everything was the obvious dearth of accurate information on these and other environmental issues. A good deal of information was cropping up in scattered fashion as individual projects were dealt with in the NEPA (National Environmental Policy Act) process. However, there was no concerted effort to pull all of this information together and take a comprehensive look at the combined, cumulative effects upon the natural and human environment from all types of activity in the basin.

This is the purpose of the San Juan Basin Regional Uranium Study. The Bureau of Indian Affairs was designated lead agency in this Department of the Interior project largely because of Indian lands and people involved or in the path or vicinity of potential development. In 1978 about 740,000 acres of tribal and allotted lands were under lease for uranium exploration with development possible on a portion of that acreage (U.S. Department of the Interior, August 5, 1976, et seq.). Navajo tribal and allotted lands in the basin were estimated to possess approximately 10 percent (slightly

Figure I-5.--Pastoral setting near Church Rock, east of Gallup

more than 43,000 tons of U_3O_8) of the basin's $50 ore reserves and almost 13 percent (65,000 tons of U_3O_8) of Probable resources at the start of 1978. Reserves of Laguna Pueblo, the only other Indian land with uranium ore reserves in the basin, are held confidential because only two companies are involved. (U.S. Department of Energy, 1978, personal communication) Total New Mexico Indian reserves of the $50/lb ore, however, were reported

by the DOE at 79,000 tons, or 17 percent of the state total, as of January 1, 1979 (U.S. Department of Energy, Statistical Data, 1979).

Aims of this Study. The study is designed to be a comprehensive analysis of the uranium resources, existing environment, existing and projected development, and associated areawide environmental impacts. This study would provide a basis for any subsequent site-specific environmental reviews necessitated by future approval actions on either Indian or federal lands in this area.

It should be stressed that analyses are based on assumed levels of exploration, mining and milling. While these levels are believed to represent the most reliable indications at this time, they do not constitute predictions by the San Juan Basin Regional Uranium Study and should not be construed as such. Historically, production could prove greater or less than the range adopted for impact analysis.

URANIUM DEVELOPMENT

The Background of Uranium

Discoveries of Uranium and Radium. One of the heaviest elements on earth, uranium was discovered in 1789 by a German chemist who named it after the planet Uranus. The discovery and isolation of radium, a daughter product of uranium, by Pierre and Marie Curie at about the turn of the 20th century is credited with eventual establishment of modern concepts of nuclear chemistry. Radium became sought after, primarily to treat disease, while uranium was considered a byproduct useful mainly for glazing glassware and ceramics. Colorado Plateau deposits of carnotite, a mineral containing both uranium and vanadium, were the major world source of radium from 1911 to 1923.

In 1939 scientists achieved fission of the uranium-235 isotope--an important step in a drive by several nations to convert mass into energy by splitting the atom. This led ultimately to the building of the first atomic bombs at the Los Alamos Scientific Laboratory northwest of Santa Fe, New Mexico. Then came history's first atomic explosion on July 16, 1945, at the Trinity test site in the desert 110 miles south of Albuquerque.

The Search for Uranium

In 1939 less than an ounce of metallic uranium existed in the United States (Lamont, 1965). The uranium used in developing the atomic bomb came largely from foreign sources including pitchblende deposits in Canada. Nearly all the uranium available in the United States was used up in building the first bombs.

In the mid-1940's uranium shifted, as two early Atomic Energy Commission engineers would put it, "from a rare metal of little value to the most sought commodity in the world" (Ballard and Conkling, 1955). Time showed there was no need to look so far afield as Africa or Canada. Within less than 80 miles was more uranium than the Los Alamos scientists could use.

Ore Discovery near Grants. Despite a few scattered finds in the San Juan Basin, it was not until Paddy Martinez, a Navajo sheepherder, discovered uranium ore near Haystack Mountain in 1950 that interest concentrated on the Grants area. Local sources told one writer that Martinez heard prospectors and geologists talking uranium, looked at an ore sample or two, then walked miles to a spot where he remembered seeing such rocks. Visiting geologists excitedly identified uranium ore among the rocks he lugged back (Armitage, 1959).

The result was not only development of a mine in the Todilto Limestone near Haystack Mountain northwest of Grants, but also attraction of attention to the region around Mount Taylor, an extinct volcano. The AEC opened a branch office at Grants in 1950, and the mesas and canyons became alive with prospectors equipped with Geiger or scintillation counters, prospecting handbooks, and dreams of riches.

Uranium-bearing ore was discovered in the Morrison Formation in Poison Canyon near Haystack in January 1951. In November 1951, the Anaconda Copper Company's aerial radioactivity explorations paid off with discovery of uranium deposits on the Laguna Indian Reservation northeast of Grants. This find became the Jackpile, for years the world's largest uranium open pit mine. By 1956, the surface had been pretty thoroughly explored.

Ambrosia Lake Discovery. But by then there was a new interest, this time in underground deposits. Even the Jackpile failed to create the public excitement that arose in 1955 when driller Louis Lothmann, guided by radioactive cuttings from a dry oil wildcat, penetrated uranium-bearing sandstone on the Ambrosia Dome some 25 miles northwest of Grants.

This was the start of the famed Ambrosia Lake region, center of much of the nation's uranium ore production and one of the richest uranium-laden areas in the world.

Development made a legend of the late Stella Dysart, upon whose land Lothmann made his strike. Since the 1920's, she had drilled for oil without success. Then, at the age of 77 she became one of the early "uranimaires," as those who struck it rich in uranium were called. The Denver Post reported in 1964 that her fortune had been estimated at $100 million, a figure she neither confirmed nor denied.

Basin Role in Uranium. The significance of the exploration and development which took place in the basin in the 1950's and afterward is suggested by the following: the world's entire production before 1940 amounted to slightly more than 7,500 tons of U_3O_8 (U.S. Department of the Interior, Geological Survey, 1975). This production was exceeded by the San Juan Basin in 1960 alone and compares with production by the basin's mines in 1977 and 1978 of 7,600 tons and 9,400 tons, respectively, of U_3O_8 in ore (Table II-4).

The basin's 1977 U_3O_8 production in ore (weighed and sampled by mills and buying stations) amounted to 46 percent of the national production of 16,700 tons. In 1978 the San Juan Basin's yield rose to 47 percent of the U.S. total of 20,200 tons. Wyoming produced 5,200 tons and 5,500 tons in

1977 and 1978, respectively. Other producing states were Arizona, Colorado, Florida, Texas, Utah, and Washington. (U.S. Department of Energy, Statistical Data of the Uranium Industry, various years)

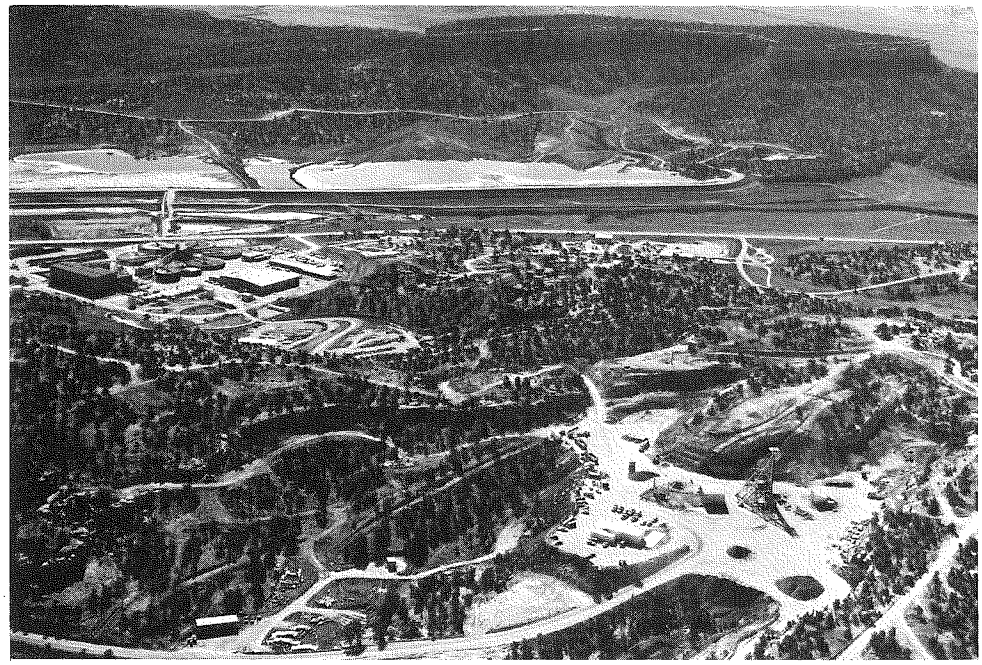


Figure I-6.--Mine and mill in Church Rock area

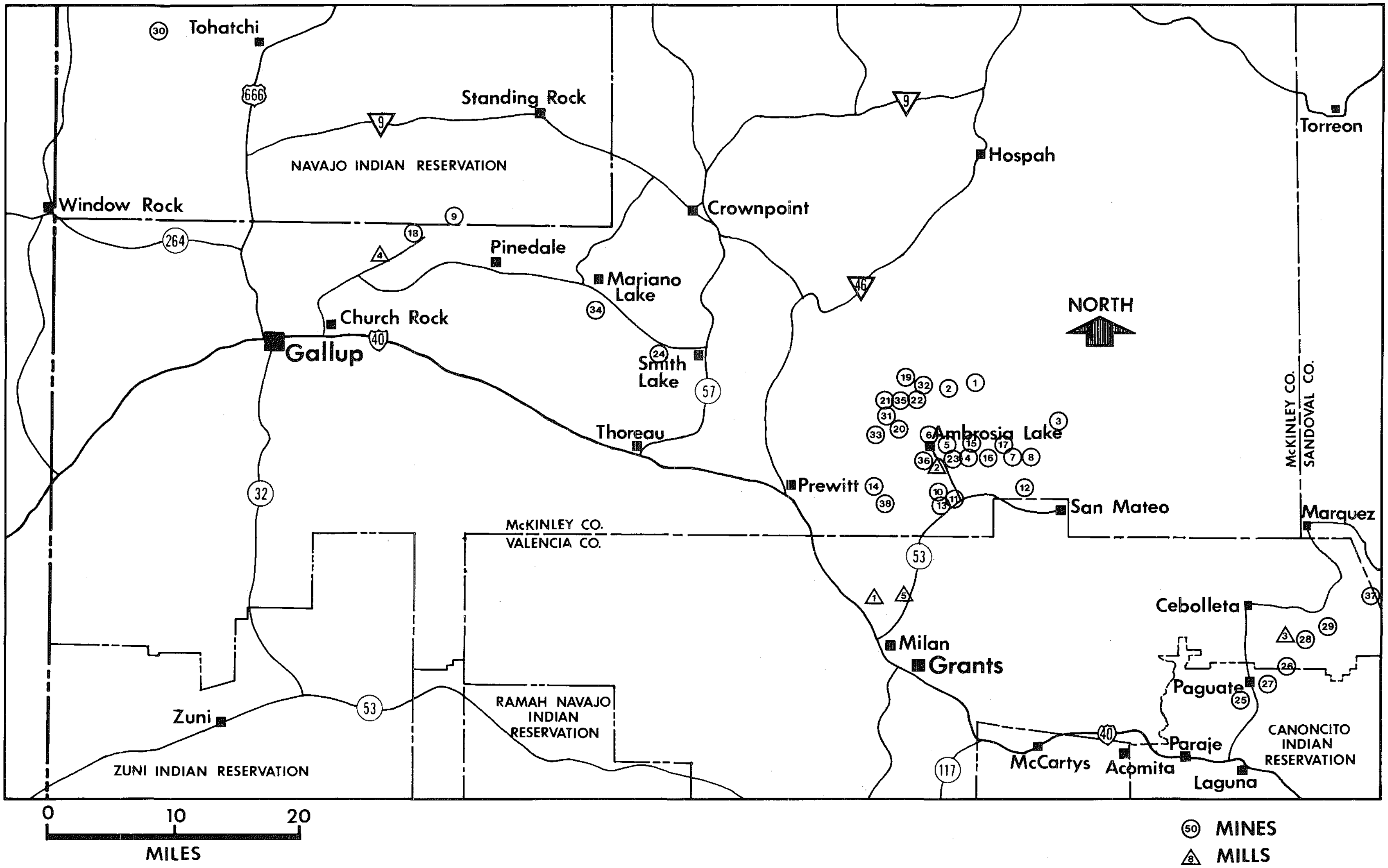
Uranium Production

After 30 years of uranium activity, the San Juan Basin seems likely on the basis of reserves to maintain its lead in the nation's U_3O_8 production for some time to come. It should be emphasized, however, that forecasting has proved risky. The trends in U_3O_8 spot market prices offer evidence: a sixfold jump in 30 months starting in 1976, followed by an apparent softening of prices in 1979 and a 25 percent drop in 1980. Longterm contracts cushion immediate impacts, but major price changes inevitably cause repercussions throughout the industry.

The Present and Future. Today, essentially 100 percent of the uranium mined in New Mexico comes from the Grants mineral belt, an irregularly defined area of about 2,500 square miles comprising less than 10 percent of the San Juan Basin region. The zone of actual production thus far extends about 85 miles from east to west and from 15 to 20 miles north-south. It lies generally north of I-40, the Interstate highway that roughly parallels the route of old U.S. 66 (Map I-5).

Important new discoveries and stepped-up exploration farther north than in the past suggest that uranium activity may well extend significantly into a parallel band of land embracing roughly another 10 to 15 miles to the north from the existing production zone (Map I-6).

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	

In general, the geology of the San Juan Basin dictates that the farther north drilling occurs, up to a certain point, the deeper the demonstrated ore bearing strata can be expected to lie. Costs of exploration and development rise accordingly. Although it could not be considered typical, the deep Gulf San Mateo mine under construction in 1979 was expected to cost approximately one billion dollars before any ore was produced.

The Uranium Market

More dramatically than most other resources, perhaps, uranium has risen and fallen on the tides of public policy. Its brief history as a factor in man's existence is marked by boom in the 1950's, bust in the 1960's, and a larger boom building in the 1970's only to be blunted. All these swings, as well as one or two smaller ones, hinged on policy shifts.

Government, the First Market. In the early 1940's, there was no uranium market in the United States. Success of the $2 billion wartime Manhattan Project created a demand for uranium--and a market--almost overnight. Predictable sales and prices were established by the AEC in 1948. So successful was the program that the supply of U_3O_8 for strategic purposes was deemed adequate by 1956. Steps were taken to ease, and eventually end, the AEC's purchasing program. Production peaked in 1960.

The New Market for Uranium. The Government ended its monopoly in 1968, sharing the market with private enterprise the next three years. The domestic market for uranium has been private since the start of 1971. The nuclear power industry provides almost the only buyers.

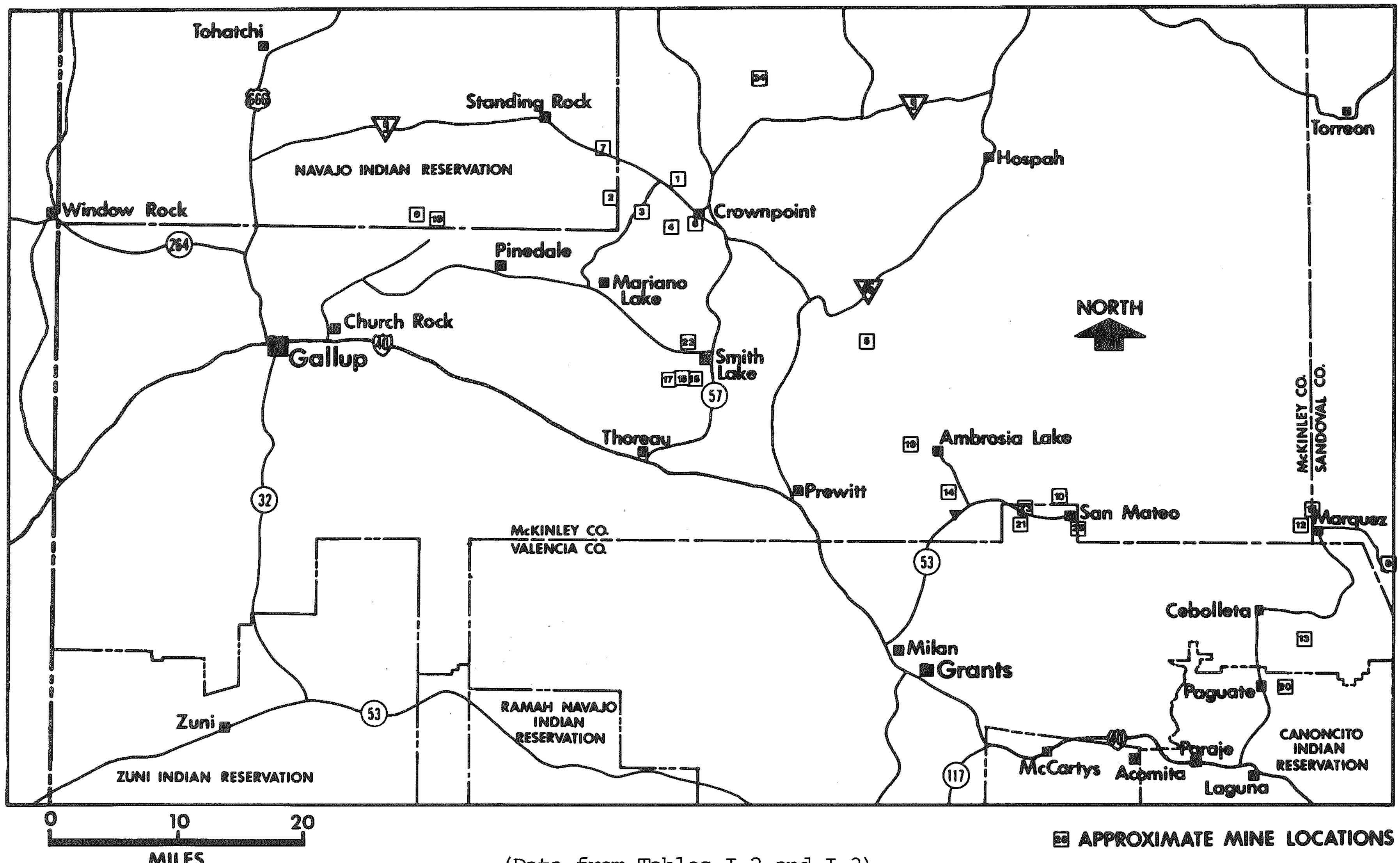
The Uranium Industry

In 1977, seven companies were actively operating thirty uranium mines in the basin. By April 1979, the count rose to 14 companies and 38 mines, although a few of the earlier 30 had ceased operation. One of the 38, however, was shut down shortly before completion (Table I-1). Eight additional mines involving three additional companies were under development in 1979, and at least 24 other mines were in various stages of discussion or planning. More than 20 companies were directly involved in these 70 existing or potential mines. The ore was processed by five mills. (See Maps 1-5 and I-6 and Tables I-1 through I-3.)

Mining Interests. An evolution has occurred in the makeup of the uranium industry, suggestive of the change in markets over the years. Hard rock mining companies were prominent in the early days. Among these were not only well known mineral operators but also smaller firms formed to grasp the opportunities opened up by the newly demanded product. There were a number of very small operations.

Oil and Energy Companies. Gradually, this changed. Oil companies had shown little interest. As they encountered problems in discovering and producing their traditional products under prevailing conditions, they sought new horizons. Uranium was an energy resource in growing demand.

Map I-6



(Data from Tables I-2 and I-3)

URANIUM MINES: UNDER CONSTRUCTION, ANNOUNCED OR PLANNED

Table I-2

N.M. URANIUM MINES UNDER DEVELOPMENT (April 1979)

COMPANY	NAME	LOCATION	EXPECTED DEPTH (FT.)	EXPECTED PRODUCTION	STATUS	CURRENT DEWATERING (gpm)	EXPECTED DEWATERING (gpm)
UNC	St Anthony	T11NR4W Sec. 19 & 30	320	N/A	Development some ore as haulage ways opened	25	Few gallons minute
Bokum Resources	Marquez	T13NR5W Sec. 25	2,100	800 T/day	At about 1,700 ft. trying to dewater shaft	1,200	Could be as high as 3000 but may be less
Kerr-McGee Nuclear Corporation	Church Rock #1E	T17NR16W Sec. 35	1,545	500 T/day estimated	Down concreting to 1,280 feet	150 (goes to Church Rock shaft)	-
Phillips Uranium Company	Nose Rock	T19NR11W Sec. 31 T19NR12W Sec. 36	~3,400	2,100 T/day	Shaft #1 - 1,000 feet Shaft #2 - 1,000 feet Shaft #3 - headframe being put in place	~1,260 -1,400 (60-200 shafts-rest dewatering wells)	3,000 - 6000
Gulf Mineral Resources	Mt. Taylor	T13NR8W Sec. 24	3,300	4,000 T/day-4,500 T/day	Shaft #1 - 3,100 feet Shaft #2 - 3,130 feet (top of Westwater)	1,000 (wells) ~3,500 (shafts)	3,000 - 10,000
UNC	Old Church Rock	T16NR16W Sec. 17	900	-	Ponds under construction headframe in (reopening old mine)	Not yet pumping	Expect 1,000 for 90 days then 450
NA - will connect to Roundy & Barbara J#2	Todilto Exploration & Dev. Corp.	T13NR9W Sec. 30	Shallow adit from surface decline	N/A	Stripping & entry preparation in progress	-	Probably dry
Mobil Oil	Crownpoint in-situ leach	T17NR13W Sec. 9	~2,000	mil. lb. year U_3O_8 full size plant	Pilot plant under-going hydrology tests	Small amount evaporating in pond	50-200 circulation

Source: Perkins, B.L., 1979, An Overview of the New Mexico Uranium Industry, New Mexico Energy and Minerals Department

Table I-3

New Mexico Proposed Uranium Mine Projects

	COMPANY	NAME	LOCATION	DEPTH (FEET)	DEWATERING (GPM)	EMPLOYMENT	PRODUCTION T/DAY ORE
1.	Mobil Oil-TVA	Mobil	T17NR13W Sec. 16	2,200	2,000	250	1,200
2.	UNC-TVA	Dalton Pass	T17NR14W Sec. 13,23,24,25	2,200	4,000	} 550 (Nos. 2 & 3)	} 3,400 (Nos. 2 & 3)
3.	UNC-TVA	Section 30	T17NR14W Sec. 30	2,200	3,000		
4.	UNC-TVA	Canyon	T17NR13W Sec. 34	~2,250	3,000	320	~ 850
5.	Continental Oil	Borrego Pass	T16NR10W Sec. 18 T16NR11W Sec. 1	2,275	3,000-6,000	193	850
6.	Continental Oil	Crownpoint	T17NR12W Sec. 29	2,200	2,700	NA	1,350
7.	Pioneer Nuclear	Narrow Canyon	T18NR14W Sec. 33,34,35,36 T17NR14W Sec. 1,2,3,4,9,10, 11,12	2,450	3,000	230	1,400
8.	Continental Oil	Bernabe	T12NR2W Sec. 36	~1,966	6,000	295	1,350
9.	Kerr-McGee	Church Rock II	T17NR16W Sec. 27	2,300	6,000	140	900
10.	Kerr-McGee	Roca Honda	T13NR8W Sec. 9 & 17	1,675	2,500	NA	600
11.	Kerr-McGee	Marquez	Near Marquez	2,000-2,200	NA	NA	NA
12.	Bokum	Marquez #1 & 2	Near Bokum Mill	~2,000	NA	NA	NA
13.	Sohio	JJ #2 & perhaps #3	Near Sohio Mill	~600	Small amount	Total 350-400 all mines	NA
14.	Koppen	Isabella	T13NR9W Sec. 6	250-450 drift from Spencer shaft	Dry	Total Sec. 6 Sec. 8 } 20	100-150
15.	Western Nuclear	Ruby #2	T15NR13W Sec. 27	~360	Dry	20-40	NA
16.	Western Nuclear	Ruby #3	T15NR13W Sec. 26	~360	Dry	20-40	NA
17.	Western Nuclear	Ruby#4	T15NR13W Sec. 25	~360	Dry	20-40	NA
18.	Kerr-McGee	Church Rock 1W	Same ore body as Church Rock #1	~1,800	150 gpm shaft	NA	NA
19.	Cobb	Ambrosia Lake	T14NR10W Sec. 10	400-700	NA	NA	NA
20.	Anaconda	P-15-17	Near Jackpile-Paguate	NA	NA	NA	NA
21.	UNC	San Mateo	T13NR8W Sec. 30	Reopen old mine	NA	NA	NA
22.	Phillips Uranium Corp.	House Lake Project	T15NR13W Sec. 17 & 20	Shaft 300	NA	NA	NA
23.	Noranda	San Mateo Project	T13NR8W Sec. 30	Shaft	NA	NA	NA
24.	Phillips Uranium Corp.	Nose Rock #1, 2 & 3 (possible #4, #5, #6, & #7)	T19NR12W Sec. 36 T19NR11W Sec. 30 T19NR11W Sec. 17 T19NR11W Sec. 10 T19NR12W Sec. 1	3,000-4,500	max. 54,309 acre ft. per year all mines	NA	NA
25.	Gulf Mineral	Mount Taylor	T13NR8W Sec. 24	3,300	5,000 plus	NA	4,000

Source: Perkins, B.L., 1979, An Overview of the New Mexico Uranium Industry, New Mexico Energy and Minerals Department

A distinct movement into uranium by the big oil and energy companies took place. Among those involved in San Juan Basin uranium today are such familiar energy giants as Exxon, Gulf, Conoco (formerly Continental Oil), Atlantic Richfield which acquired Anaconda holdings, Phillips, Mobil, Getty Oil in cooperation with two Japanese firms, and Standard Oil of Ohio.

Utility Companies. With lead times of 10 years or more involved in planning, construction, and licensing of nuclear power plants, plus an operating period of 30 years or more during which reactors rely upon uranium fuel, the entrance of public utility companies into this field was predictable. The TVA and other utilities as far away as Long Island, N.Y., have become involved, sometimes in joint ventures, as they move to assure uranium fuel supplies to meet their future requirements for electric power generation.

Figure I-7.--Thoreau on south-central edge of Grants mineral belt

Surface Ownership and Mineral Leasing. Companies show a marked preference for private lands in locating mills and, to a lesser extent, in development of mine sites. Before initiating exploration activities, they obtain the rights they would need in event of discoveries warranting development. This may involve purchase of the land or purchase or lease of mineral rights combined with acquisition of surface rights-of-way and necessary permits. Needs vary from one tract to another, depending on such details as land status.

Of the 38 uranium mines originally listed in 1979, U.S. Geological Survey records showed that 27 were located on privately owned land, as were all five mills. The other 11 mines included: 1 on state land; 1 on federal land (public domain); 3 on Laguna tribal land; 2 on Navajo tribal

land; 1 on Navajo allotted land; 2 on lands where the surface was in Navajo trust and the mineral rights privately owned; and 1 where the surface was Navajo allotted land and the mineral rights privately owned.

Leases on the six mines operating on exclusively Indian lands covered 10,469 acres, 63 percent of which was Laguna. Approved uranium mine plans on Indian lands covered 17,729 acres altogether, of which 59.4 percent was Laguna tribal land. Mine plans submitted but not yet approved covered an additional 14,560 acres, the majority Navajo tribal and the rest Navajo allotted holdings. Mine plans approved or unapproved thus embraced 32,389 acres of Indian lands. (For discussion of land ownership and jurisdiction matters, see Chapter XI.)

Calculations by San Juan Basin Regional Uranium Study staff assistants based on uranium rights maps published in 1978 indicated that in the area within which uranium exploration and mining might occur by 2000 (Map II-5), Indian tribes owned mineral rights on slightly more than one million acres. Indian allotted land, which included mineral rights, embraced almost another 200,000 acres. According to this reckoning, Indians thus held mineral rights on approximately one-third of the 3.6 million acres contained in what might be termed the overall impact area. Information was lacking on approximately 24 percent of the acreage. Mineral rights on approximately 23 percent of the land, taking in more than 800,000 acres, were in private ownership. Almost two-thirds of this privately-owned mineral rights acreage was owned by the Santa Fe Pacific Railroad Company (SFPR). The SFPR with Santa Fe Mining Inc. is a member of the Santa Fe Industries family of companies. The SFPR holdings in the overall region cover more than one million acres, and many of the existing and proposed mines in the Grants mineral belt are on SFPR lands. (Santa Fe Mining Inc., 1980, personal communication)

The mineral leasing picture is complex and fluid. While the extent of acreage leased does not necessarily have any bearing on the amount of uranium a company may find and develop, it does give a company potential leverage and control. It also indicates company interest. (Implications relative to the region's social fabric are discussed in Chapter VII.)

Of 46 mineral rights lessees identified in the map-based study mentioned above, eight companies held leases on more than 800,000 acres at the time. This comprised almost one-fourth of the potential uranium impact area shown on Map II-5. In order they were Exxon, Keradamex/Noranda, Ranchers Exploration Development Corp., Mobil Oil, Teton Exploration Drilling Co., Kerr-McGee, United Nuclear, and Atlantic Richfield. United Nuclear was not far behind Exxon in acreage leased when holdings of Teton, a wholly-owned subsidiary, and United Nuclear-Homestake Partners, a partnership 70 percent owned by United Nuclear, were included. (Extrapolated from Chapman, Wood and Griswold, Inc., 1979) Much leased acreage may be relinquished after preliminary exploration.

CHAPTER II

BASIC STRATEGY OF THE STUDY

Chapter II

BASIC STRATEGY OF THE STUDY

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Chapter II

Summary

The front end of the nuclear fuel cycle occurs in the San Juan Basin. This consists of exploration for and mining and milling of uranium ore deposits ranging to more than two-thirds of a mile deep. The milled product is a concentrate called yellowcake and commonly defined as uranium oxide (U_3O_8).

The extent of activity is determined by demand for nuclear power plant fuel. This demand was uncertain throughout the course of the study, with future prospects for U.S. nuclear power falling off from unprecedented levels. To enable its complex set of study tasks to proceed, the study team weighed divergent projections and reviewed: 1) U.S. demand for electricity through 2000; 2) the anticipated nuclear share of generating capacity; 3) the uranium fuel this would require; and 4) the basin's feasible share of national demand for U_3O_8.

This resulted in selection of three levels of U_3O_8 production which were assumed in order to provide a feasible range of activity upon which impacts could be analyzed. They were not intended as predictions of production. As eventually settled upon, the curves were: a) a no-further-development baseline scenario; b) a 1979 Government mid-level uranium projection; and c) a High projection which in 1976 the Edison Electric Institute had considered "moderate."

The team's Moderate, or middle, assumption would involve near tripling of the basin's U_3O_8 output from 1978 to 2000, the High one a nearly sixfold rise in that period. These levels were translated into the number of mines and mills needed, with their approximate locations. Employment, population and other factors were then projected. Uranium activities were analyzed in terms of their outputs which could cause impacts on the environment. Non-uranium developments were taken into account.

Chapter II

Basic Strategy of the Study

INTRODUCTION AND OVERVIEW

The purpose of the San Juan Basin Regional Uranium Study is to determine environmental impacts likely to result from uranium production in the basin for the rest of the 20th century and to identify needed controls, monitoring, and mitigation.

Impacts, both favorable and adverse, are studied on a combined, cumulative basis.

The study recognized from the outset that impacts in the 1980's and 1990's would rarely, if ever, come to a pristine setting. Significant areas have seen 30 years of uranium development. For more than three-fourths of that time, production took priority over environmental concerns. Also taken into account are regional impacts from other mining, industrial, and agricultural activities.

A Developing Area. The product of this effort, in effect, is a portrait of a landscape in transition. It encompasses a frontier of mesas, mountains and plains equivalent to nine-tenths the expanse of Maine thrust by geologic circumstances into the nation's energy drama.

Extent of Future Activity. To perform the assignments of the project, two prerequisites were: 1) an assumed range of future uranium development in the study area; and 2) the estimated extent of future activities related to coal, gas, oil, irrigation, power generation, and other non-uranium development.

The study team assumed certain levels of future non-uranium developments based on the most authoritative official and industry information available. For uranium, while stepped-up development appeared inevitable, the extent and timing were debatable. It is important that qualifications and reservations involved be clearly understood. Hence, assumptions and procedures are reviewed here.

Chain of Logic. The study was prepared at a time when U.S. nuclear power prospects were showing signs of growing uncertainty after reaching unprecedented heights. The base line of activity established in the late 1970's was known, but future trend lines needed for impact assessment were wavering.

Therefore, the study team elected to identify three potential levels of uranium activity: high, medium or moderate, and low. While it was

hoped that the mid-level curve would prove to be close to the actual future trend, the team felt it best to base impact estimates on the magnitude or range of development expected, rather than be tied to numbers. Even so, it was found that invariably the magnitude of uranium development was tied to projections which in turn were based upon numbers.

It must be emphasized, nevertheless, that the set of projections was one of several tools used in determining impacts. For this study, the projections are of no interest in themselves and do not constitute predictions of activity nor specific timing of that activity.

Analysis based on various projections of uranium reserves and demand produced the desired three uranium production curves. The middle curve, representing an approximate development level considered feasible under the circumstances, is referred to as the Moderate level in this report. The upper curve, called the High level, depicts the upper limit of uranium production deemed possible--though not considered likely. The third, a no-further-development scenario, added a bottom line. The latter indicated the development and impacts that could be expected if only the existing mines and those under construction were operated to serve a winding down nuclear energy industry.

As outlined below, the assumed Moderate or probable level of production was based on the Government's official 1977 projection through the first part of the study and was revised downward along with the official 1979 projection in preparing this report.

The Moderate and High curves were translated into the number of mines and mills required to supply the indicated U_3O_8. These were given approximate map locations, based on public information about undeveloped uranium ore deposits.

Uranium Model. The result might be termed a hypothetical model of the San Juan Basin uranium industry from the present through 2000. It could not be described as precise, based as it was on variables and unknowns. An ore discovery in another state of the calibre of Ambrosia Lake, for instance, is one of many unpredictables that could make the model obsolete.

The study team now moved into the projections of employment, population, and other uranium-related factors. Basic cause-and-effect relationships were examined. For each phase of uranium development, inputs were viewed as they pertained to activities which produced outputs. The outputs, in turn, gave rise in many cases to impacts.

It is these natural and socioeconomic impacts upon the environment of the San Juan Basin region, separately and in combination with impacts from other activities, with which this report deals.

ASSESSING THE BASIN'S URANIUM FUTURE--Detailed Review

A half-dozen forecasts using procedures along the lines cited here show: 1) an increase in demand for U_3O_8 during the rest of the century, and 2) a steady decline since 1974 in the amount of that predicted

increase. Currently the industry is in a steep downward trend. However, over the next 20 years the outlook is for an eventual turn-around and higher production, although not nearly as high as the soaring predictions of a few years ago.

Cutbacks. A brief review suggests the reduction in uranium prospects for the two-decade study period. In 1974 the Federal Energy Administration (FEA) foresaw nuclear power as generating 45 to 60 percent of the nation's electricity by 1990 (Table II-1). As recently as March 1976, the Edison Electric Institute projected the nuclear generating share at a possible 53 percent by 2000.

At the end of 1976, however, the FEA reported deferrals or cancellations of the equivalent of 105 proposed new nuclear power plants in the United States during the preceding 18 months. (U.S. Federal Energy Administration, 1976). Another 43 plant deferrals and 6 cancellations occurred in 1977 (Energy Resources Report, 1978). The 1977 DOE estimates shown in Table II-1 reacted to these uncertainties and were relied upon in earlier phases of this study.

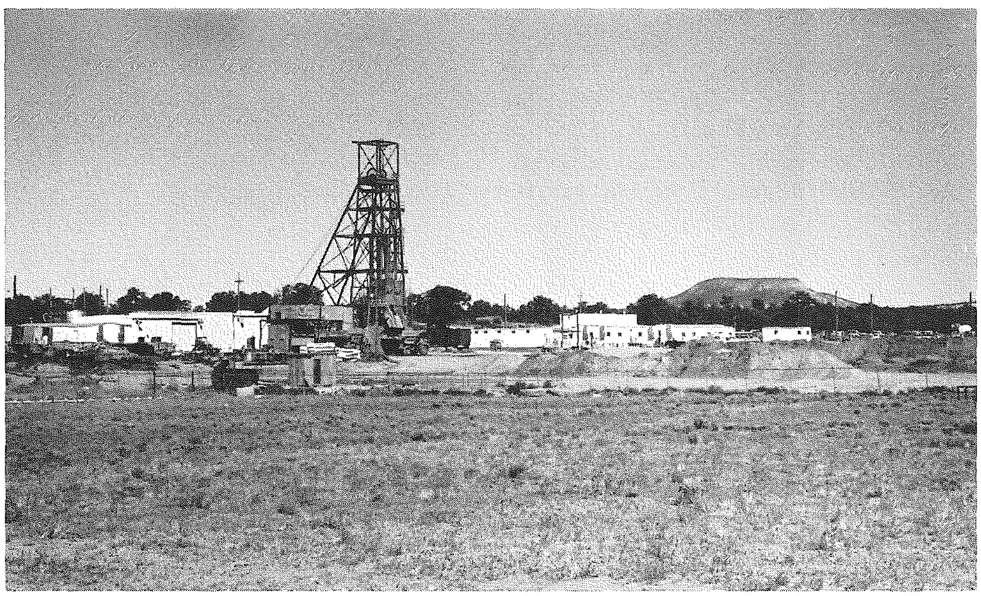


Figure II-2.--New Mexico uranium mine

The downward trend reflected the cumulative effects of a number of complicating factors. Among these were expressions of public concern over safety of nuclear generating plants in populated areas and over disposal of waste materials; regulatory uncertainties; environmental delays; capital requirements in an inflationary and high-interest period, and the relative costs of nuclear power plants as opposed to fossil fueled plants. Also contributing to uncertainty have been the political and economic climate, the possibility of renewed changes in government policy that might stem, perhaps, from new elections or international developments, and the prospects for rising imports.

The DOE in 1978 further reduced its projections of domestic nuclear power generation. The revised projections assumed that electricity would continue to grow at about double the growth rate of total U.S. energy requirements and that nuclear power would continue to increase at a rate approximately twice that of electricity.

In 1979 the DOE made a major reevaluation in the wake of the Three Mile Island Incident and other events, including announcements by TVA, Duke Power Company, and Commonwealth Edison Company of major delays in their nuclear construction programs. DOE spokesmen said events of 1979 had the effect of creating "a 'bow wave' of delayed or deferred projects." The DOE's October 1979 figures, shown in Table II-1, are lower than the 1977 estimates used originally in this study and constitute the DOE'S lowest nuclear power estimates in recent years. The 1979 estimates can be attributed partly to a scaling back more closely to the firmer ground provided by plant capacity currently operating or well along in construction. (U.S. Department of Energy, 1979b)

Seventy-three nuclear power plants are presently completed and licensed, and 87 others are under construction (Atomic Industrial Forum, Inc., personal communication, 1980). Some of the latter are in the early stages of work and presumably could be cancelled without extreme financial loss to the utility. Therefore, even this latest projection could erode further if electrical energy demands, in the United States and overseas, should drop radically or costs continue to rise exponentially. The DOE said the overriding factors in the nuclear power future are a demand for electrical capacity and the financial means to construct that capacity.

The effects of the 1974-1979 trends on uranium demand are reflected in Table II-2. The studies shown are those identified in Table II-1. The level of activity selected as the study team's Moderate case represents latest official figures and the administration's 1979 position. The assumptions of national cumulative U_3O_8 in concentrate demand through 2000 used in the later phases of this study are:

Moderate: 849,000 tons (U.S. Department of Energy, 1979);
High: 1,740,000 tons (Edison Electric Institute, 1976).

<u>San Juan Basin Uranium</u>. Since the basin's uranium production has virtually all occurred in New Mexico and comprises the state's total output, the San Juan Basin and New Mexico may reasonably be referred to interchangeably in this context. The production needed from the basin in coming years to fulfill its share of the projected future demand for U_3O_8 was derived by taking into account:

--New Mexico's share of national uranium ore reserves;
--New Mexico's role in national production of U_3O_8.

Uranium ore potentials are figured on the basis of <u>Reserves, Probable resources, Possible resources</u>, and <u>Speculative resources</u>. Uranium <u>reserves</u> are the estimated quantities of uranium which occur in known deposits of such grade, quantity, configuration, and depth that they can be recovered at a specified cost or less with state-of-the-art mining and processing

Table II-1

Comparison of Projected Installed Nuclear Power
(Gigawatts Electric)

Year	Federal Energy Administration[1]				Edison Electric Institute[4]			U.S. DOE, 1977[5]		U.S. DOE, 1979[6]
	Scenario I	Scenario II	Revised 1976[2]	OECD/ IAEA[3]	High	Moderate	Low	NEP	No NEP	Mid
1975	47	47		40	40	40	40			
1976			54					42	42	---
1980	120	150	100	82	85	77	73	N/A	N/A	---
1985	275	400	202	205	204	185	157	127	127	106
1990	500	730	359	385	389	340	213	195	210	140
1995	N/A	N/A	N/A	---	---	---	---	---	---	179
2000	N/A	N/A	N/A	1,000	1,005	805	507	380	440	---
Exhibit: Nuclear as % of total electricity:										
1990	45%	60.2%	N/A		---	---	---	---	---	---
2000	---	---	---		53%	46%	32%	32%	32%	---

[1]Federal Energy Administration, Project Independence. Task Force Report, Nuclear Energy, November 1974. Scenario I based on projections reported by electric utilities in 1974; Scenario II used as upper limit during 1980's.

[2]Based on a 30 percent slower growth estimate than Scenario I. See National Energy Outlook, 1976, p. 32.

[3]Uranium, Resources, Production and Demand. A joint report by the Organization for Economic Cooperation and Development Estimates (OECD) Nuclear Agency and the International Atomic Energy Agency (IAEA), December 1975, p. 28.

[4]Edison Electric Institute, Nuclear Fuels Supply, March 1976. The "Moderate" column is the basis of the SJBRUS "High" U_3O_8 assumed production level.

[5]Brown and Williamson, "Domestic Uranium Requirements," U.S. Department of Energy (DOE), October 26, 1977. The projection provides in one column for a National Energy Plan (NEP) and was originally the basis of the SJBRUS "Moderate" assumed production level.

[6]U.S. Department of Energy, 1979, Clark & Reynolds, Updated Mid-case forecast, Table 5. The SJBRUS "Moderate" assumed production level for this report was derived from this projection.

Source: Boyle, Supporting Document No. 3, p. 17, with 1980 revision per Footnote 6.

Table II-2

Projections of Cumulative U.S. Demand
(Thousands of Short Tons U_3O_8)*

Year	FEA Scenarios[1] I	FEA Scenarios[1] II	OCED/IAEA[2] Low	OCED/IAEA[2] High	Edison Electric Institute[3] Low	Edison Electric Institute[3] Moderate	Edison Electric Institute[3] High	U.S. DOE, 1977[4] NEP	U.S. DOE, 1977[4] No NEP	U.S. DOE, 1979[4] Mid
1975	45	56	14	14	13	13	13	12	12	---
1980	132	168	115	125	110	121	130	60	60	60
1985	342	511	306	330	280	339	385	194	196	175
1990	783	1,142	619	700	475	689	790	399	420	348
1995	N/A	N/A	N/A	N/A	740	1,137	1,365	730e	790e	571
2000	N/A	N/A	1,780	2,100	1,125	1,740	2,150	1,060	1,180	849

*For identification of sources, see Table II-1.

[1]Scenario I, .20% tails assay through 1995 and .30% thereafter; Scenario II, .20% tails assay through 1983 and .30% thereafter, with recycle in 1980.

[2]0.25% tails assay and with recycle beginning 1981.

[3]0.3% tails assay and with recycle beginning 1979.

[4]0.25% tails assay and no recycle.

N/A = Not available

Source: Boyle, Supporting Document No. 3, p. 21, with 1980 revisions per Table II-1, footnote 6.

technologies. Reserves are based on drilling and sampling and are the most reliable resource class. Probable potential resources are those estimated to occur in known productive uranium areas in extensions of known deposits or in undiscovered deposits within known geologic trends or mineralized areas. Possible potential resources are those estimated to occur in undiscovered or partly defined deposits in formations or geologic settings productive elsewhere in the same geologic province or subprovince. Speculative potential resources are those estimated to occur in undiscovered or partly defined deposits in formations or geologic settings not previously productive within a productive geologic province or subprovince, or within a geologic province or subprovince not previously productive. (Summarized from U.S. Department of Energy, National Uranium Resource Evaluation, 1979)

On January 1, 1978, New Mexico had 53 percent of the $30 per pound of U_3O_8 in ore (forward cost) reserves and 52 percent of the nation's $50 per pound reserves. One year later the state's share of $30 per pound reserves had risen to 54 percent, with the $50 per pound percentage unchanged at 52 percent. New Mexico had 36 percent of the U.S. $50 per pound probable resources as of January 1, 1979 (U.S. Department of Energy, Statistical Data, 1978, 1979). On January 1, 1980, the state had 48 percent of U.S. $50 reserves.

New Mexico, or the San Juan Basin, yielded 40 percent of U.S. U_3O_8 in ore from 1946 through 1977. In both 1976 and 1977, New Mexico produced 46 percent of the nation's U_3O_8 in ore. In 1978, the basin's share rose to 47 percent.

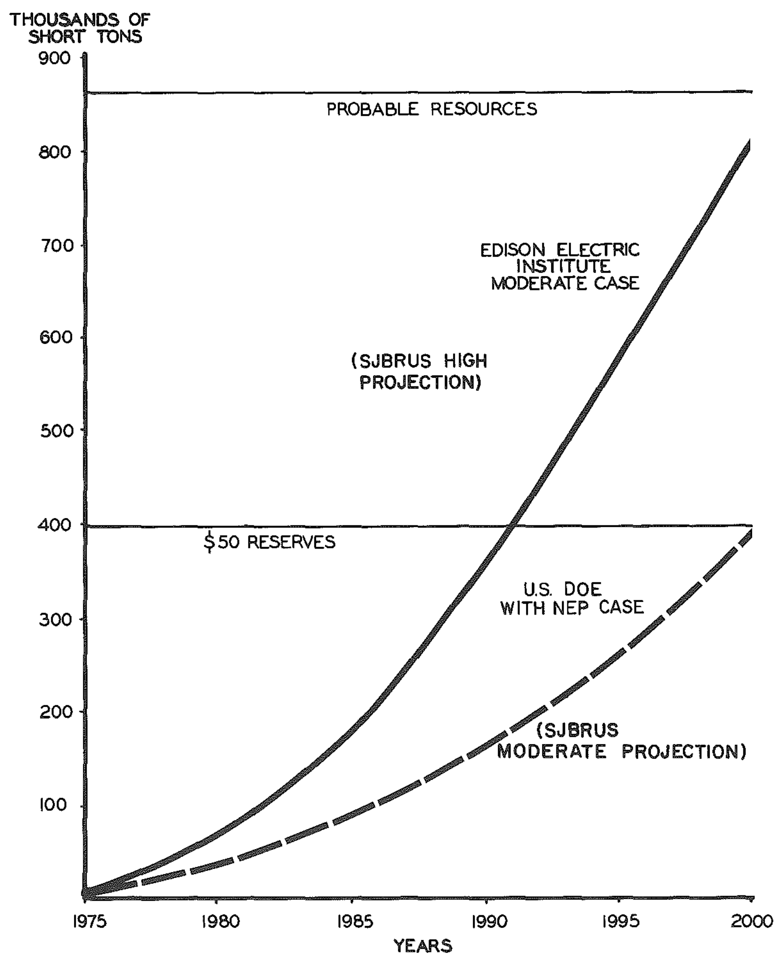
The assumption was made that New Mexico, with a historical production rate of more than 40 percent and future reserves of about half of national totals, will account for between 45 and 50 percent of U.S. production of

U_3O_8 until the $50 reserves are depleted. The basin's reserves should yield about 413,000 short tons of U_3O_8. This could meet close to half of the U.S. requirements to the early 1990's under the team's High curve and more than 40 percent throughout the period for the Moderate curve. Production of probable resources would start before exhaustion of reserves.

Based on these assumptions, the San Juan Basin share of uranium output in cumulative tons of U_3O_8 in ore from 1975 to 2000, as shown in Figure II-3 and Table II-3, is approximately as follows:

Moderate: 399,000 tons (DOE - mid);
High: 788,000 tons (EEI - Moderate).

The approximate annual production figures for the San Juan Basin under the High and Moderate levels of activity are shown in Figure II-4 and Table II-4. As stated earlier, these should be considered not as forecasts by the study but rather as a range of production levels assumed for the purpose of analyzing possible impacts.



NEW MEXICO CUMULATIVE U_3O_8 PRODUCTION TO 2000

Figure II-3

Table II-3

Assumed U.S. and New Mexico Mine Production of U_3O_8
(Thousands of Short Tons)*

EEI - Moderate Case[1]

	United States		New Mexico		
Year	Cumulative	5 Year Increments	5 Year Increments	Cumulative	Annual
1975[2]					6
1980	121	108	54	61	15
1985	339	218	109	170	27
1990	689	350	175	345	39
1995	1,137	448	202	547	43
2000	1,740	603	241	788	51

1979 U.S. DOE [3]

	United States		New Mexico		
Year	Cumulative	5 Year Increments	5 Year Increments	Cumulative	Annual
1975[2]					6
1980	60	48	24	30	9
1985	175	115	54	84	12
1990	348	173	79	163	18
1995	571	223	109	272	24
2000	849	278	127	399	27

*For identification of sources, see Table II-1.

[1]Selected as the SJBRUS "High" projection.

[2]Actual 1975 U_3O_8 production in ore by New Mexico was 5,500 tons; actual 1977 and 1978 production was 7,600 and 9,400 tons, respectively, as reported by DOE.

[3]Selected as the SJBRUS "Moderate" projection.

Source: Boyle, 1978, No. 3, with revisions, 1980.

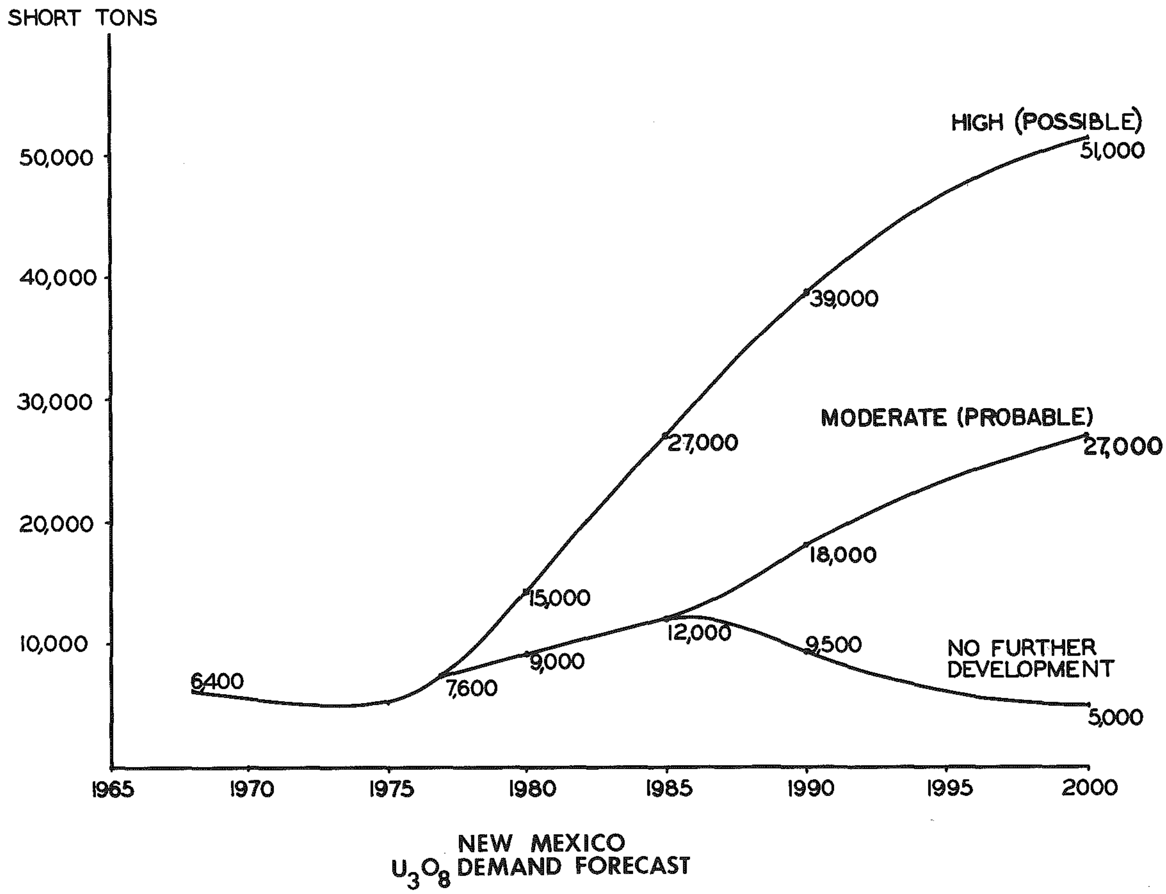


Figure II-4

Number of Uranium Mines. To translate the production estimates into mines, the quantity of ore that must come from new mines in order to supply the demand for U_3O_8 was determined. A 20-year life span was assumed for the average mine. Of the 38 New Mexico mines which were completed or virtually so by 1979 (Chapter I, "Uranium Industry") and the 25 then being constructed or announced as planned for construction, some would presumably still be operating in 2000. The estimated U_3O_8 production from the 63 units during the rest of the century was subtracted from the basin's anticipated total, and the remaining tonnage was presumed to require new mines beyond those either existing or announced as of the base year of 1979. It was assumed, in both the original and Final phases of this study, that the average mine would produce about 1,000 tons of ore per day. The logic for this is discussed below.

To estimate the average U_3O_8 production from mines in the future, something must be known about the grade of the ore. Ore grade is among the most uncertain of the many unknowns about ore deposits that have not yet been discovered or developed. The new deeper ore deposits could turn out to be much higher or much lower than the 0.21 percent average of the past in the basin. However, this analysis follows the view of most authorities that ore grades will decline in keeping with recent trends.

Table II-4

Annual New Mexico Output of U_3O_8 in Ore[1/]
(Short Tons)

Year	Actual U_3O_8 Output	Projected U_3O_8[2/] Moderate	Projected U_3O_8[2/] High
1968	6,442		
1969	6,210		
1970	6,056		
1971	5,464		
1972	5,722		
1973	4,984		
1974	5,400		
1975	5,500		
1976	6,500		
1977	7,600		
1978	9,400		
1979		---	---
1980		9,265	14,800
1981		9,900	16,750
1982		10,355	19,300
1983		10,900	21,800
1984		11,300	23,800
1985		11,800	27,250
1986		13,500	30,350
1987		15,000	32,850
1988		16,300	35,200
1989		17,250	37,400
1990		18,350	39,050
1991		19,500	40,180
1992		21,250	41,472
1993		22,520	42,582
1994		23,435	42,826
1995		24,250	42,245
1996		24,800	47,500
1997		25,350	51,686
1998		25,900	51,702
1999		26,450	50,963
2000		27,000	50,920

1/ Represents mine output, which is usually higher than the actual milled U_3O_8 product. Changing mine stockpiles can cause fluctuations in annual mill output.

2/ Totals will differ slightly from those in text due to rounding and transposition to annual basis.

Source: Myers, 1978, No. 10, Tables 1, 2, & 3, revised 1980.

The average grade of ore mined in New Mexico was down to about 0.18 percent in 1977. That grade was used to compute the mine size in the draft edition of this study. The grade fell to 0.15 percent in 1978 (U.S. Department of Energy, Statistical Data). This Final edition of SJBRUS assumes an ore grade of 0.14 percent.

Combining assumptions of a 265 day work year, ore grade of 0.14 percent, and production of 1,000 tons of ore per day translates into an annual U_3O_8 production per mine of 370 to 375 tons. An annual output of 375 tons of U_3O_8 in ore per year was settled upon for the future average mine. Present mines in the basin average about 225 tons of U_3O_8 per year.

Division of the 375-ton average into the total U_3O_8 tonnage projected for New Mexico in the next 20 years (Table II-3 and Figure II-4), yields the number of mines shown in Figure II-5 (48 by 1990, 72 by 2000). The curve in Figure II-5 shows the trend; the actual number of mines for any given year may be above or below the trend line. For example, at present some mines are being shut down, and the actual number of mines in 1981 and 1982 may fall below the trend line. Later the line predicts recovery. In other words, the number of mines shown in Figure II-5 is hypothetical. Numbers were estimated and locations selected only to help locate impacts. The important figure in determining impacts is quantity of ore mined. This determines the number of miners needed and the quantities of water, radon, and waste involved.

How do the assumptions on mine size jibe with the facts? Fairly well, when the following points are considered:

1. New mines will almost certainly be deeper than those of the past. This involves sharply higher costs. Only deposits capable of yielding a large production will justify the investment.

2. Due to higher costs, only large companies with access to substantial capital will open new mines. Such companies are interested only in major production sustaining large returns.

3. Mines announced for future operation, such as the United Nuclear-TVA operation at Dalton Pass, specify 500 tons of U_3O_8 per year as the goal. The Mobil Oil-TVA operation at Crownpoint hopes to produce 500 tons of U_3O_8 per year by the in situ method in addition to production from the same deposit by conventional underground mining methods. Mobil's underground mine output is scheduled to reach 312,000 tons of ore annually by the early 1980's. Depending on ore grades, this could yield more than 500 tons of U_3O_8 in ore per year.

Gulf Oil Corporation's Mount Taylor mine will be a large operation served by a mill with a capacity of 4,200 tons of ore per day. The mine is scheduled eventually to reach a production capacity of 1.42 million tons annually of ore with an average grade of 0.3 percent U_3O_8 (New Mexico Energy and Minerals Department, 1979, p. 80) If this grade holds, the yield could exceed 4,000 tons of U_3O_8 annually.

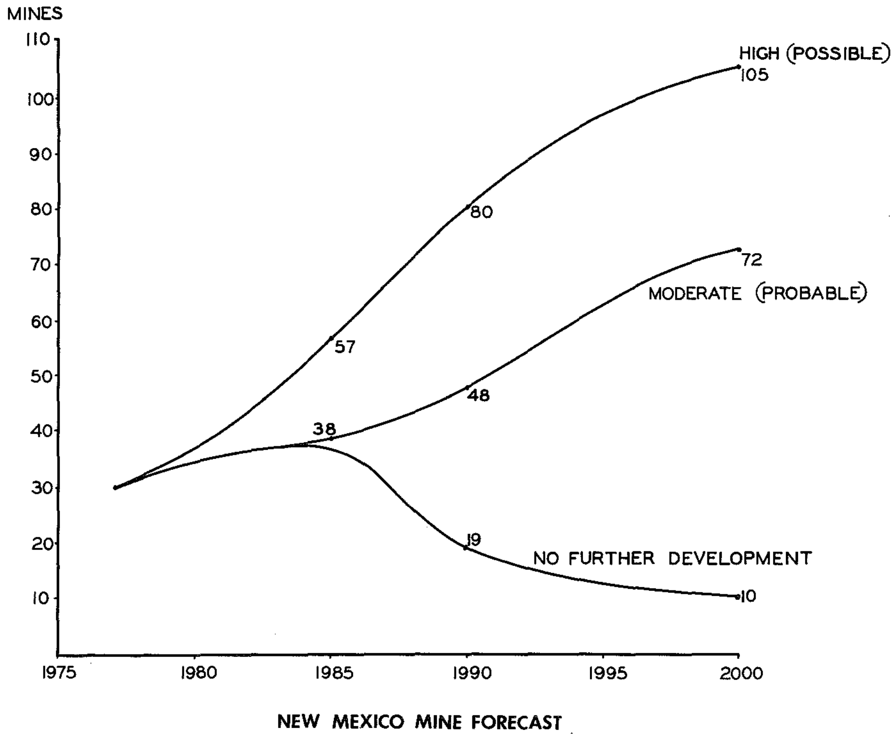


Figure II-5

Phillips Petroleum can be expected to produce at least 500 tons of U_3O_8 per year at Nose Rock (Hibpshman, 1978, No. 31). Phillips hopes to reach full production of 1,000 tons of U_3O_8 annually sometime in the mid-1980's (Form 10-K Annual Report, 1979, and 1980 announcement).

4. Lowering the average production level based on large mines will be that of some much smaller mines that are active or planning to re-open. The 375-ton figure falls between the extremes and compares with the current average production of about 225 tons of U_3O_8 in ore annually.

This analysis disclosed an interesting uncertainty. The projections for U_3O_8 production in the basin may well drop in future forecasts. However, some authorities expect the ore grade to drop, too, to as low as 0.09 percent (U.S. Department of Energy, 1980). If this should occur, the number of mines, and also their impacts, could well increase even with a decline in U_3O_8 production. With what is known today, the range of numbers of mines for the three curves in Figure II-5 seems reasonable and is in approximate agreement with the numbers used in the draft version of SJBRUS. These curves will be used as the trend lines to measure impacts in the later pages of this final edition of the study.

Uncertainties in Technology. At this point, one more imponderable in uranium development must be noted: the extent to which in situ leaching like that being tested by Mobil Oil may prove adaptable to the San Juan Basin. Described in detail in Chapter III ("Mining"), this method of uranium extraction is experimental in the region. In south Texas where it

has proved usable, in situ leaching converts uranium mining into an operation more reminiscent of oil production and eliminates the need for underground mines at specific sites. Value of the procedure in the study area is unpredictable pending completion of field tests.

If in situ leaching should come into significant use, many of the projections in this report, including employment numbers and environmental impacts, would be affected. Similar reservations apply to water-jet mining, described in Chapter III, and to developments outside the basin in recovery of uranium found in combinations with other minerals such as phosphates. By-product recovery from phosphate plants in the United States has been estimated at a potential 6,000 tons of U_3O_8 by 1985, decreasing to 5,000 by 2000. New Mexico's share of national uranium output could also be affected by foreign import and export developments.

Location of Mines. Mines required to meet the projected tonnages were divided among nine "ore reserve areas" defined by the Energy Research and Development Administration (ERDA) and retained by its successor agency, the Department of Energy. The ore reserve areas involved are Shiprock, West Chaco, East Chaco, Gallup, Ambrosia, Nacimiento, Mount Taylor, Laguna, Blackjack, and Chama. Their general locations, scattered across the New Mexico portion of the basin, are indicated on Maps IV-4 and IV-5. (Details are contained in Ridgley, et al, 1978, No. 8.)

In computations which allow for exploration and construction lags, as well as other factors, new mines to meet projected demands were spotted within the various ore reserve areas. Their locations were based on the premise that reserves would be tapped first, then probable and possible resources as warranted.

New unannounced mines could be expected to be needed from 1982 on to supply High demand projections and within the 1990's to supply Moderate projections.

Number of Mills. It was anticipated that existing and planned mills could handle all uranium ore mined into the 1980's. However, it was assumed that for every five new mines coming on stream, one new mill would be required. Each mill was assumed to have a production capacity of 5,000 tons of ore per day and 2,500 tons of U_3O_8 per year.

Location of Mills. Mills were initially allocated by the ERDA-DOE reserve areas, but this pattern failed to take into account the possibility that a mill in one region might be expected to process ore from mines in another. To allow for this, mills were shifted on a selective basis from one area to another.

Location Qualification. It should be understood that the sites chosen for possible future mines or mills are theoretical. They are not based on "inside" information and by no means constitute predictions of specific locations.

For impact analysis, it was necessary to approximate the areas that might be expected to experience increasing exploration, mining, and

milling. For this, general locations of proven and potential uranium ore deposits were used. Some data were aggregated to protect proprietary information.

The resulting development patterns are considered adequate for the study and offer hypothetical usefulness as a point of departure. However, the only actual locations on the maps depicting uranium-related activity through 2000 are those of existing or announced mines and mills.

ASSESSING OTHER URANIUM-RELATED FACTORS

Development Level the Key. Specific time frames are used in examining and reporting upon impacts that might occur between now and 2000. For example, 5-year and 10-year intervals are variously applied, in addition to the overall time span. This is done for convenience and to provide a frame of reference.

However, the controlling factor is not the date but the degree of development, which stems from U_3O_8 requirements. Trends, rather than specific figures, are the important factors. Specific timing cannot be predicted with any assurance of accuracy and in any event is secondary to the development level in assessing impacts. (See Maps II-1 through II-5.)

While the study period is basically the interval from the present through 2000, 1975 baseline data were used in certain instances. It is felt they provide a useful trend line in a period of change, particularly in cases where annual data are not maintained.

Employment

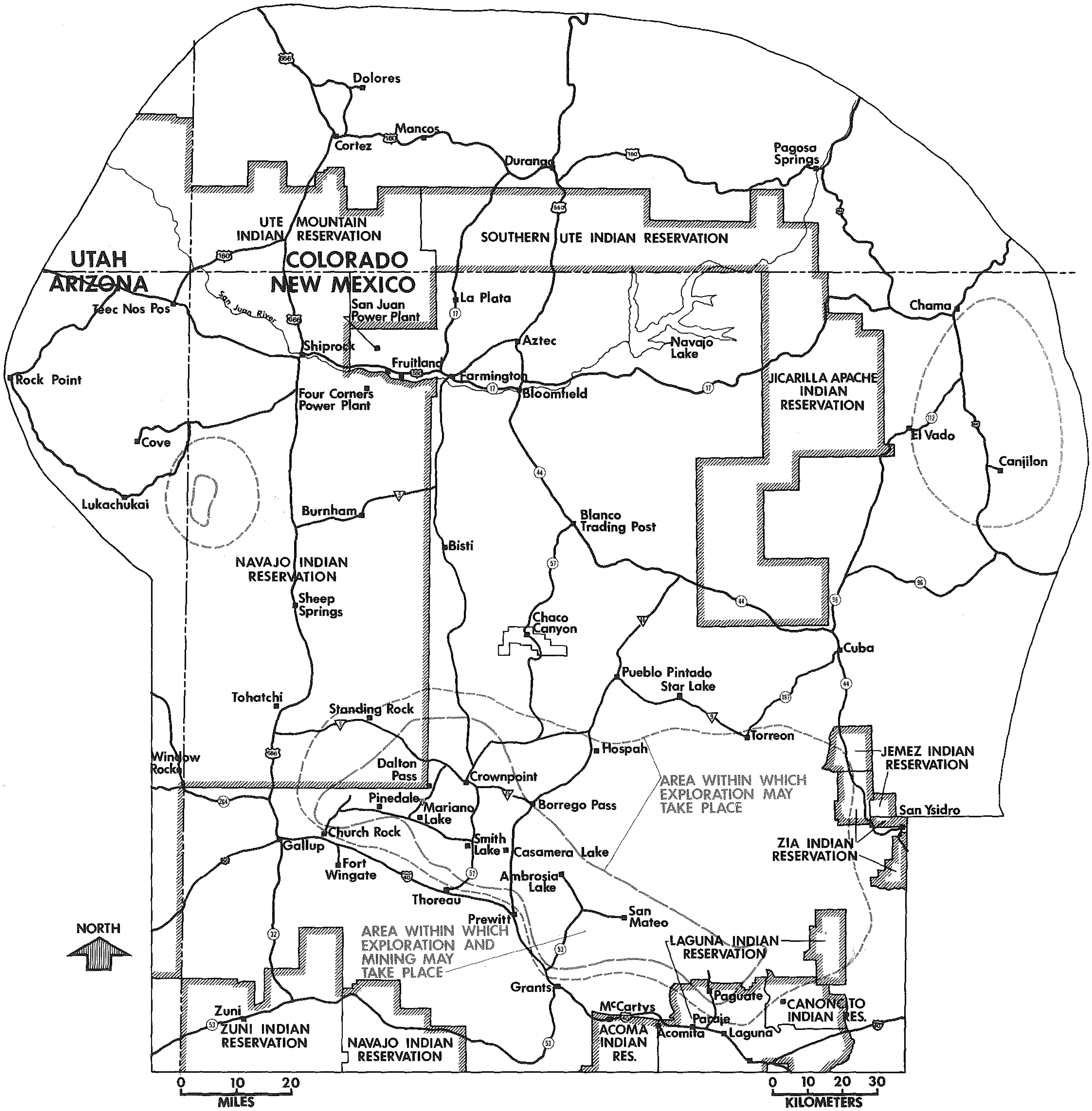
Many potential impacts can be expected to hinge on the number and type of people who move into a lightly populated area with the growth of an industry. Direct employment by the industry is the key in this regard.

Labor in the basin's uranium industry falls into five categories: Exploration and development, mine construction, mine operation, mill construction, and mill operation. Labor demand is keyed to output and labor productivity.

Ore Output and Employment. The close relationship between uranium ore output in the Grants mineral belt and the mine-mill employment levels is suggested in Figure II-6.

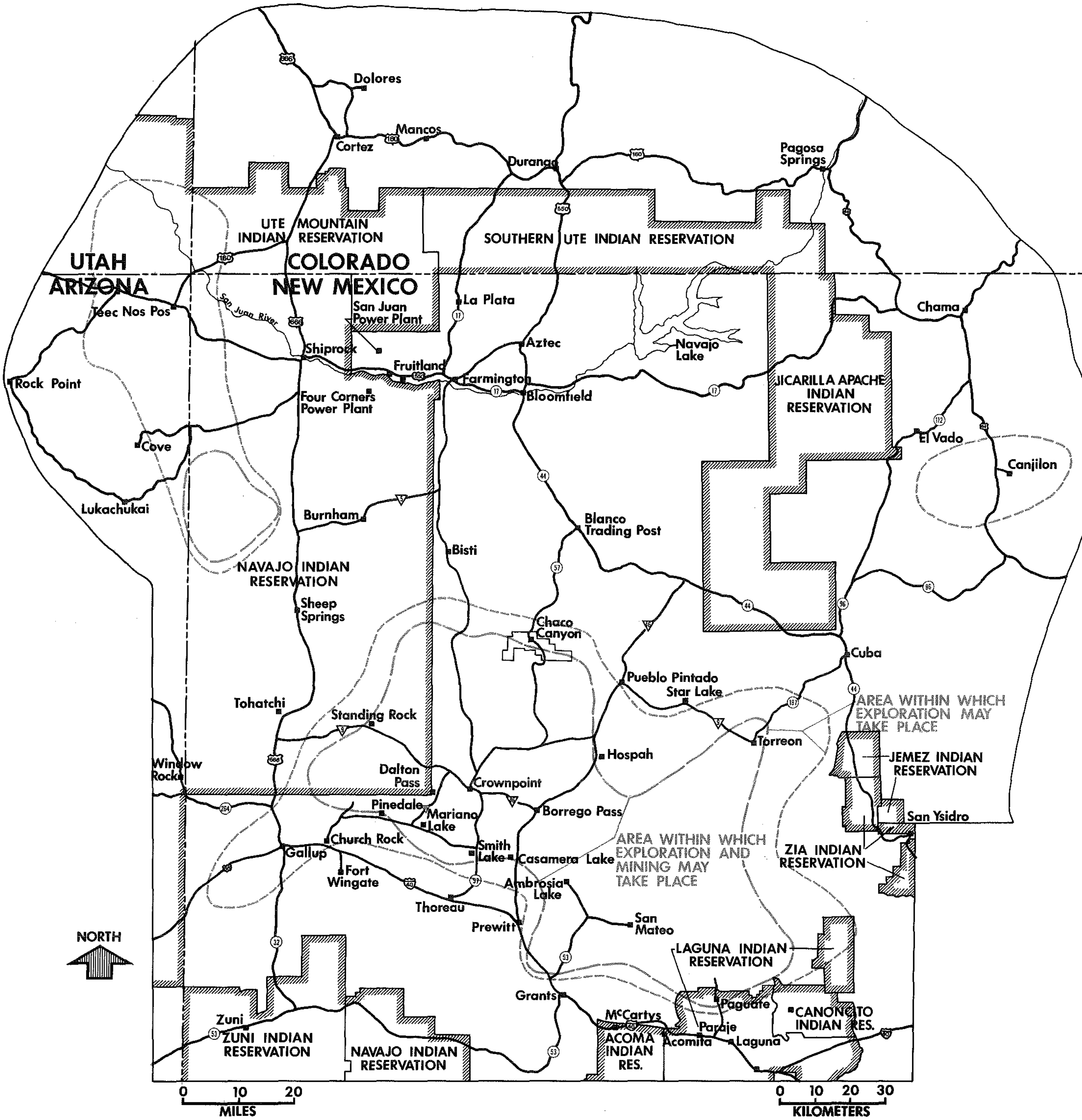
As shown on the chart, as ore production held relatively steady from about 1967 to 1970, so did employment. As output fell off in the early 1970's, so did employment. Output climbed from 1973 on, and employment rose sharply after 1974, reflecting the mining of deeper and/or lower grade deposits. Mill capacity, meanwhile, held at almost double the ore production during the period shown.

Mine Operations Employment. The number of mining personnel needed for any given mine depends upon the amount of ore the mine can produce and the mining technology used. The projections used here to determine the level



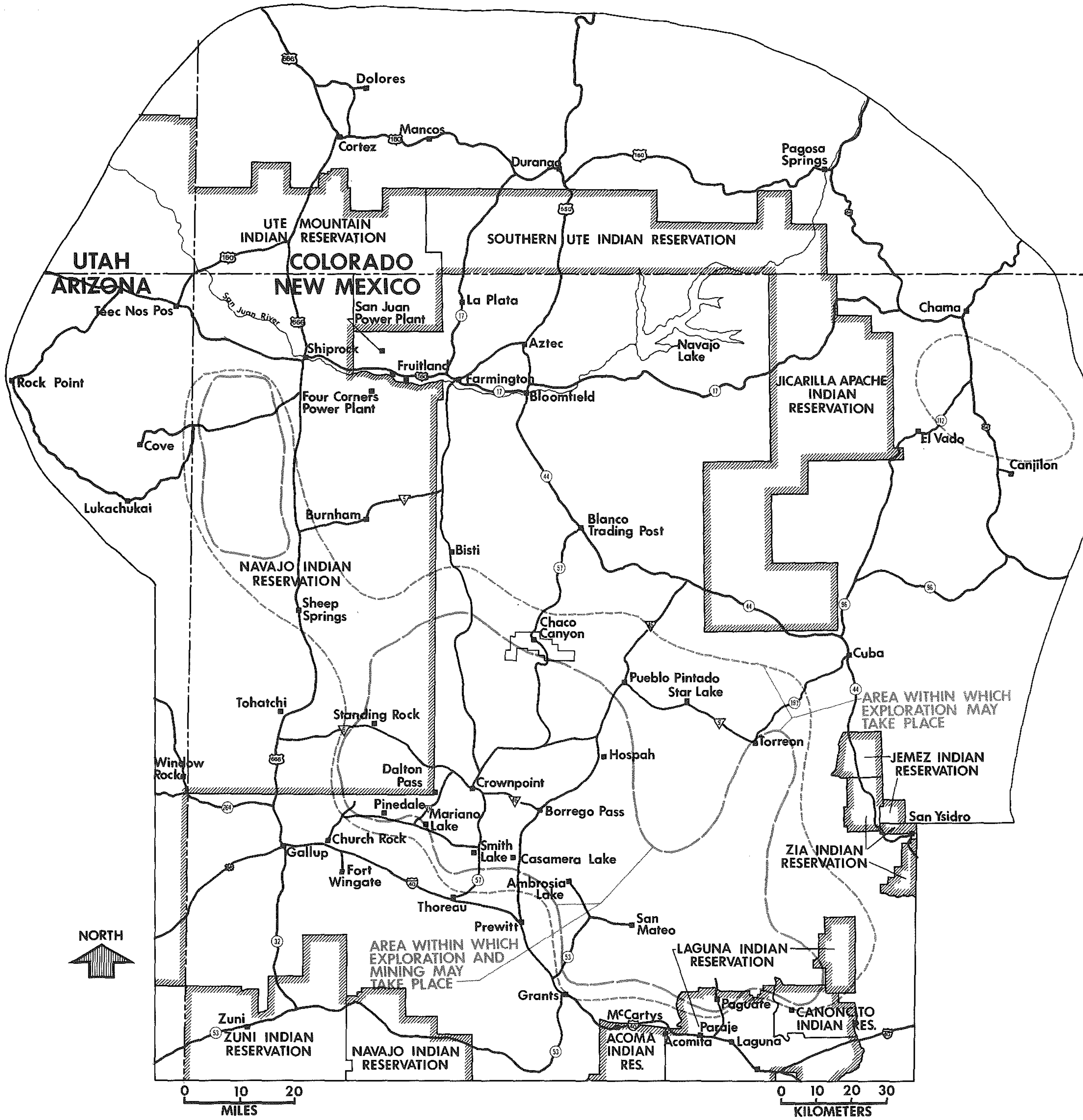
EXPLORATION AND MINING FORECAST-1980

Map II-1



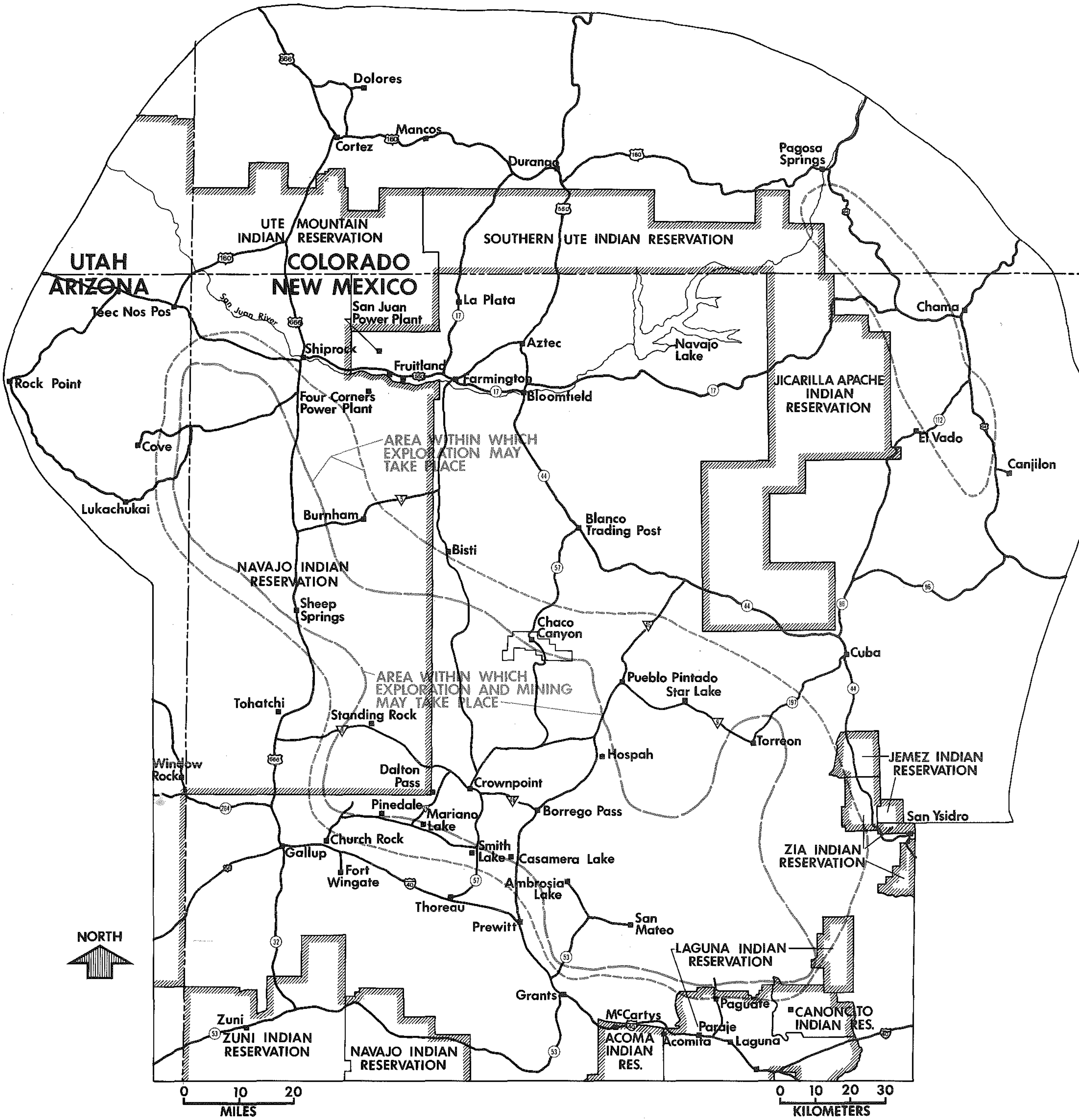
EXPLORATION AND MINING FORECAST-1985

Map II-2



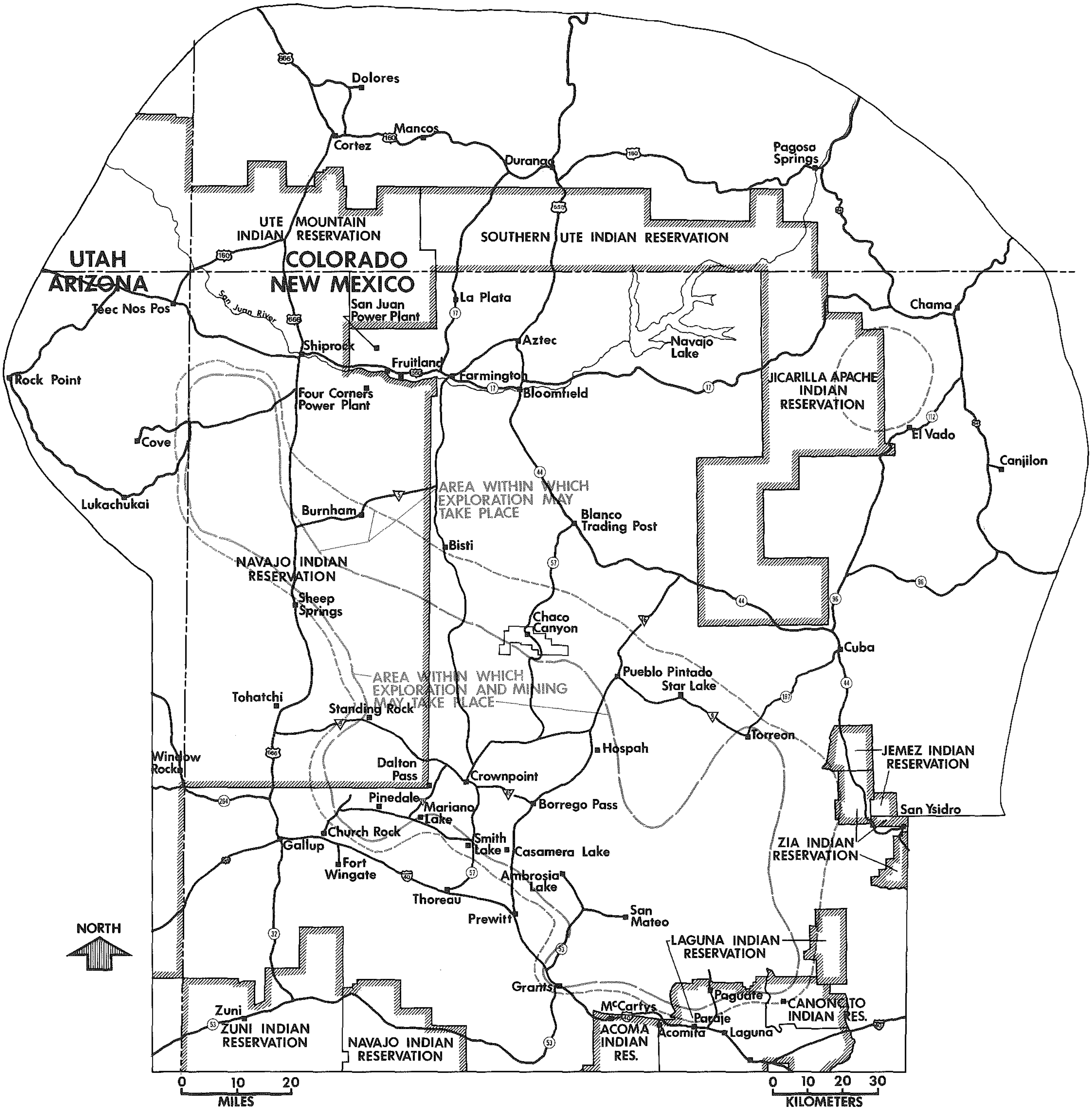
EXPLORATION AND MINING FORECAST-1990

Map II-3



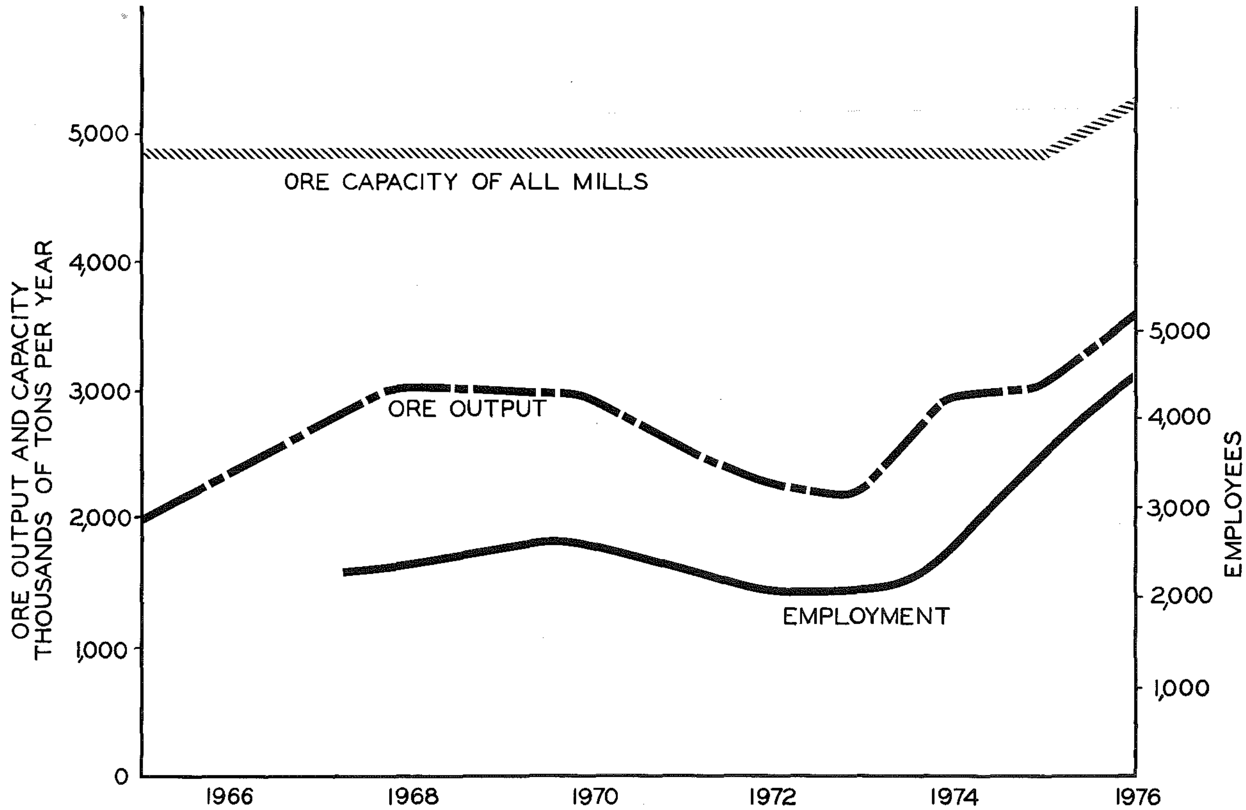
EXPLORATION AND MINING FORECAST-1995

Map II-4



EXPLORATION AND MINING FORECAST-2000

Map II-5



NEW MEXICO ORE OUTPUT, MILL CAPACITY, AND EMPLOYMENT IN URANIUM INDUSTRY

Figure II-6

of mining were based on U_3O_8 demand. This can be converted approximately into tons of ore produced if one knows the grade of the ore. Dr. John P. Myers based his projections of labor demand for this study in 1978 on U_3O_8 forecasts. As he said, however, "....the ore-based labor demand projection would be easier to use." Since then U_3O_8 projections have changed downward, but estimated ore grades have also dropped. The result has been that ore tonnage produced from the average mine using today's projections is close to the tonnage produced from the average mine used for the original labor projections two years ago. Therefore, the employment projections based on uranium demand continue to serve for the current analysis due to the combination of declining U_3O_8 demand prospects and declining ore grade.

Mining technology is another matter. Here, significant change which would affect employment is virtually certain. Consequently, two sets of mine labor projections were made for the study. One assumed constant technology. The other allowed for a major change in mining methods that can be foreseen with some confidence in the San Juan Basin--a switch entirely to underground mining for uranium. The second set assumed, though with no assurance of complete accuracy in the absence of firm figures, that the production of U_3O_8 in the study area was 44 percent from surface mining and 56 percent from underground mining for a base period of 1968 through 1974.

The surface output was assumed to fall linearly from 44 percent of the basin's production in 1977 to zero in 1985, in keeping with present trends. One result of this would be a decrease in labor productivity, increasing the mine personnel requirements with phasing out of surface operations. Underground mining technology was assumed to remain essentially unchanged during the study period.

The labor needed for an underground mine with a capacity of 375 tons of U_3O_8 in ore per year or 1,000 tons of ore per day is shown in Table II-5.

Table II-5

Labor Needed for 1,000-Ton (Ore) per Day Mine

	Number	Percent
Miners	123	51
Service and Support	75	31
Technical	13	5
Clerical	8	3
Supervisory	23	10
Total	242	100

Source: Based on data in ERDA, Statistical Data of the Uranium Industry, GJO-100 (various years).

Mill Operations Employment. In projecting the employment needed to operate uranium processing mills over the study period, ore grade and mill labor productivity were assumed to be constant. Productivity was measured in terms of U_3O_8 input to mills. This, in turn, was taken to be the U_3O_8 output from mines for a given year.

As in the case of mine employment, the resulting formula for estimating labor needs represented a compromise. The assumptions of constant productivity and constant grade, or that any changes in grade would be offset by changes in productivity, were deemed unavoidable due to the impossibility of predicting grade and productivity changes (Myers, 1978, No. 10). The labor needed for a mill with a capacity of 2,500 tons of U_3O_8 per year is shown in Table II-6.

Mine-Mill Labor Total. Employees needed to operate mines and mills should comprise about two-thirds of the direct employment of the uranium industry in the San Juan Basin moving ahead in the 1980's. Under the production estimates used in this study, the mine-mill employees are predicted to increase to some four-fifths of the labor force in 1990 and to

Table II-6

Labor Needed for 2,500-Ton (U_3O_8) per Year Mill

	Number	Percent
Operations	100	38
Maintenance	84	32
Technical	29	11
Other	13	5
Supervisory	37	14
Total	263	100

Source: Based on data from New Mexico Energy and Minerals Department.

constitute nearly all of the industry's employment by 2000. In all cases, mining is projected to require three to five times as many employees as milling (Tables II-7, II-8, II-9).

Construction. Actual mine and mill construction employment totals are not broken out in published uranium industry employment data. It was estimated, based on the information available, that construction of the average new mine would require 305 employees per year and that construction of the average new mill would require 105 employees per year. Two years' construction time was allowed for mines built in the near future, with a step-up to three years as the mines tap deeper ore deposits. Construction of mills was figured at three years each.

A falling off of construction employment toward the end of the century is depicted in Figure II-9 and Tables II-7 and II-8. The study team considers it reasonable to expect that the industry should be operating at a healthy pace in the San Juan Basin at the turn of the century. Actual production may peak after 2000.

Exploration. Exploration employment represents a small percentage of the overall industry employment, though an important one. The exploration category ordinarily refers both to pure exploration aimed at finding new ore deposits and to development drilling to map out known deposits. For purposes of this study, development drilling employees were considered part of the mine construction work force. Some office employees also are required in this phase.

Indications are that by 2000 about 37 percent of field activity may be for pure exploration, with 63 percent devoted to developing known ore

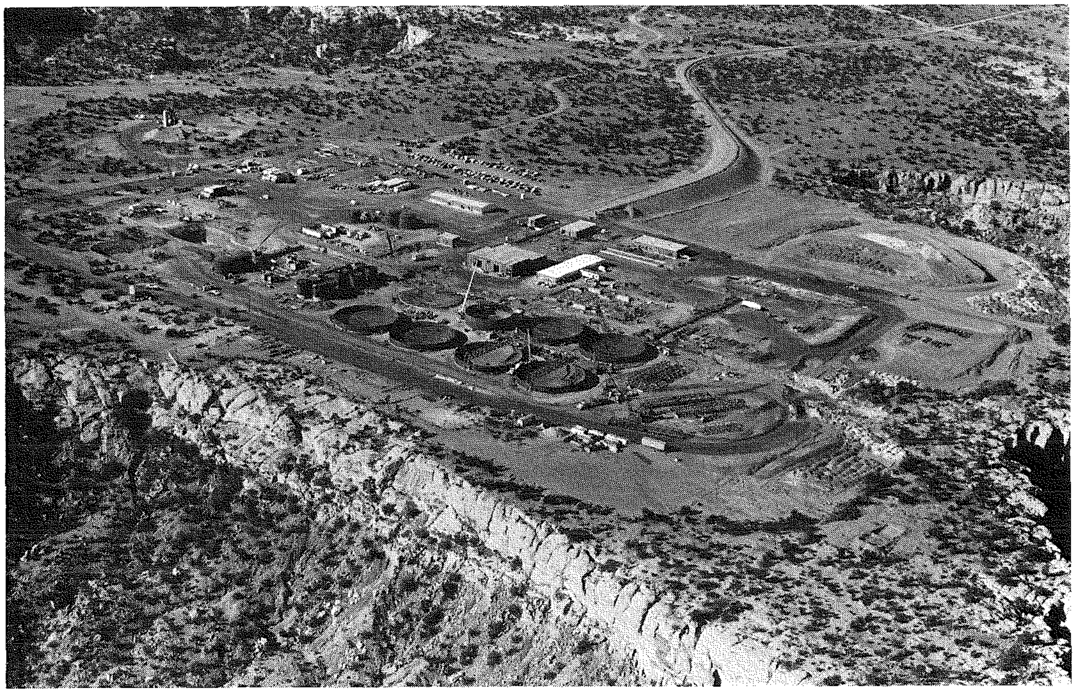


Figure II-8.--Mill under construction near
Bokum mine northeast of Mount Taylor

deposits. This would be close to reversal of ratios prevailing in the early 1980's. These projections are based on discernible trends.

Other Labor Estimates. From the various employment projections derived from specified U_3O_8 demand levels, estimates were made concerning total uranium employment requirements, the approximate expected ratios of local and in-migrant labor, and the extent of Indian employment that might be anticipated.

Population

Numbers. Population estimates are based on accepted practice, with a variety of group sensitive multipliers used to obtain the likely numbers of newcomers attributable to increased uranium industry activity. Also taken into account was population growth from other types of development and from such spin-off activities as service industries, utilities, transportation, and public agencies.

Distribution. The relative isolation of potential uranium development dictates that most workers must live elsewhere and commute to work by automobile or pickup. Their choice of residence would ordinarily be based on such factors as the availability of housing, personal preferences, community attractiveness, and travel time. The situation is complicated by the shortage of existing housing, the reluctance of lenders to finance

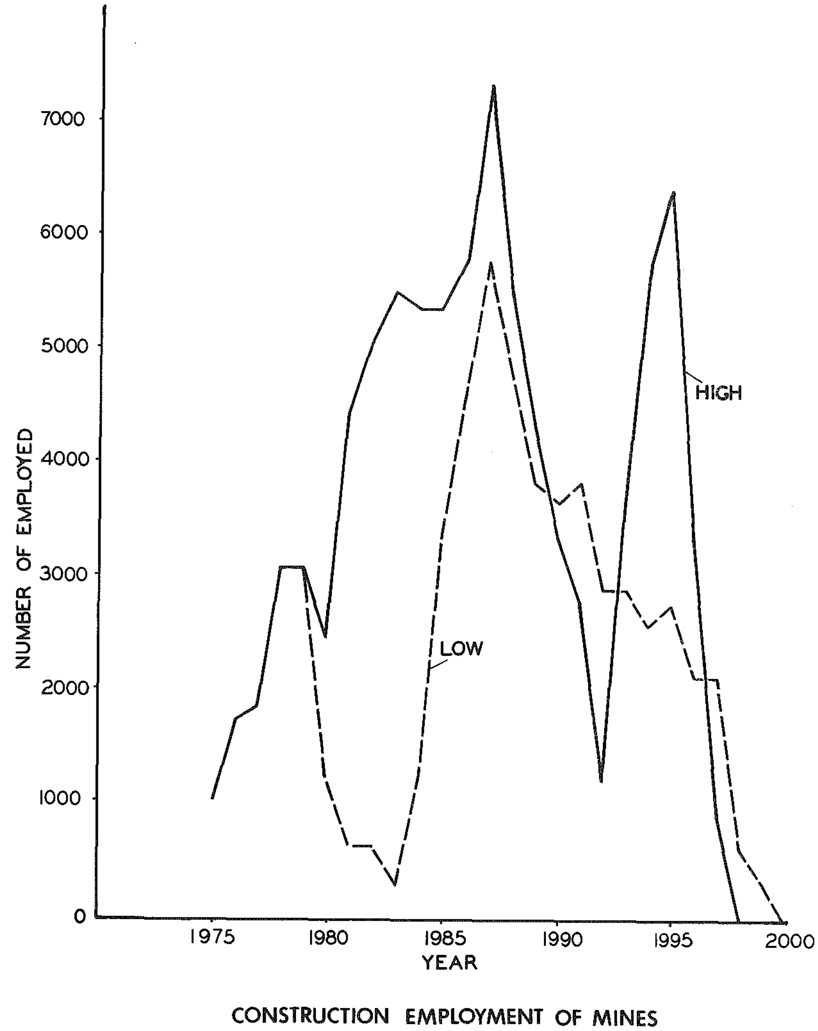


Figure II-9.--Uranium mine construction employment

longterm housing in communities with uncertain longterm prospects, serious questions on water supplies, and Indian and federal land ownership which restricts private developments in some places.

With 15 well established communities in the region, including the more distant metropolis of Albuquerque, early prospects were that most newcomers would tend to seek homes in or near the larger towns around the fringes of the uranium country.

This picture appeared subject to possible rapid changes, based on future decisions by a variety of entities. For example, a uranium producer moved a sizable number of mobile homes into one small community, producing a sudden population influx that would not otherwise have occurred at that particular time. Some consideration was being given to founding of a new town near the Navajo Indian Irrigation Project.

Since such decisions were not subject to prediction, it was assumed that larger communities would have more drawing power to incoming workers and their families because of housing availability and living amenities such as schools and markets. This attraction could be expected to lessen as commuting difficulties increased with travel distance or poor road conditions.

A gravity model, assessing community drawing power, was used for assigning energy employment to the various communities. In this computation designed to make comparisons possible, the population of a community was discounted by such factors as those cited above to yield a measure of the community's attraction. An approximation of the proportion of workers that might choose to live in particular communities if housing was available thus was obtained.

Basic Uranium Development Projections

Moderate Basin Development. Under the study's Moderate projection, production of U_3O_8 in ore would climb from the 5,500 tons and the 9,400 tons produced by basin mines in 1975 and 1978, respectively, to about 12,000 tons in 1985, 18,000 tons in 1990, 24,000 tons in 1995, and 27,000 tons in the year 2000 (Table II-4). The study team's calculations show such a production schedule could increase:

Mines: from 37 in 1979 to 72 in 2000 with greater individual capacity.

Mills: from 5 in 1979 to 15 in 2000, with individual mills possessing almost 20 percent more average daily ore capacity.

Mine Operating Employment: from less than 3,000 in 1975 to 17,532 in 2000.

Mill Operating Employment: from less than 900 in 1975 to 3,645 in 2000.

Total Uranium Employment: from about 4,300 in 1975 to approximately 21,000 in 2000 after peaking in 1996 at about 23,000.

Population: from about 200,000 in the New Mexico part of the study area in 1977 to about 400,000 in 2000 assuming moderate industrial development.

The maximum rate of increase in total industry employment would occur from the mid-1980's on, perhaps creating more than 1,200 new jobs annually during an expansion period. Approximate estimates prepared in 1978 are shown in Table II-7.

High Basin Development. Under the High uranium demand projection, production of U_3O_8 in ore would climb from 5,500 tons in the basin in 1975 and 9,400 tons in 1978 to about 27,000 tons in 1985, 39,000 tons in 1990, 42,000 tons in 1995, and 51,000 tons in 2000 (Table II-4). The study team's calculations indicate increases along these lines.

Mines: from 37 in 1979 to 105 in 2000, with greater individual capacity.

Mills: from 5 in 1979 to 22 in 2000, with individual mills averaging almost 20 percent more daily ore capacity.

Mine Operating Employment: to more than 24,700 in 2000.

Mill Operating Employment: to more than 5,100 in 2000.

Total Uranium Employment: to almost 30,000 in 2000 after having peaked at about 33,000 in 1995.

Population: to about 450,000 in 2000 assuming moderate industrial development.

Table II-7

Estimated New Mexico Uranium Employment
Based on Moderate U_3O_8 Demand Assumptions

	Year 1975	Year 1980	Year 1990	Year 2000
Exploration[1]	---	303	222	155
Mine Construction[2]	---	1,421	3,895	---
Mine Operation[3]	---	3,490	11,634	17,532
Mill Construction[4]	---	600	0	---
Mill Operation[4]	---	912	2,420	3,645
Total[5]	4,345	6,726	18,171	21,332

[1]Exploration includes only field exploratory drilling employment; for breakdown see Gibson, p. 19.

[2]Mine Construction includes development drilling employment; for breakdown, see ibid, p. 27.

[3]Mine Operation figures assume switch to 100 percent underground mining in 1985; see ibid, p. 28.

[4]Mill Employment, 1978; source: ibid, p. 28.

[5]Figure for 1975 is based on Department of Energy data and is not strictly comparable to other years shown due to differing definitions.

Principal Source: Gibson, 1978, No. 5, p. 15.

As with the lower projection, industry employment would grow most rapidly from the mid-1980's on, perhaps reaching 2,000 or more additional job openings annually for several expansion years. Approximate employment estimates prepared in 1978 are shown in Table II-8. Comparisons of mine and mill employment prospects are given in Table II-9.

Table II-8

Estimated New Mexico Uranium Employment
Based on High U_3O_8 Demand Assumptions

	Year 1975	Year 1980	Year 1990	Year 2000
Exploration[1]	---	341	224	91
Mine Construction[2]	---	2,666	3,592	---
Mine Operation[3]	---	5,706	18,969	24,736
Mill Construction	---	600	450	---
Mill Operation	---	1,492	3,938	5,135
Total	4,345	10,805	27,173	29,962

[1]Exploration includes only field exploratory drilling employment; for breakdown see Gibson, p. 74.

[2]Mine Construction includes development drilling employment; for breakdown, ibid, p. 82.

[3]Mine operation figures assume switch to 100 percent underground mining in 1985, ibid, p. 83.

[4]Figure for 1975 is based on Department of Energy data and is not strictly comparable to other years shown due to differing definitions.

Principal Source: Gibson, 1978, No. 5, p. 70

Employment Makeup

If local participation rates in the uranium work force persist in the future, from 50 to 75 percent of the total work force will be provided by migration from other areas. Immigration rates are likely to average from 600 to 800 employees per year but with high development could range considerably higher in the second half of the 1980's.

Underground mine employment, which provides a large share of uranium mining and milling positions, has been found less popular than other occupations among Navajos, although many are employed in mines near Church Rock. Expectations are that 4,000 or more Navajos and perhaps 1,000 Laguna, Acoma, and other Indian workers may find employment somewhere in the industry by 1995 (Myers, 1978, No. 10).

Table II-9

Estimated New Mexico Mine-Mill Operations Employment[1]

Moderate Projection	1980	1990	2000
Mine Operation[2]	3,490	11,634	17,532
Mill Operation	912	2,420	3,645
Sub-Total	4,402 (65%)	14,054 (77%)	21,177 (99%)
High Projection	**1980**	**1990**	**2000**
Mine Operation[2]	5,706	18,969	24,736
Mill Operation	1,492	3,938	5,135
Sub-Total	7,192 (67%)	22,907 (84%)	29,871 (99.7%)

[1]With percentage of total uranium employment in basin.

[2]Assuming switch to 100 percent underground mining in 1985.

Source: Gibson, 1978, No. 5.

ASSUMPTIONS ON NON-URANIUM DEVELOPMENT

Other development taken into account in assessing the combined, cumulative environmental impacts in the San Juan Basin region includes 19 coal mines which might be operating by approximately 1990. Impacts assessments also are based on assumptions of four coal-fueled electric generating plants, one coal gasification plant, a geothermal generating plant, and construction of two railroad spurs and a 730 KV transmission line. The Navajo Indian Irrigation Project and oil, natural gas, and helium activities also were considered.

ASSUMPTIONS ON URANIUM RECOVERY OPERATIONS

Organization of Study. The SJBRUS covers two broad divisions: 1) Natural environment, and 2) Human or Socioeconomic environment. Specialists based their calculations on projections and information summarized in this report and detailed in working papers.

In addition to assumptions on non-uranium activities, it was necessary to assume certain details concerning possible impact-producing activities in uranium recovery. From these, analyses could be made based on the three assumed uranium development levels in the basin.

Exploration Assumptions. For impact assessment purposes, these assumptions were derived from industry and government sources concerning uranium exploration activity in the basin:

Average Exploration Project

Number of Projects	1990	2000
Moderate	32	22
High	32	13
Area of Disturbance:		
Exploration drilling	150 holes/project	
Drill holes	1/10 to 1/3 acre/hole	
Roads to site	1 acre/hole	
Total Area Disturbed	165 to 200 acres/project	
Life Expectancy	3 years	

Mine Assumptions. The following assumptions, based on industry and government sources, were made concerning the average new uranium mine going into operation in the basin from 1980 on:

Average New Mine

Capacity	375 tons U_3O_8 in ore/year 1,030 tons ore/day Grade: 0.14 percent U_3O_8
Life Expectancy	20 years
Area of Disturbance:	
Development drilling	258 holes/mine
Drill holes	1/3 acre/hole
Roads to site	1/2 acre/hole
Sub-total	215 acres
Mine Site	45 acres
Roads to site (12 miles)	60 acres
Sub-total	105 acres
Total Area Disturbed	320 acres
Vents	3
Exhaust Air	Varies to 400,000 or more cubic feet/minute
Mine Water Discharge*	500 to 3,000 gallons/minute (720,000 to 4.3 million gallons per day, 800 to 4,800 acre-feet per year

* Academic use only. U.S. Geological Survey model uses other methods.

Mill Assumptions. The following assumptions, derived from industry and government sources, were made concerning the average new uranium mill going into operation in the basin henceforth (average 1977 capacity in parentheses):

	Average New Mill
Capacity	2,500 tons U_3O_8/year (1,360 tons) 5,000 tons ore/day (4,200 tons)
Life Expectancy	20-30 years
Area of Disturbance:	
Mill	30-40 acres
Tailing pond*	250-500 acres
Roads	10-15 acres
Total Area Disturbed*	290-555 acres
Water Requirement	1.5 million gallons/day

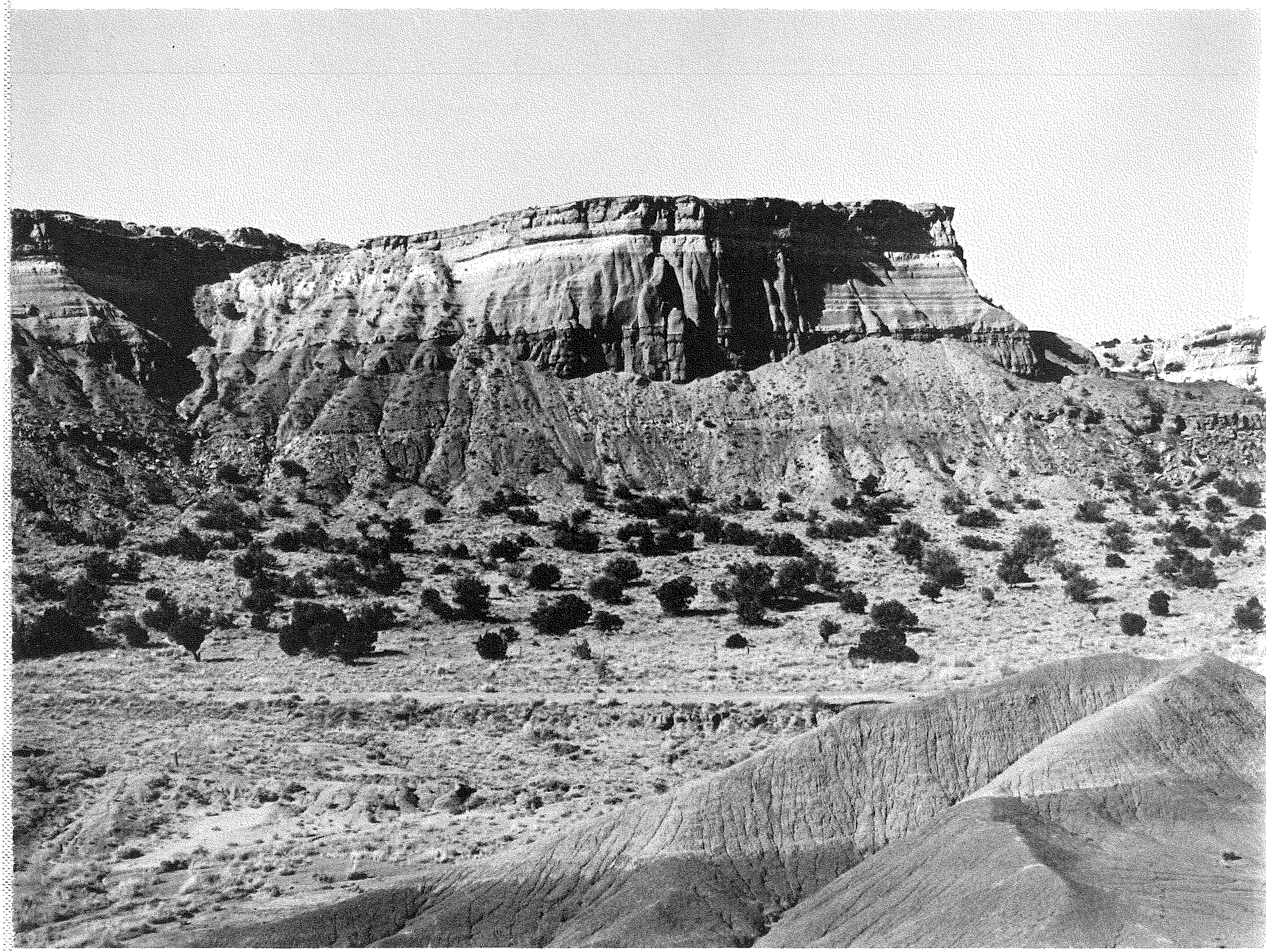
* Actual area will vary with terrain.

CHAPTER III

THE GEOLOGICAL OCCURRENCE

and

PRODUCTION OF URANIUM



Chapter III

THE GEOLOGICAL OCCURRENCE AND PRODUCTION OF URANIUM

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Figure III-1 (oversheet).--Cliffs of Jurassic Section near San Ysidro, N.M. At base lies Triassic age Chinle Formation, towered over by cliffs of Entrada Sandstone capped by Todilto Limestone.

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Chapter III

The Geological Occurrence and Production of Uranium

INTRODUCTION AND PURPOSE

The purpose of this chapter is to provide an overview of the geologic setting of the San Juan Basin and its relationship to mining operations. The geology of ore-bearing strata is one of the determining factors in choosing an exploration and mining method.

It is anticipated that future uranium operations will use exploration, mining, and milling methods similar to those now used in the basin. A brief overview description of these methods is presented here to set the stage and provide a basis for analysis of impacts at various levels of possible future uranium development. Information on leasing and the regulatory processes associated with the uranium industry is provided on Chart XI-1 (in the back cover pocket).

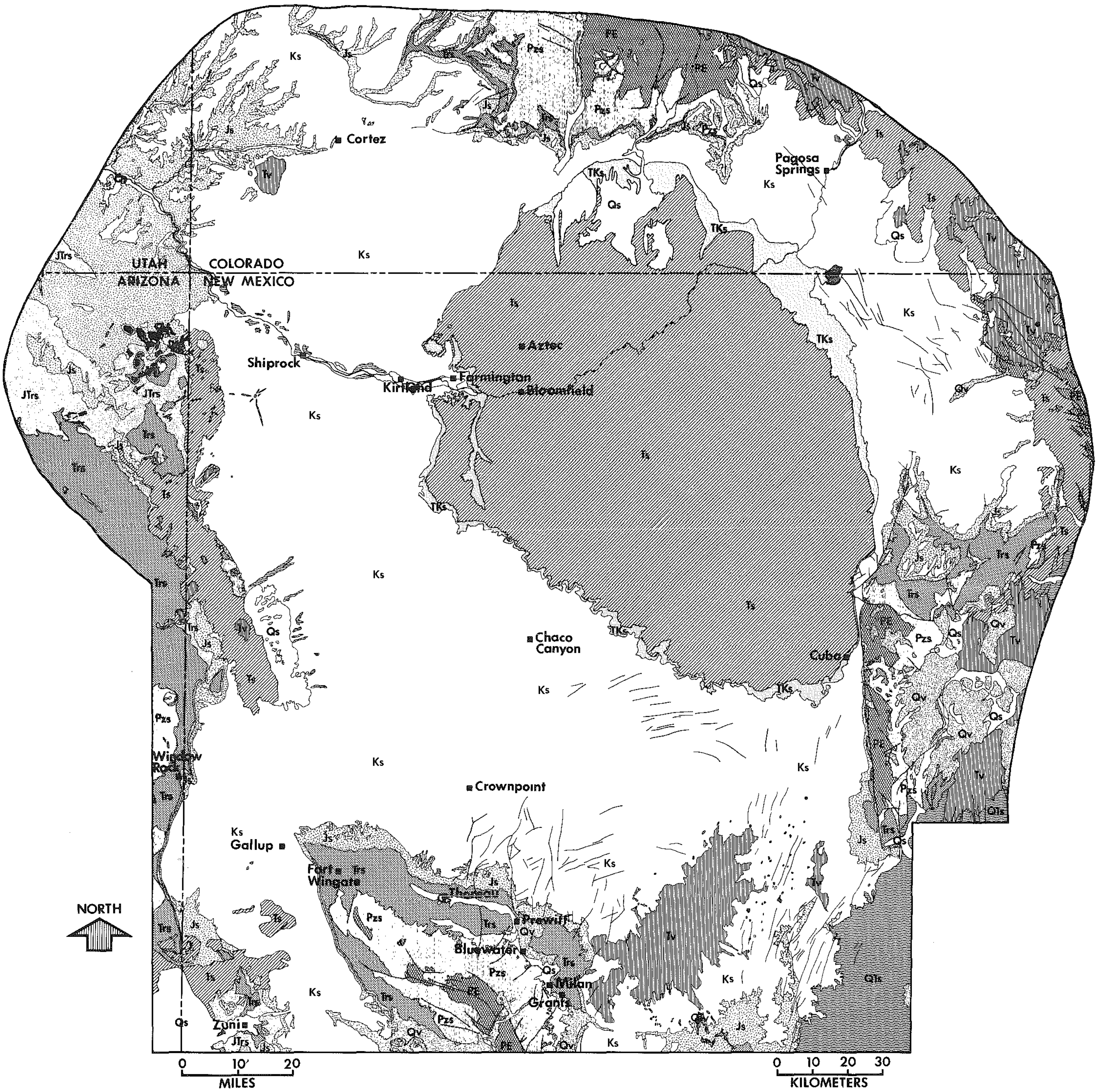
GEOLOGIC SETTING OF THE SAN JUAN BASIN

Overview

The San Juan Basin region is a semiarid domain of mesas, volcanic remnants, canyons, cliffs, plains, and badlands. Rock formations in many places are laid bare by erosion as though by a cleaver. The rocks tell a dramatic history of a series of past geologic environments. The earth's crust in the area heaved up and later sank to be immersed beneath seas. The land bears the imprints of seaways, seashores, swamps, sand dunes, great lakes, rivers, streams, and volcanoes. Such volcanic reminders as Mount Taylor and Shiprock, though youthful by geologic reckoning, are heavily eroded survivors of their even greater past.

During the eons in which these convulsions occurred, the stage was set for the emergence of the San Juan Basin region into the 20th century energy limelight. It was within the last 70 million to 150 million years that most of the large deposits of uranium, sub-bituminous coal, natural gas, and oil were formed. They are found in specific layers of the sedimentary rocks which cover the area.

<u>Note: Surface features, which might logically be described here, are discussed at the beginning of the Topography section in Chapter VI. Environmental aspects and possible impacts upon them are discussed together in this report wherever possible.</u>



GENERALIZED GEOLOGIC MAP

Source of Map and Key: Ridgely, et al, 1978, No. 8.

Map III-1

EXPLANATION

		Period	Era
Qs	Shown only in areas where deposits are appreciably thick or have large aerial extent. Includes consolidated and unconsolidated surficial deposits of alluvium, dune sand, landslide and mudslide debris, spring deposits, caliche, and glacial deposits. Qs deposits are of Pleistocene and Recent age and have been deposited in a variety of depositional environments. Most of the deposits in the map area have in the past and are presently accumulating under arid to semi-arid climates in fluvial, lacustrine eolian, and gravity environments present within intermontane basins. Caliche deposits, although relatively minor as compared to fluvial and lacustrine deposits are the products of diagenesis of bolson and other alluvial deposits. Glacial deposits are restricted to the northern part of the map area at higher elevations and are associated with past periods of alpine glaciation.	QUATERNARY	CENOZOIC
Qv	Found mainly in the areas adjacent to the Zuni Uplift. Includes all compositional and depositional types of extrusive and intrusive igneous rocks of Quaternary age. Also includes sedimentary rocks of fluvial origin which are composed predominantly of clastic sediments of volcanic origin.	QUATERNARY	CENOZOIC
QTs	Includes conglomerate, sandstone, siltstone, and claystone of Quaternary-Tertiary age deposited predominantly in fluvial, lacustrine, and eolian, depositional environments. QTs rocks are found mainly in the Rio Grande Trough and eastern part of the San Juan Sag.	QUATERNARY-TERTIARY	CENOZOIC
QTv	Found mainly in the areas adjacent to the Zuni Uplift. Includes all compositional and depositional types of extrusive and intrusive igneous rocks of Quaternary-Tertiary age. There are no known occurrences of uranium in these rocks within the map area.	QUATERNARY-TERTIARY	CENOZOIC
Ts	Found mainly in Rio Grande Trough-Chama Basin area, central San Juan Basin, and areas on the south-southwest and east flanks of the Defiance Uplift. Includes thick beds of conglomerate sandstone, siltstone, and claystone. Locally contains thin limestone beds and intercalated lava flows and tuff beds in the Rio Grande-Chama Basin areas. Thick accumulations of Ts rocks were deposited by high to low energy streams into several small rift basins extending north-south in the Rio Grande Trough area.	TERTIARY	CENOZOIC
Tv	Tertiary igneous rocks occur in clusters and isolated outcrops throughout the map area, indicating that Tertiary igneous activity was widespread. Although Tv rocks shown on the map include a wide variety of compositional and depositional types of extrusive and intrusive igneous rocks, most outcrops are basaltic and ryolytic in composition and occur in the form of volcanic necks, stocks, laccoliths, dikes, sills, lava flows, or accumulations of air laid and water laid volcaniclastic sediment. Frequently, these rocks are interbedded with Ts rocks.	TERTIARY	CENOZOIC
TKs	Outcrops of Tks rocks are found primarily in the central San Juan Basin and are composed of thick rock sequences formed in continental environments under dominantly fluvial and lacustrine conditions. Conglomerates, sandstone, siltstone, and claystone, arkosic in composition, and locally carbonaceous comprise the TKs rocks.	TERTIARY-CRETACEOUS	CENOZOIC / MESOZOIC
TKv	Found mainly in areas adjacent to the Rio Grande Trough in the southeastern part of the map area, eastern flank of the Zuni Uplift and Acoma Sag, and on the northeast flank of the Defiance Uplift. Tkv rocks are similar in composition and depositional type to Tv rocks.	TERTIARY-CRETACEOUS	CENOZOIC / MESOZOIC
Ks	Outcrops of thick sequences of Ks rocks are widespread in the map areas. Rocks are composed of conglomerate, sandstone, siltstone, claystone, limestone, coal, lignite, and thin beds of bentonite deposited in deep marine, shallow marine and coastal marine depositional environments during several periods of transgressive and regressive marine invasions during Cretaceous time.	CRETACEOUS	MESOZOIC
Js	Includes redbeds of conglomerate, sandstone, silt stone, claystone, and limestone of Jurassic age deposited predominantly in continental fluvial, lacustrine, and eolian depositional environments. Some units of shallow marine origin may also occur in the sequence, particularly in the northern part of the map area. Thick sequences of eolian dune sandstone and siltstone are widespread in lower and middle Js rocks, indicating a dominance of arid desert conditions during early and middle Jurassic time. Desert dune and sabkha environments dominated. Upper Js rocks were apparently deposited under less arid conditions in fluvial and lacustrine environments rich in carbonaceous matter.	JURASSIC	MESOZOIC
JTrs	Includes redbeds units of Jurassic and/or Triassic age similar to those in the lower part of the overlying Js sequence.	JURASSIC-TRIASSIC	MESOZOIC
Trs	Widespread continentally deposited redbeds of conglomerate, sandstone, siltstone, claystone, and limestone deposited in fluvial, lacustrine, and eolian depositional environments. The sequence is dominantly of fluvial and lacustrine origin and, with the exception of the dominance of water laid sediments over wind laid sediments, is similar to the overlying Js sequence of rocks.	TRIASSIC	MESOZOIC
Pzs	Rocks of Paleozoic age (Cambrian, Devonian, Mississippian, Pennsylvanian, and Permian periods) are present throughout the map area and consist of beds of both marine and continental origin. A wide variety of depositional environments and subenvironments are known including fluvial, lacustrine, eolian, shallow and deep marine, coastal and evaporite basin. Rock types include continental redbeds of conglomerate, sandstone, and siltstone which intertongue laterally with marine evaporite sequences of limestone, dolomite, gypsum, anhydrite, and salt.	PERMIAN, PENNSYLVANIAN, MISSISSIPPIAN, DEVONIAN, CAMBRIAN	PALEOZOIC
PE	PE rocks in the map area consist mainly of a variety of metamorphic rocks; however, some sedimentary and igneous rocks are also present. PE rocks all lie mainly in the subsurface and are exposed most commonly in the core areas of the major uplifts.		PRECAMBRIAN

CONTACT

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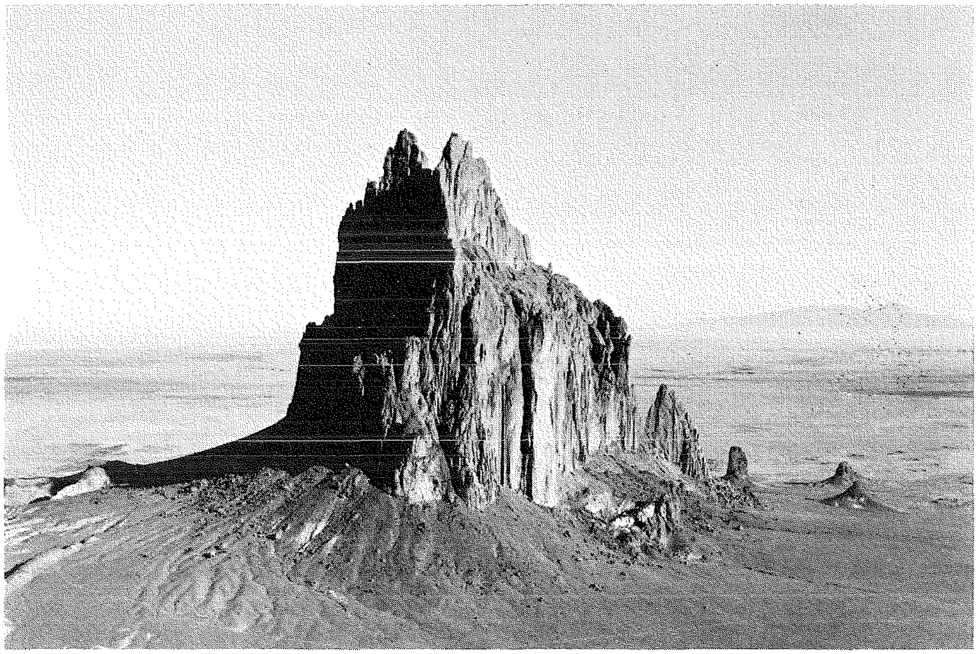


Figure III-2.--Shiprock

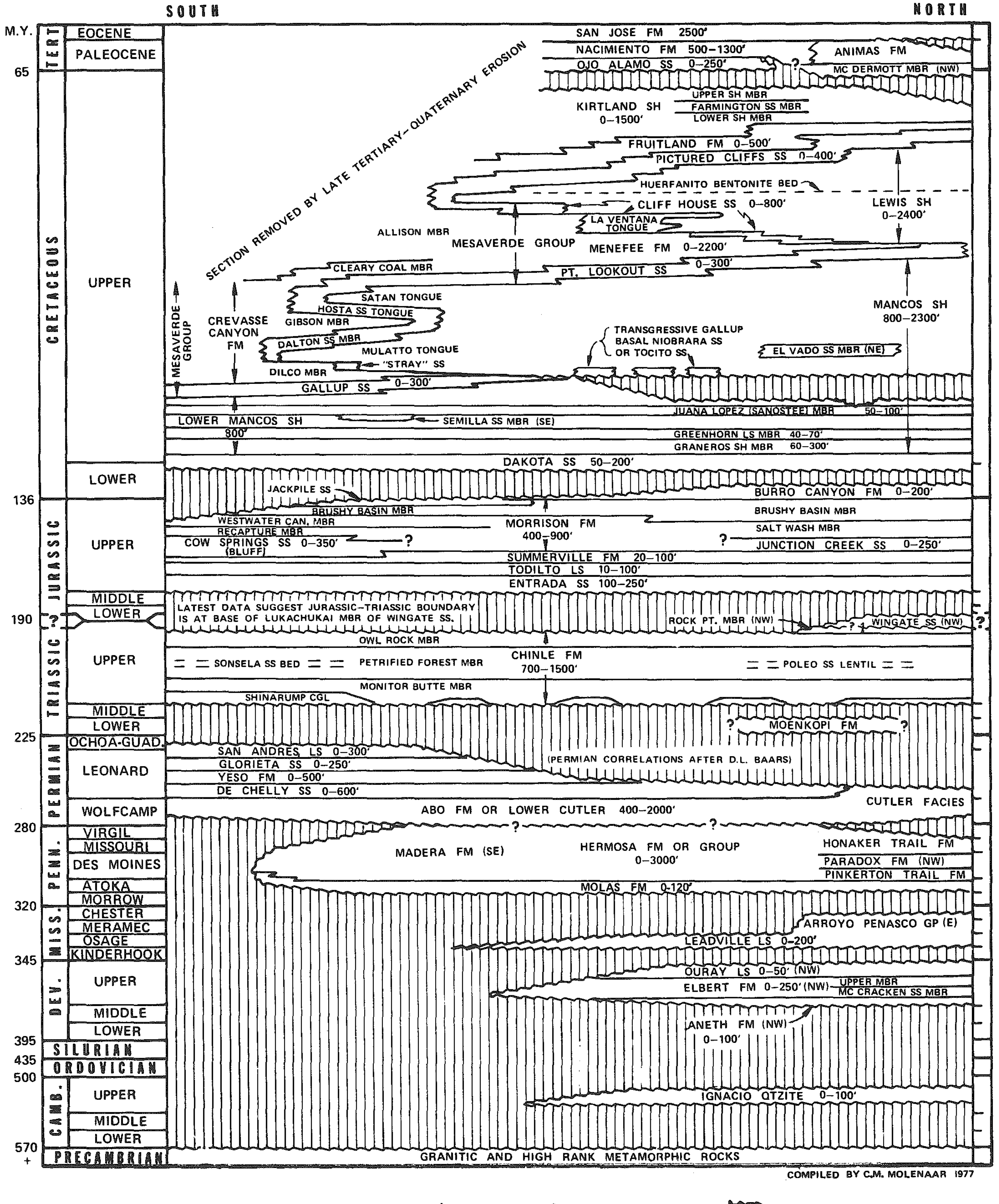
Geologic studies of the region have been extensive. The description of the geology and occurrence of uranium deposits is summarized from Ridgley, et al, 1978, No. 8. (For a generalized portrayal of the study area's geology, see Map III-1.)

The Colorado Plateau, within which the basin lies, is underlain by Precambrian basement rocks which are more than 570 million years old. (See stratigraphic section, Figure III-3.) These rocks are overlain by generally horizontal sedimentary rocks up to 11,000 feet thick and a variety of volcanic rocks.

The sedimentary rocks are commonly eroded and well exposed near the margins of the basin. Tectonic, or mountain-building, activity which deformed the earth's crust built the platforms, monoclines, and other structural features of the present basin. Map III-2 shows the tectonic zones in the study area. Formations which lie flat toward the west side of the basin may be tipped upward on the east side of the basin and sometimes to the north. Toward the basin center, these formations lie well below the surface.

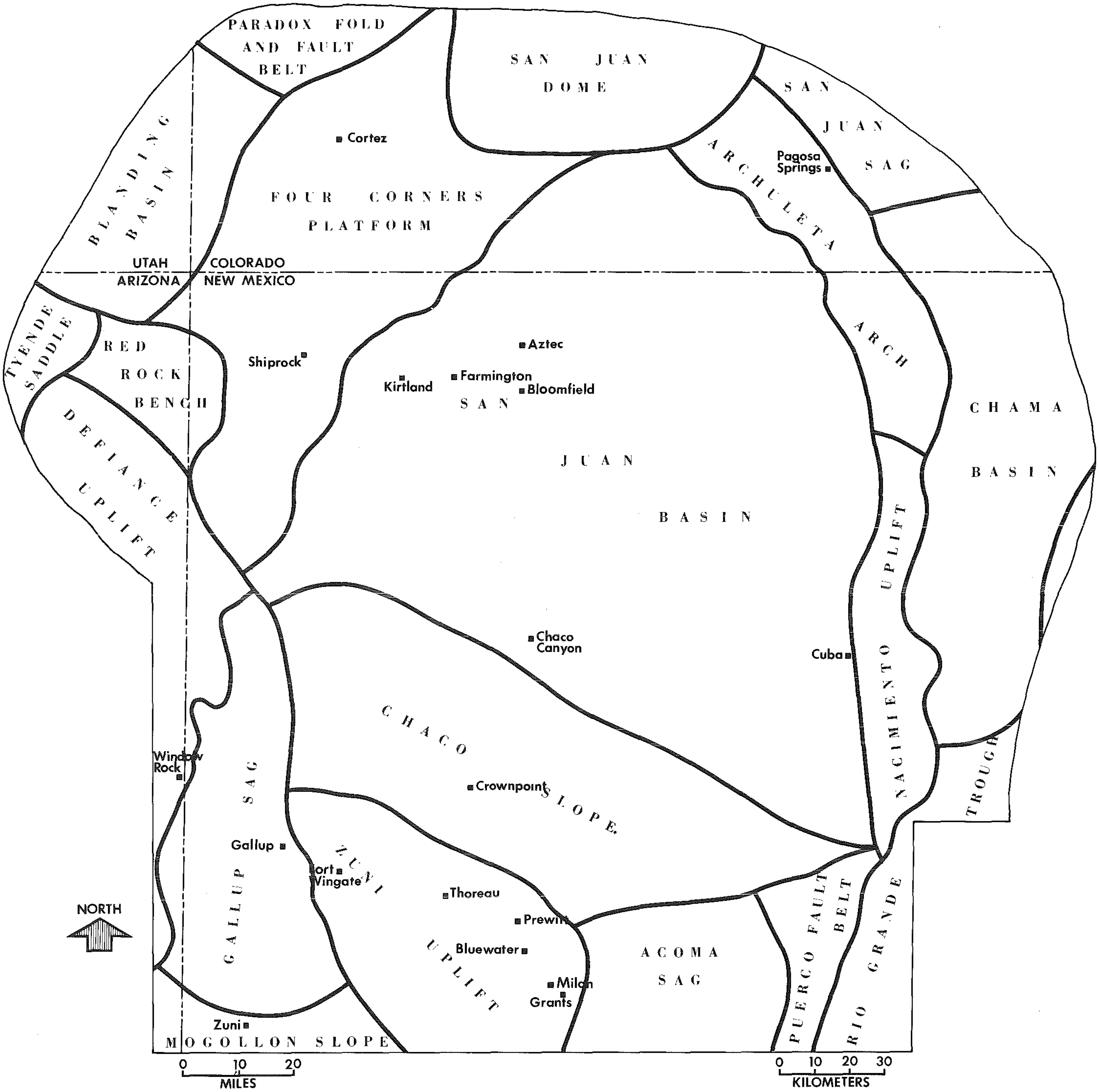
It is sedimentary rocks of Jurassic age (more than 130 million years old) in the southern part of the basin that contain the largest known uranium deposits in the United States and offer promise of more. Most production from the San Juan Basin has come from the Morrison Formation sandstone of Jurassic age. The boundaries of the study area were selected to encompass the known outcrops of the Morrison Formation in this vicinity. (See Map III-3).

SAN JUAN BASIN TIME-STRATIGRAPHIC NOMENCLATURE CHART



Source: USGS

Figure III-3



TECTONIC ZONES

Map III-2

Uranium Occurrences and Deposits

In the study area, uranium is found mainly as tabular, or flat-lying, deposits in sedimentary rocks that range in age from Paleozoic through Cenozoic, in pegmatites and veins in igneous and metamorphic rocks of Precambrian age, in veins in volcanic rocks of Tertiary age, in pipe deposits in sedimentary rocks of Jurassic age, and in diatremes (volcanic vent remnants) in sedimentary rocks of Tertiary age.

Most of the uranium obtained to date from the Colorado Plateau has come from tabular deposits in sedimentary rocks. Some deposits end in a sharply defined curved surface and have been commonly known as roll-type uranium deposits. Production from deposits in the Morrison Formation, Chinle Formation, Todilto Limestone, and Dakota Sandstone account for almost all of the ore mined. Minor occurrences and small deposits are known in sedimentary rocks of other ages (Hilpert, 1969). No significant production has come from veins, pegmatites, or diatremes, and only one of the pipe deposits has been an important producer.

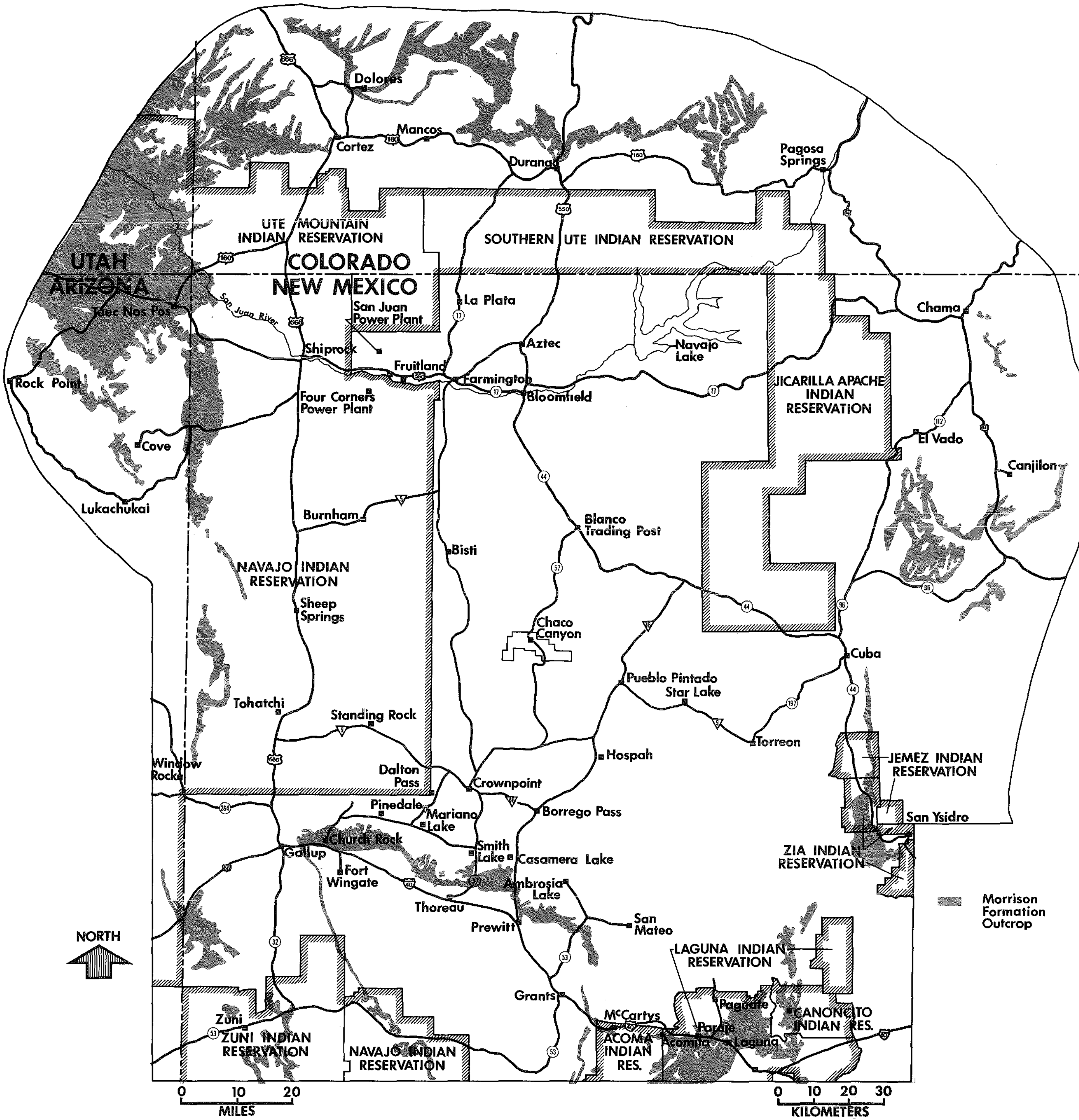
Tabular deposits in sedimentary rocks are generally lenticular bodies which are roughly parallel to the bedding of the host rock. They range from thin layers a few feet in width and length to bodies as much as 30 feet thick, several hundred feet wide, and several thousand feet long (Hilpert, 1969, p. 64). The most important host rocks are crossbedded and conglomeratic sandstone. Lake bed-formed limestone and marginal-marine carbonaceous sandstone, shale, lignite, and coal contain small to medium-size tabular deposits in the southern and southeastern parts of the San Juan Basin and vicinity. Wind deposited sandstones along the northwestern flank of the San Juan Mountains in Colorado contain uranium-bearing vanadium deposits. Ore minerals (Granger, 1963; Fischer, 1968) found in the sedimentary rocks consist of primary pitchblende, uraninite, or coffinite, as well as such yellow secondary minerals as tyuyamunite, carnotite, zippeite, and others. Uranium often occurs as a urano-organic complex in carbonaceous shale, lignite, and coal. The ages of the primary deposits are often nearly as great as the ages of their respective host rocks; however, subsequent remobilization and reprecipitation of the uranium may produce deposits much younger than the rock in which they are found.

Uranium in Precambrian Rocks

Precambrian rocks in the San Juan Basin and adjacent region consist mainly of metamorphic rocks of various types, although some igneous and sedimentary rocks are present. Uranium is found in pegmatites along the northeastern border of the Chama Basin and in altered granite in the core of the Zuni Uplift (Lovering, 1956). None of the occurrences is commercially important.

Uranium in Paleozoic Rocks

Rocks of Paleozoic age are present throughout the study area and consist of conglomerate, sandstone and siltstone along with limestone, dolomite, gypsum, anhydrite and salt.



THE MORRISON FORMATION

Source: Ridgley, et al, 1978, No. 8.

Map III-3

A number of occurrences and a few small deposits of uranium are found in Paleozoic rocks in the southeastern part of the region. The host rocks are mainly of the Cutler and Abo Formations of Permian age. The Madera Limestone of Pennsylvanian age contains a few small deposits associated with faults.

Uranium in Mesozoic Rocks

Triassic Rocks. Mineable deposits of uranium in Triassic rocks occur mainly in southeastern Utah and northeastern Arizona in the Monument Upwarp and Defiance Uplift areas. A few minor occurrences are known along the southern and eastern sides of the San Juan Basin. In the study area, the mines in Triassic rocks are more productive than any except those in Jurassic rocks.

The uranium is found mainly in channel sandstone and conglomeratic sandstone of the Chinle Formation of Late Triassic age. Carbonized plant material is common in the ore-bearing parts of the rocks.

Jurassic Rocks. Minor amounts of uranium are found associated with vanadium in the wind-deposited Entrada Sandstone, and small to medium-size uranium deposits occur in the lake-deposited Todilto Limestone. Medium-size to very large uranium ore bodies are found in river-deposited sandstone of the Morrison Formation.

One deposit in Jurassic sandstone northwest of Silverton, Colo., is in the Entrada Sandstone. This deposit on the northwestern flank of the San Juan dome contains mainly vanadium and has minor amounts of uranium.

Uranium deposits in the Todilto Limestone are found mainly along the southern margin of the Grants mineral belt, where the limestone has been deformed by folding within the formation. Uranium occurrences in limestone are also known in the Sanostee, N.M., area, as well as near the town of Coyote, N.M., on the southern margin of the Chama Basin.

Deposits in the Morrison Formation are found along the southeastern, southern, and western parts of the basin. Deposits similar to those on the western side are found to the north in the Blanding Basin and in the Paradox Fold and the Fault Belt. One deposit in a collapsed pipe structure, the Woodrow deposit (Hilpert, 1969, p. 106), is found in the Morrison Formation north of Laguna, N.M.

Deposits in the southeastern part of the San Juan Basin and vicinity are small, but deposits in the southern part of the area in the Grants mineral belt are very large. These deposits are found mainly in carbonaceous, river-deposited sandstone of the Westwater Canyon and Brushy Basin Members of the Morrison Formation. The belt is roughly coincident with the Chaco slope and extends from Laguna to Gallup, N.M., a distance of about 84 miles. Results of drilling suggest that the belt may be at least 25 miles wide. However, only a very small part of the belt, perhaps one percent or less, is underlain by rocks containing anomalous amounts of uranium.

Deposits on the western side of the San Juan Basin, as well as in the Blanding Basin and the Paradox Fold and Fault Belt, are found mainly in sandstones of the Salt Wash Member of the Morrison Formation. Some deposits are found in the Recapture Member in the Sanostee area of New Mexico. The deposits are generally much smaller than deposits in the Grants mineral belt.

Cretaceous Rocks. Cretaceous uranium deposits and occurrences are found mainly in the southern and southeastern parts of the San Juan Basin. A few scattered occurrences are known in the western and northwestern parts of the San Juan Basin as well as in the central part of the Blanding Basin. The deposits are found mainly in sandstones, but some are found in lignite and in shales which were formed in swamp environments. Most of the deposits are in the Dakota Sandstone, but some are found in the Menefee, Fruitland, and other formations above the Dakota.

Uranium in Cenozoic Rocks

Small, noncommercial tabular deposits of uranium are found on the northern and eastern sides of the San Juan Basin in sedimentary rocks of the Nacimiento and San Jose Formations of Tertiary age. Uranium, generally in non-commercial grades or quantities, is also found in the Tertiary volcanic rocks of the San Juan Mountains north of Silverton, Colorado.

Origin of the Deposits

The tabular deposits in sedimentary rocks are generally believed to have been derived by precipitation of dissolved uranium in ground water, by reaction with carbonaceous material present in the sediments, or by the action of bacteria which have the ability to live without air inside rocks. The source of uranium in the ground water can probably be traced to the leaching of source rocks (granitic, arkosic, and/or tuffaceous types). Permeable beds of the host rocks allowed passage of the uranium-bearing waters, whereas interbedded claystone and mudstone acted to constrain and thus concentrate flow of the waters.

Uranium in pegmatites was probably deposited at a late stage of igneous activity at temperatures considerably higher than those attained during formation of the tabular deposits in sedimentary rocks. Vein deposits were probably formed at temperatures between those of tabular and pegmatite types. Uranium in veins may have come entirely from hydrothermal solutions from igneous sources derived deep in the earth's crust or from descending or laterally moving waters that had leached uranium deposits. Uranium in the diatremes may have a depositional history somewhat similar to that for the veins, whereas the uranium in the pipes or collapse structures may have an origin related to that of the tabular deposits in the sedimentary rocks in which the pipes are found.

Bibliographic references and additional information on the origin of tabular uranium deposits in general, and of the deposits of the San Juan Basin region in particular, can be found in Ridgley, et al, 1978, No. 8.

TECHNOLOGY OF URANIUM PRODUCTION

Acquisition of Rights

Before commitment of resources to surface exploration affecting property rights, the necessary rights to obtain access and perform the intended operations must be obtained. Land thought to hold potential may be purchased outright or leased; provision must be made for both surface and mineral rights, which frequently are in different hands. Complexities in ownership and jurisdiction, particularly in the basin's checkerboard area, figure importantly in this regard and can dictate the negotiating process.

Leases customarily confer rights to conduct exploration operations, with mining authorized where warranted. Terms may provide a limited period, a minimum level of activity, annual lease payments, royalty percentages on any production, reclamation and damage terms, and other provisions. Arrangements may be included for conversion of test holes to water wells. In certain cases joint venture agreements have been established.

Exploration

The primary method of exploration for uranium deposits in the study area is drilling. However, airborne radiometric surveys, surface-related radon gas sampling programs, and geochemical exploration programs often precede drilling.

Exploration and development drilling activities are generally performed in phases, with each succeeding phase requiring closer hole spacing. Initial drilling is generally on 1 to 2 mile spacing and if encouraging mineralization is found, additional holes are drilled more

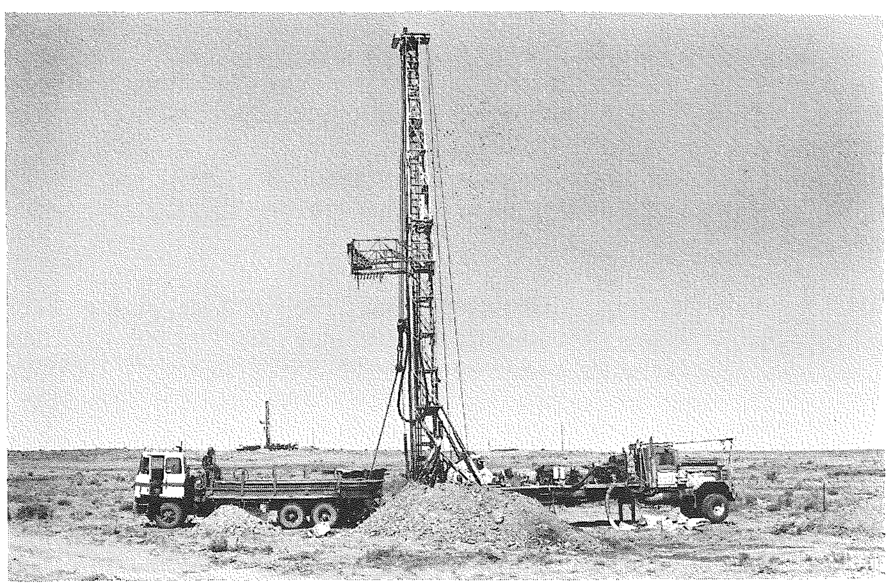


Figure III-4.--Typical exploration drilling operation in the study area

closely together to delineate the extent, thickness, and quality of the mineralization.

Holes are usually 4 to 6 inches in diameter, drilled by conventional rotary-drilling methods using truck mounted drill rigs. Drill sites on relatively level terrain are about 1/10 acre in size, while drill sites on steep terrain may be as large as 1/3 acre or about 100 by 150 feet. A drilling mud pit 10 to 15 feet long and 5 to 6 feet wide and deep is excavated near the drill-hole location to be used as a catchment basin and recirculation pond for the drilling mud. This mud is used to carry the rock chips, or cuttings, up the test hole to the surface, where some are collected for examination and the others are disposed of in the mud pit. When the drilling is completed, this mud is allowed to dry, the hole is filled, topsoil is replaced, and all disturbed areas are graded and planted.

Most drill holes are plugged by filling them with the drill cuttings, mud, and cement. This is to seal the various aquifers from each other. By arrangement between the surface owner and the drilling company, holes that produce an adequate supply of good water are sometimes cased and equipped for stock watering or irrigation use. Drilling is performed along existing roads as much as possible. When this is not feasible, temporary roads are constructed.

It should be noted that while typical exploration operations are described here, procedures adopted at specific sites may vary depending on the mineral and surface ownership circumstances. The complex land and minerals ownership, leasing, and regulatory conditions in the area are discussed in Chapters I and XI.

Mining

It is anticipated that the mining methods currently used in the San Juan Basin will probably be used for future operations. At present most ore recovery is by modified room and pillar or open pit methods. There is also an experimental in situ leaching operation near Crownpoint in McKinley County. The open pit mining methods are used at three mines in the basin, but at current production levels these ore bodies should be depleted within 5 to 10 years.

Room and Pillar Mining. Because most ore bodies in the San Juan Basin are lenticular most mines are expected to use some type of modified room and pillar method to extract the ore. With this method, drifts are driven from a shaft to the ore or property limits, and mining usually progresses from the outer limits back toward the shaft. Rooms are driven into the ore zone, usually in a systematic pattern, leaving pillars to support the overlying strata. (See Figure III-5.) The pillars may be recovered later; however, because taking them out can cause the overlying strata to cave (collapse), artificial supports must sometimes be used so that the caving does not interfere with removal of still other pillars.

The typical underground mine usually has one main, large diameter, vertical shaft and a number of smaller diameter ventilation shafts. The

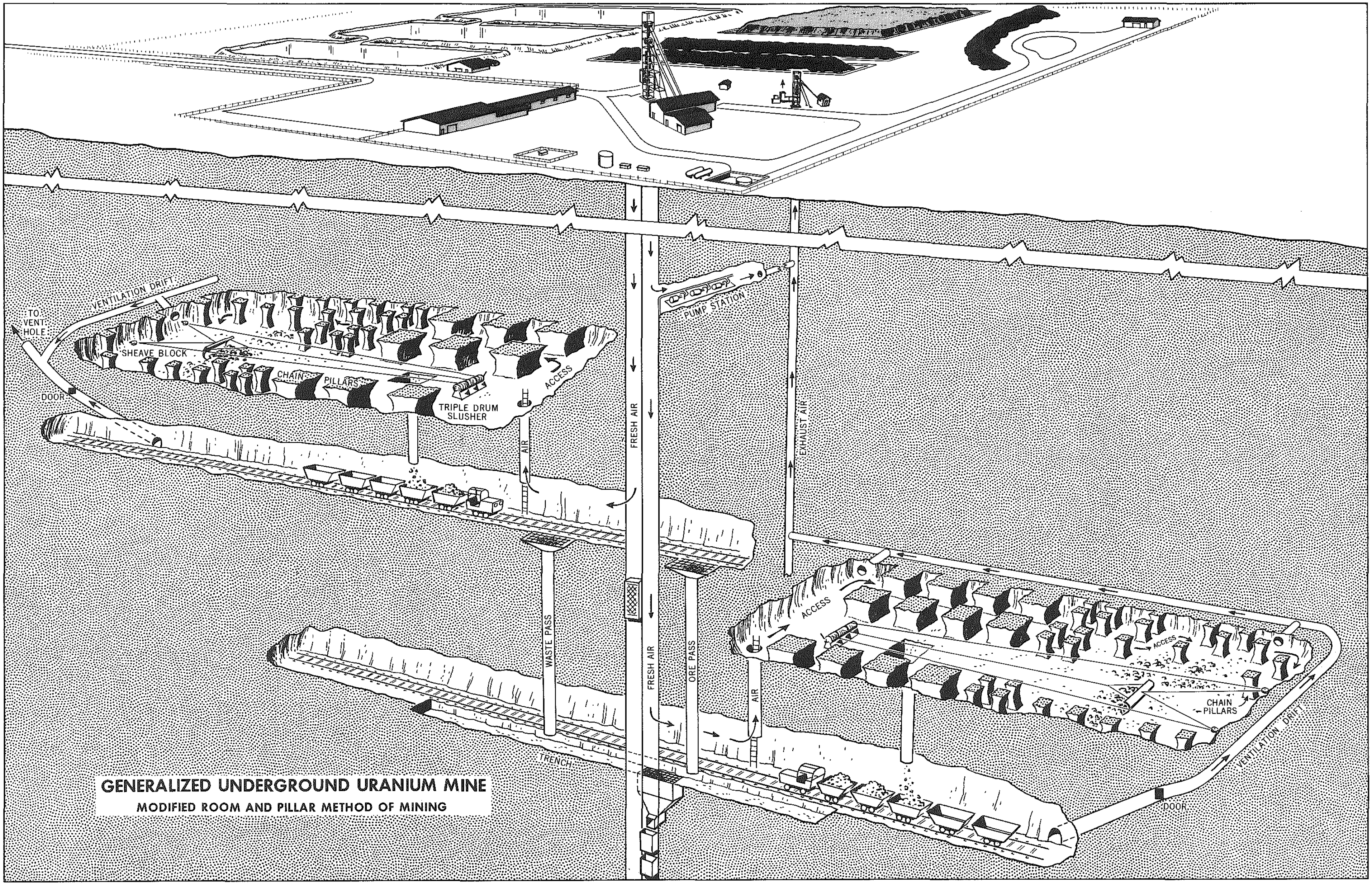

VENTILATION DRIFT
TO VENT HOLE
SHEAVE BLOCK
CHAIN PILLARS
DOOR
TRIPLE DRUM SLUSHER
ACCESS
AIR
FRESH AIR
EXHAUST AIR
PUMP STATION
WASTE PASS
FRESH AIR
ORE PASS
AIR
ACCESS
ACCESS
CHAIN PILLARS
VENTILATION DRIFT
DOOR
TRENCH
GENERALIZED UNDERGROUND URANIUM MINE
MODIFIED ROOM AND PILLAR METHOD OF MINING

Figure III-5

main shaft is usually divided into two compartments, one fitted with elevators to haul personnel and equipment and the other with large ore buckets called skips. The shafts all allow access to haulways which radiate from them, sometimes for distances of more than a mile. Many of the mines in the basin contain several levels of ore deposition; hence, a haulway is constructed for each ore level.

The haulways are horizontal tunnels with a slight slope toward the shaft. The slope is to facilitate ore haulage and allow ground water drainage toward the hoisting shaft. The haulways are normally constructed in barren rock beneath the ore bodies and contain a sophisticated system of railroad tracks. The ore is mined above the haulway and is slushed (mucked) to a vertical shaft, where it is dumped through a chute into the underlying ore cars. The ore cars are transported down the haulway by a diesel locomotive to an area near the hoisting shaft and dumped into an ore bin, where the ore is mucked into the skips and hoisted to the surface. Most haulways have ditches along the tracks which carry ground water down

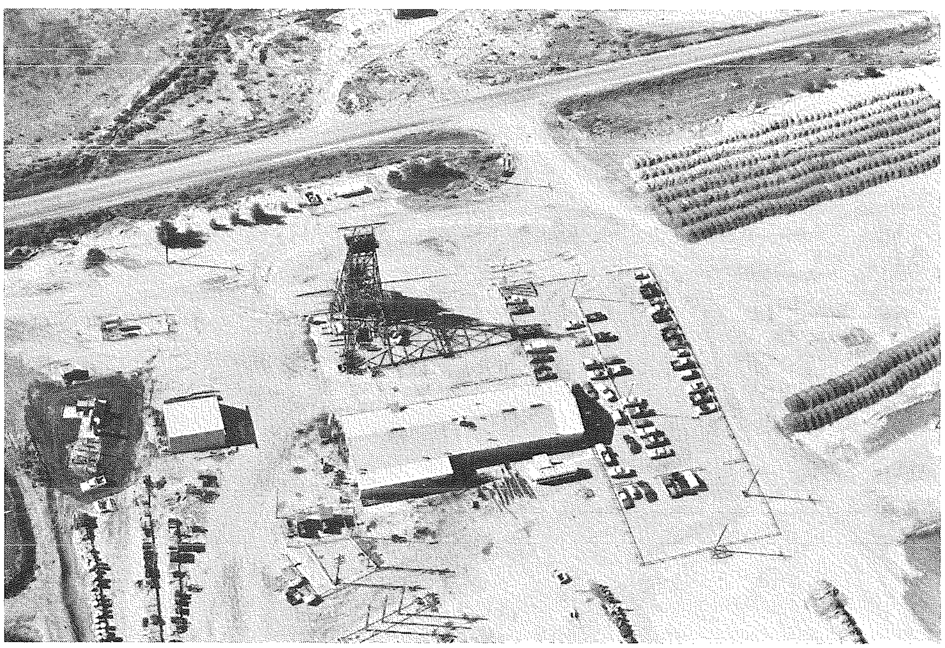


Figure III-6.--Surface facilities at typical underground uranium mine in Ambrosia Lake area

to the sumps near the hoisting shaft. This water is pumped eventually from the sump to surface installations that treat the water and release it to the environment.

Ventilation is maintained through the mine by fresh air forced down the shafts by large fans and exhausted through other shafts or large-diameter drill holes. About 60 to 90 percent of the available ore can be recovered by this method.

Longwall Retreat Method. The retreating longwall mining method has been attempted at several mines in the basin, but, for the most part, has not been entirely successful. This may be due to the fact that, for this method to be truly effective, the ore must be essentially flat-lying and continuous, and most ore bodies in the basin are somewhat rolling and discontinuous. Nevertheless, because the method has been tried on several occasions and may be attempted in the future, a short description is included here.

Ore recovery usually starts at the outer boundaries of the ore zone or property line and progresses toward the main shaft. To form a longwall face, a long narrow room is opened along the boundary between, and at right angles to, two haulage drifts. The size of the room is dependent upon the shape and size of the ore body. After the first slice is drilled and blasted and the ore is removed, one or two rows of jacks are placed at a proper distance from the face to support the roof while the next slice is removed. After that slice has been removed, the jacks are moved nearer the new face, and the unsupported roof over the area from which they were removed is allowed to cave. Recovery by this technique approaches 100 percent.

In Situ Leaching. This is a method by which the uranium is extracted, not by removing the uranium bearing formation, but by leaching the uranium from the rock while it is still in the ground. This is accomplished by pumping a lixiviant (leaching solution or solvent) through the uranium ore zone, using wells, then extracting the uranium containing solution (called leachate) from other wells. (See Figure III-7.)

Pilot scale tests run on the Irigaray operation in Wyoming show recovery rates approaching 50 percent using a 5-hole pattern (U.S. Nuclear Regulatory Commission, 1978). More tests will probably be necessary to see

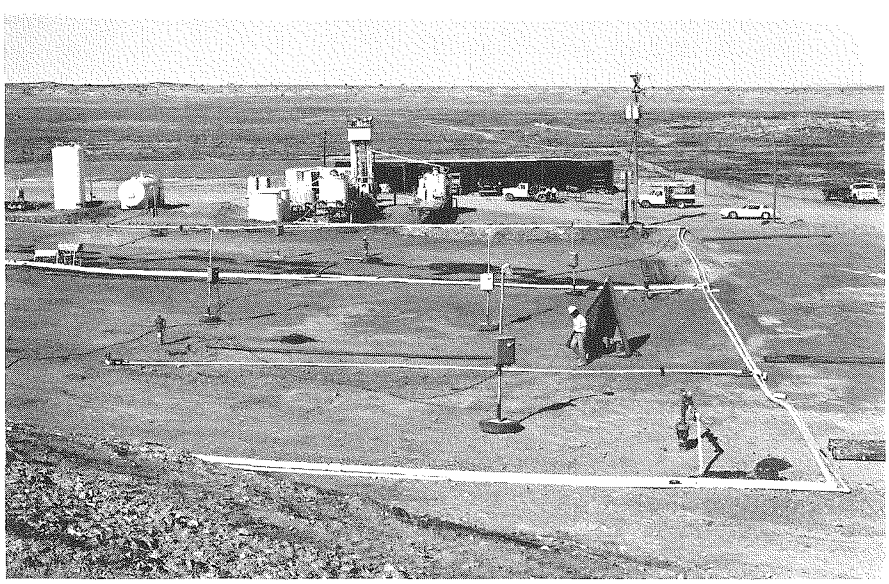


Figure III-7.--Surface production and injection wells for Mobile in situ leaching pilot project west of Crownpoint, N.M.

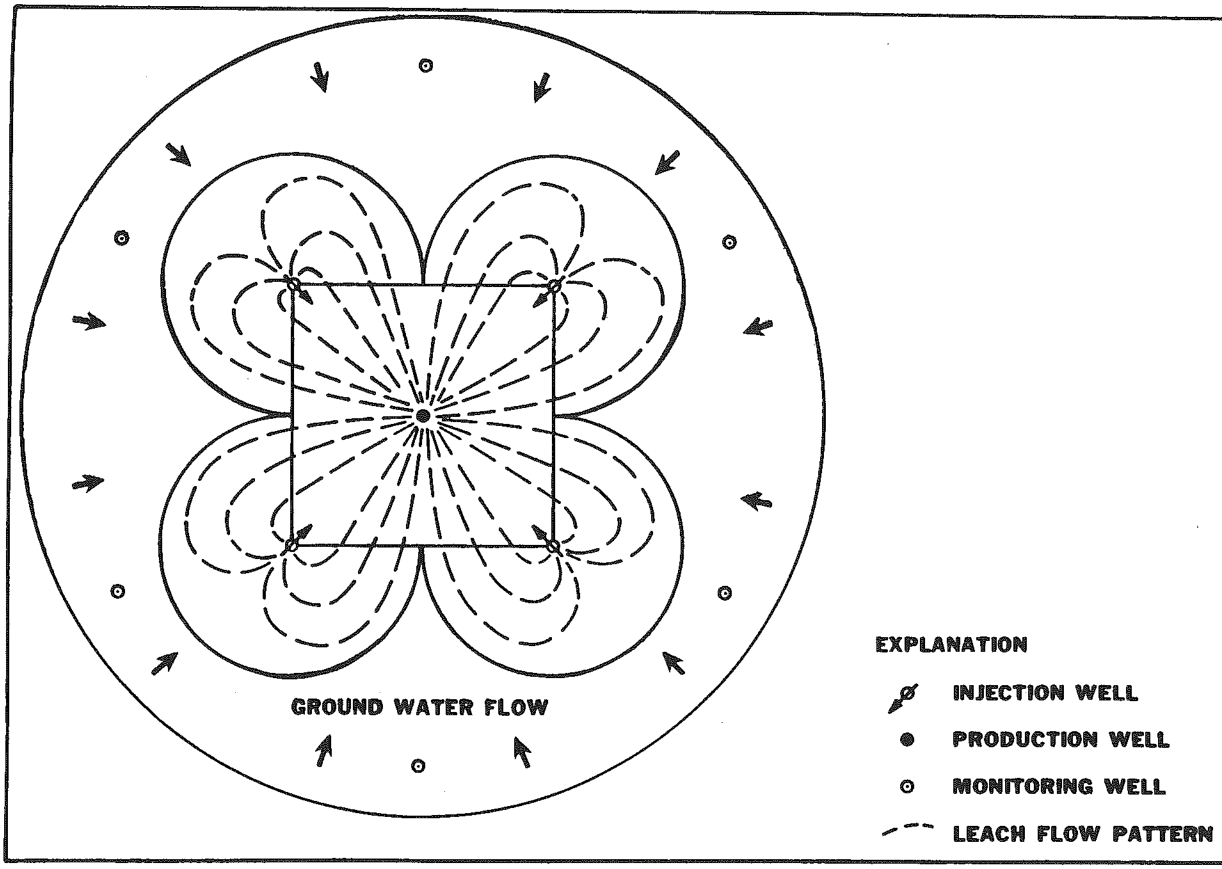
if this recovery rate can be increased. One advantage of in situ operations is that they make available recovery from uranium mineralization which is too low in grade to be economically mined by other methods.

The production well is drilled in the center of a circle or grid of injection wells. The size of each grid is fairly small, possibly 40 to 50 feet on a side; however, by drilling a number of adjacent grids, an entire ore body covering many acres can be mined. Several additional wells are drilled outside the injection wells to monitor the process and to detect any leachate movement outside the production area. Figure III-8 shows a plan view of the well pattern and the direction of lixiviant flow. After drilling and casing of the drill holes, the casing is perforated in the interval through the uranium bearing rock zone. A mild lixiviant that has the property to dissolve the uranium minerals in the ore (much as water dissolves table salt) is pumped into the injection wells under high pressure. Simultaneously a pump on the center production well creates a suction or a low pressure center (Figure III-9). The solution migrates through the rock from the ring of high pressure injection wells toward the center of low pressure, dissolving the uranium minerals as it goes. The production well pumps the leachate out into a chemical treatment plant where the uranium is precipitated. The barren lixiviant is reconstituted as necessary and is recycled to the injection wells to continue the process.

Where it proves practical, the in situ leaching method can eliminate the need for underground mining in specific locations and some of the problems that evolve from it. This would lessen socioeconomic problems, with fewer people involved in the production operation than those employed in an underground mine. This system has some limitations, which are based on the permeability of the ore body (it must be reasonably porous) and of the overlying and underlying strata (they must be almost impermeable). In addition, the uranium must be in a chemical state which is conducive to leaching. Some of the environmental problems concern the possible contamination of ground water and the necessity to control the direction of flow of the leaching solution. This can be remedied, to a certain extent, by close control of the pumping rates and by producing slightly more solution than is injected. In this way there should be a positive flow toward the production well. It must also be demonstrated that post-mining restoration of the aquifer is possible. Radon venting from surface works also is a consideration.

Mobil Oil Corporation began its New Mexico in situ leaching pilot program five miles west of Crownpoint in November 1979. Much of the description of the project was taken from the company's mining and reclamation plan filed in 1978. The pilot program is to determine the technical feasibility, environmental impact, and uranium resource recovery and economics of in situ leaching of uranium on some of Mobil's leases in the Crownpoint area.

The well field consists of four production wells and nine injection wells arranged in an array of four five-spots. The wells range from 2,100 to 2,200 feet deep and are surrounded by 12 monitoring wells. Sodium hydroxide (NaOH) and carbon dioxide (CO_2) are the lixiviants added to the injection wells to leach uranium from the rock formation.



Source: Mobil-TVA Environmental Impact Statement.

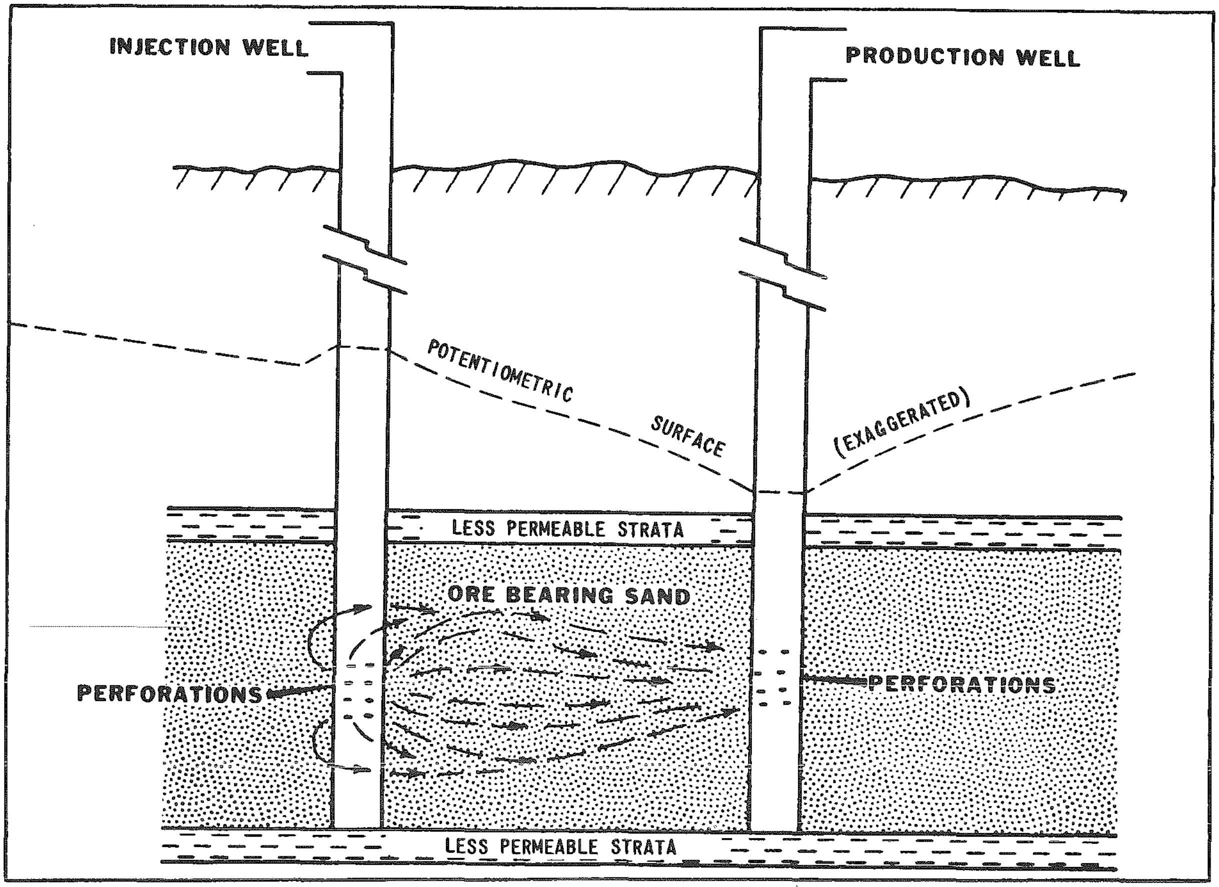
Figure III-8.--Plan view well pattern and direction of leachate flow

Yellowcake has been produced from the project and the aquifer restoration tests will be conducted after the production tests are complete. The results have been encouraging so far, but it will be a year or more before it is known if the in situ mining technique is viable for this specific limited location.

Exxon Minerals Company U.S.A. filed applications in 1980 which would allow it to begin an in situ leaching pilot test in the area, on a 2.5-acre plot on the L-Bar Ranch east of Mount Taylor where Exxon had uranium leases on 60,000 acres. "A small-scale in situ project is needed to allow the feasibility of a large-scale in situ mining operation to be evaluated," the company's application said. Exxon has used the process in Wyoming and Texas. Its New Mexico test was planned to continue through 1985 or 1986.

It will certainly be several years or more before it is known whether the in situ mining process is applicable over a large part of the San Juan Basin.

Additional details on expected impacts and other problems associated with specific in situ mining proposals can be found in the Crownpoint Uranium Mine Project environmental impact statement (Tennessee Valley Authority, 1979).



Source: Mobil-TVA Environmental Impact Statement.

Figure III-9.--Side view diagram of leach flow pattern

Water-Jet Mining. The U.S. Bureau of Mines has recently demonstrated another new in situ mining method for recovery of uranium. This is called the water-jet mining system and was developed from an earlier system used to extract coal. The Bureau of Mines said the method was scheduled to be used commercially for the first time at a mine in Wyoming. Although not demonstrated on deposits in the San Juan Basin, the method is felt to hold promise for recovery of small, deeply buried deposits that would otherwise prove uneconomic to recover.

Briefly, this method utilizes a high pressure jet of water ejected from a nozzle at the bottom of a borehole to fragment sandstone that can then be pumped to the surface through another borehole. The method has the same advantages as the in situ leaching method, including elimination of the need to expose miners to the hazards of underground mining. The water-jet method has an added advantage in that corrosive chemicals would not be pumped into underground formations. One disadvantage of water-jet mining that does not occur with conventional in situ mining is that a cavity would be mined out of the producing formation. However, potential subsidence problems could be alleviated somewhat by returning the waste sand after mill processing to the mined out cavity. (U.S. Department of the Interior, news release, January 17, 1979)

Open Pit Mining. Open pit mining is the preferred method of extraction for shallow deposits and is used presently at three mines in the basin. Though open pit mining is only a remote possibility in other areas of the basin because of ore depth, a brief description of this type of operation may be appropriate. (See Figure III-10.)

Open pit uranium mines can vary in size from a few acres to that of the Jackpile-Paguate mine (encompassing a disturbed area of about 2,700 acres) or larger. Stripping depths can vary from a shallow 20 to 50 feet to about 400 feet.

Early development of an open pit mine requires construction of roads, surface facilities, utilities, and the removal of vegetation, as well as stripping and stockpiling topsoil for future mine area reclamation. Equipment generally used in this part of the operation includes bulldozers, scrapers, loaders, and trucks.

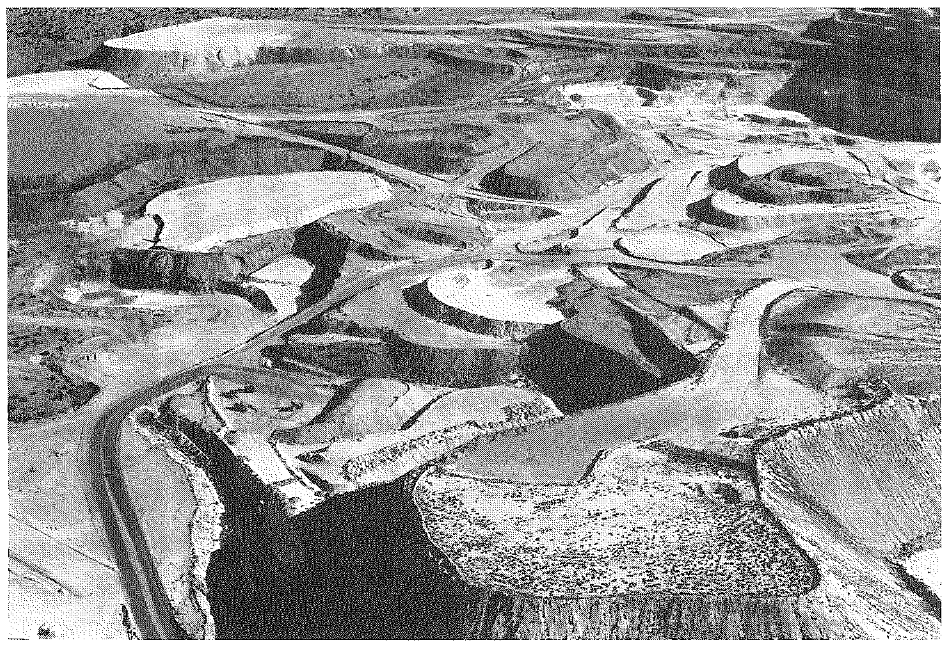


Figure III-10.--Jackpile-Paguate open pit uranium mine showing some of the pit areas and waste dumps

If necessary, the overburden (material above the ore body) in one or more successive layers is fractured with explosives. Once the overburden is broken up, or if it is naturally soft, it is removed or stripped away with loaders, scrapers, stripping shovels, and/or draglines. As the depth of overburden removal increases, benching of the successive layers provides stability of the pit sidewalls.

Removal of the ore body employs methods essentially similar to those used for the overburden. Natural variations in ore quality usually require the stockpiling and blending of different grades of ore in order to provide

the mill with a uniform grade. Mining proceeds until the ore body is depleted. Ore recovery by this method can approach 95 percent.

In some instances it is possible that the pit can be backfilled with much of the overburden which was originally removed or with overburden from an adjacent pit. However, due to economic considerations, complete backfilling is not usually accomplished. Backfilled areas and/or overburden dumps are shaped and graded, spread with the previously stockpiled topsoil, fertilized, and finally seeded. Water is sometimes added for the first several years to aid in establishing vegetation.

These are typical reclamation operations, but site-specific procedures are dependent on the particular mineral and surface ownership involved. Chapter XI discusses the complex land ownership and regulatory situations.

<u>Milling</u>

The basic objectives of the milling operation are to separate the uranium mineral from the host rock and to discard the host rock and waste as tailings. Industry commonly refers to the solid component of the waste as sands, the liquid component as slimes, and the complete waste product as tailings. For this particular discussion, the solid component of the waste is defined as the tailings and the liquid component as mill effluent.

The desired uranium ions are separated from the ore by two basic methods, acid leach or alkaline leach. The acid leach is generally more efficient and preferred by most companies; however, this method cannot be used for milling ores in limestone host rock because most of the acid would be consumed in dissolving the limestone. An alkaline leach is used primarily where limestone is present. Only one mill in the study area, United Nuclear-Homestake Partners, is known to use an alkaline leach mill circuit. All others use acid leach circuits.

The first step in milling is to blend the raw ores. According to Merritt and Pings (1969, p. 6) blending provides an ore of uniform composition and may be necessary to reduce the large concentrations of some undesirable minerals. (For a general view of a mill, see Figures III-11 and III-12.)

After blending, the ore is analyzed for chemical and metallurgical composition and then is crushed and ground to a size appropriate for chemical leaching. With alkaline leaching it is usually necessary to grind the ore much finer than with acid leaching. Grinding is done in ball and/or rod mills, usually in series, or by autogenous or semi-autogenous grinding, until the necessary size is achieved.

Next, the ground ore is transported to the leaching circuit, where the uraniferous minerals are dissolved from the ore. Normally, other minerals are dissolved also, but with experience and careful control of the leaching fluid, the dissolution of unwanted minerals is minimized. The uranium ions that are formed are chemically stable only in discrete pH and redox or Eh ranges. The pH is a measure of the acidity or alkalinity of a solution. On a scale from 0 to 14, a pH of 7 is usually considered neutral, with a pH

below 7 acidic and above 7 alkaline. The redox or Eh, for purposes of this discussion, is a measure of the proportion of ions of a given element that are in different oxidation states. Many elements with differing oxidation states can form ions. Uranium, for example, exists in nature in several oxidation states. In the oxidation state of +6, uranium forms stable ions in acidic solutions of sulfuric acid and in alkaline solutions containing large concentrations of carbonate ions (CO^2).

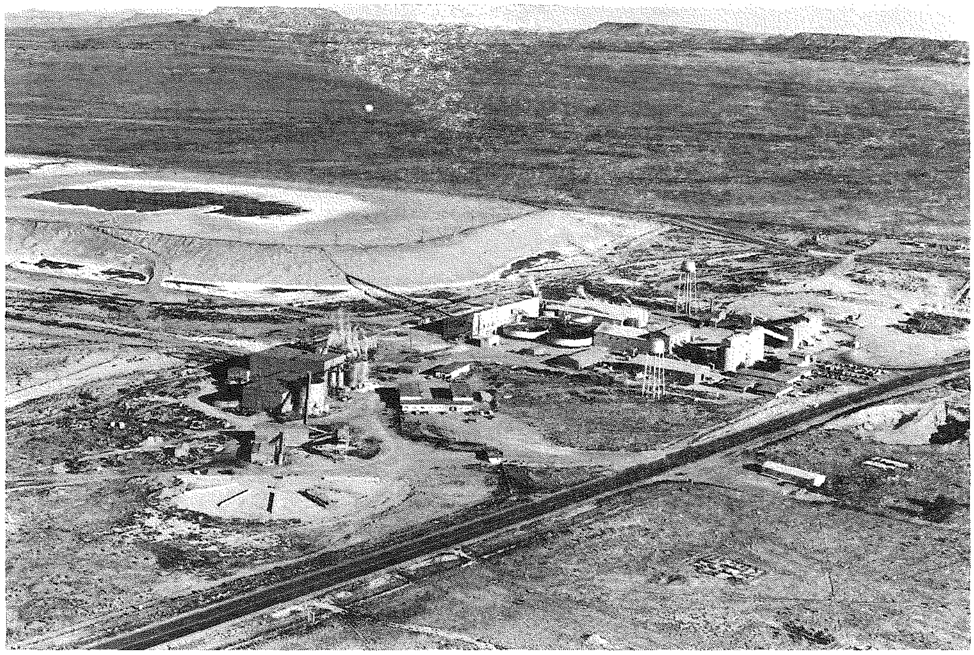


Figure III-11.--United Nuclear-Homestake Partners uranium mill with tailings pond at Ambrosia Lake

Normally, a part of the uranium in minerals is in the +4 oxidation state and is not very soluble unless chemicals are added to the leaching solution to oxidize virtually all uranium atoms to the +6 oxidation state.

The leaching circuits of the uranium mills are known to differ in design. Some mills recycle much of the leaching solution but others recycle little if any. Moreover, the types of chemical treatment in these circuits vary with specific mills.

Sulfuric acid (H_2SO_4) is the main component of the acid leach solution. This acid is used to dissolve uraniferous minerals to form complex uranyl sulfate anions such as $UO_2(SO_4)_2^{-2}$ and $UO_2(SO_4)_3^{-4}$. These ions are stable only in large concentrations of sulfuric acid. The pH of this acid is reported to be about 0.5 in the mill circuits, but the pH of mill pond acid sampled during this study appears to be about 2.0, although the New Mexico EID has reported values as low as 1.0. The mill effluent is weaker than the acid used in the mill circuits.

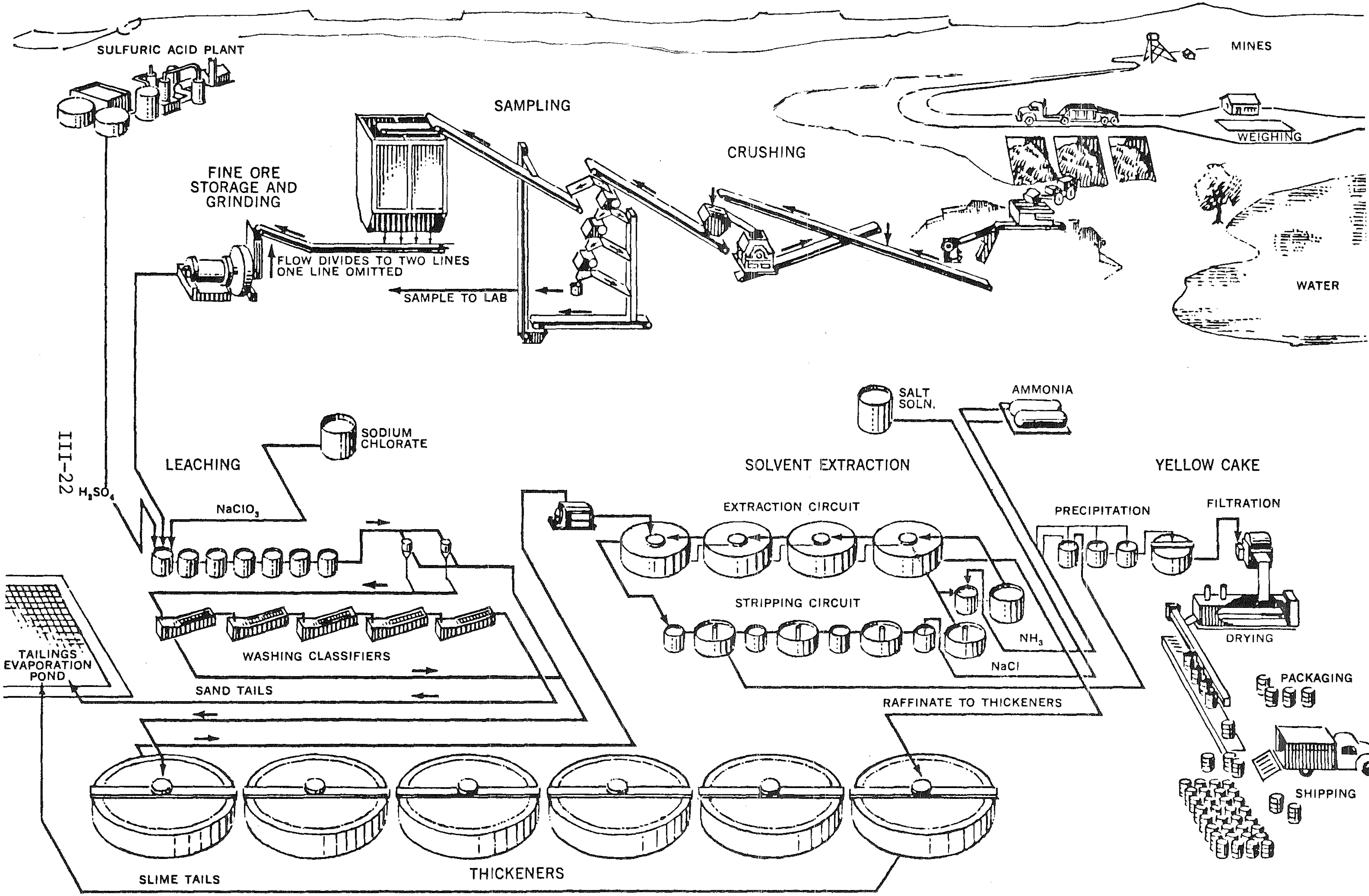


Figure III-12.--Schematic diagram of Kerr-McGee Uranium Mill

Most of the uranium atoms in the ore minerals of the study area have an oxidation state of +4, and, as explained previously, the oxidation state of these atoms must be raised to +6 for efficient dissolution of the minerals. Several chemical additives can be added to the leach to oxidize the uranium atoms. The most common oxidants are probably constituents of the ore minerals. The ferric ion (Fe^{+3}) is commonly used to oxidize uranium atoms, and this could be obtained from pyrite (FeS) in the ore provided that some other constituent is added to oxidize the iron (Fe) to a +3 oxidation state. Apparently, sodium chlorate ($NaClO_3$) is added to many acid leach circuits to oxidize iron which in turn oxidizes the uranium atoms. The mineral pyrolusite (MnO_2) may be used, usually in conjunction with Fe^{+3}, to oxidize uranium atoms, and this constituent is preferred by some uranium mills (Merritt, 1971, pp. 63-71).

After the uraniferous minerals have been dissolved from the ore, the solid waste is separated from the aqueous phase or leach solution. This is a complex operation and is described in detail by Merritt (1971) in several sections of a discussion on uranium extraction.

When the uranium has been dissolved and the waste rock has been separated from the liquid phase, there remains the problem of separating the uraniferous ions from other ions and finally converting the uraniferous ions into yellowcake. One of two methods is used for this separation. The most common method is solvent extraction (Sx). In this method, the uranium is much more soluble in the particular solvent used than it is in water. The solvent must be immiscible (unmixable) with water. Moreover, it must have chemical characteristics that allow reactions with the uraniferous ions, and it must be selective with these reactions so that other ions are not absorbed.

The organic solvents and clarified acid containing the uraniferous ions are thoroughly mixed and agitated, which causes the uraniferous ions to transfer from the acid to the solvent. The solvent is then mechanically separated from the acid, because it is insoluble in the acid, much as gasoline is insoluble in water. Once separation of these immiscible liquids is accomplished, the solvent is moved to another circuit where it is stripped of the uraniferous ions by another aqueous solution. The stripped organic solvent is then recycled to recover more uranium, and the aqueous solution containing the uraniferous ions is chemically treated to produce yellowcake.

In the past some mills recovered uraniferous ions from the acid leach by various resin ion exchangers. This method of removing uraniferous ions was similar to those used for removing uraniferous ions from mine effluent.

The final stages of mill operations whereby yellowcake is produced from solutions of the ion exchange process or the extraction method range through a wide spectrum of chemical options. In an acid solution the uranium is usually precipitated by neutralization with some basic material such as ammonia or lime. The precipitate is then filtered, dried, and prepared for shipment to another plant, where it is refined. There are also several types of miscellaneous chemical treatments employed to remove undesirable constituents from the ion exchange resins and organic solvents

and to purify the final products. The extent to which these added chemicals become mill waste is unknown. It is anticipated that the Ammonium ion (NH_4^{+1}) is a normal constituent in the mill pond acid. It is also suspected, based on the odor of some collected samples of mill pond acid, that this liquid contains one or more unknown organic constituents that are not removed by neutralization with calcium carbonate.

From Yellowcake to Power Plant

Some of the yellowcake is exported to other countries for refining, but most of it goes to one of two plants in Oklahoma and Illinois where it is refined and converted to a gaseous form, uranium hexafluoride (UF_6). This is sent to a government-owned enrichment plant in Ohio, Kentucky, or Oak Ridge, Tennessee. There the naturally radioactive isotope ^{235}U is concentrated from its natural proportion of 0.7 percent to the approximate 2 to 3 percent mixture required by today's light-water power reactors.

The enriched product goes to a fuel fabricating plant in one of nine states, where it is reduced to uranium dioxide (UO_2) and made into fuel elements. Commonly, stainless steel or zirconium alloy tubes 10 to 12 feet long and a half inch in diameter are filled with half-inch pellets of UO_2. These loaded fuel rods are delivered to power plants, where they are fed into reactors in bundles. After the fuel elements have served their purpose, later phases of the nuclear fuel cycle include the handling and centuries-long storage of radioactive wastes.

PART 2

ENVIRONMENTAL IMPACTS:

Natural Environment

CHAPTER IV

IMPACTS ON AIR QUALITY

Chapter IV

IMPACTS ON AIR QUALITY

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Chapter IV

Summary

The air pollutants of greatest concern in uranium mining and milling are gaseous radon-222, its decay products, and particulate materials--mostly dust--which in some cases are radioactive. Mine exhaust vents are by far the leading sources of radon-222 emissions, followed by inactive mill tailings. Trailing far behind in radon emissions are active tailings, which usually are partly covered with water and are saturated beneath the surface.

The study confirmed there is a need for more information, of a reliable nature, concerning the possible impacts which radon may produce on human health. On the basis of known data, the study's experts concluded that both mines and mills appear to be capable of producing off-site radon concentrations that could exceed federal or state standards or regulation limits at some locations. Proper controls adopted as part of the environmental review procedures required for specific projects could prevent such excesses.

Scientific analysis using the available mine and mill emission data and assuming worst-case conditions produced estimates that radon emissions resulting from uranium development at the assumed Moderate level might increase the annual lung cancer risk in the region by approximately one percent by 2000. This would mean a possible theoretical increase of about 5 cases that year, above the 412 lung cancer cases that can be statistically expected in the study area from all causes in the year 2000. This would leave the Grants uranium belt population still below the national average for lung cancer incidence, and the increase would not be detectable statistically.

This does not mean there are no dangers at the local level. On a site-specific basis, detailed studies are essential to determine the potential air quality, food chain, and health impacts from proposed uranium recovery facilities, when added to effects from existing units and background radiation.

Chapter IV

Impacts On Air Quality

INTRODUCTION AND OVERVIEW

The possible effects of increased uranium mining and milling on air quality have been a major source of concern among many people in and near the San Juan Basin. Questions have centered around radiation and the extent to which it might jeopardize the health of inhabitants and underground miners. Many information gaps have existed in this field, and much remains to be learned.

In search of answers, air quality and radiation scientists for the San Juan Basin Regional Uranium Study (SJBRUS) analyzed the dispersion and concentration of potentially significant atmospheric pollutants. For this they used digital dispersion modeling. The work concentrated on a regional analysis, but important site-specific and subregional impacts were also highlighted when data were available.

Abstract of Findings

Pollutants of Concern. The pollutants of greatest concern in uranium mining and milling are gaseous radon-222 (Rn-222), its decay products, and particulate materials--mostly dust. Radon and its decay products are considered pollutants because they are radioactive. The major sources of Rn-222 emissions are mine exhaust vents, followed by mill tailings piles.

Airborne particulates in themselves may be pollutants because they lower visibility and under certain circumstances can damage human lungs. In uranium milling they are considered pollutants because they sometimes carry increased concentrations of naturally occurring radionuclides with them. The major sources of radioactive particulates are mill tailings piles.

Concentrations of Radon-222. Based upon recent information prepared for the Nuclear Regulatory Commission (NRC) (U.S. Nuclear Regulatory Commission, 1979b), it appears that radon emission rates from an individual mine may equal or exceed the total radon emission rate from a uranium mill including the tailings pile. As this is written there are no regulations which would limit the radon emission rate from active mill tailings piles.* Instead, there are regulations which limit the concentrations of radon in the atmosphere where people live or work (10 CFR 20). No regulations exist as yet that limit radon from mine vents.

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* The NRC and EPA are developing criteria for uranium mill tailings radon emissions.

The limitation for tailings piles is for a maximum permissible concentration (MPC) averaged over one full year. The SJBRUS analysis indicates that although short-term concentrations of radon and its decay products might well exceed these MPC's at several locations in the basin, it is not clear that these limits would be exceeded on an annual average basis at any permanently occupied locations.

The SJBRUS analysis is a projection of radon concentrations over the next 20 years. In arriving at these projections the SJBRUS air quality scientists consider it unlikely that radon emissions from uranium mines can be substantially reduced in the near future. Consequently, the study team assumed that with continued or expanded uranium development the radon emissions would increase in proportion to those observed under current technology.

The regulations and SJBRUS's future estimates of radon concentrations are discussed in detail later in this chapter.

Concentrations of Particulates. The SJBRUS analysis indicates that uranium mining and milling processes should not produce concentrations of particulates exceeding state and federal standards except on a short-term basis, such as when uranium trucks raise dust clouds on a dirt road.

However, the concentration of radioactive isotopes associated with particulates cannot be dismissed so readily. The radioactivity on the dust particles is caused primarily by isotopes of radium, thorium, polonium-210 and lead-210. Concentrations of these isotopes can lead to radiation doses to individuals which must be limited in accordance with federal regulation 40 CFR 190. Wind-blown dusts from ore and tailings piles can produce off-site concentrations that could exceed the limits on radiation doses set forth in 40 CFR 190 if certain food pathways were to coincide with the locations of high concentrations. As discussed in Chapter XII, however, mitigation control measures are available (PL 95-604, 92 Stat. 302 (1978)). The study team assumed that the application of these controls as uranium development grows would prevent routine or extensive violations of the dose limits set forth in 40 CFR 190. On this basis, concentrations of radiation from wind blown particulates would be low. These concentrations are discussed in detail later in this chapter. As in the case of 10 CFR 20, the concentrations refer to mill emissions--not mine emissions.

Health Effects. Until recently, there was a shortage of data on air quality in the San Juan Basin. This made it difficult to analyze the basin's health problems. However, within the last few years several of the most critical data gaps have been at least partly filled. The SJBRUS study began more than three years ago and the draft, which went to press in 1979 before much of the new information was published, cited a number of data gaps and weaknesses. Many of these shortcomings have been remedied by the ongoing field investigations designed for that very purpose. For example, the NRC and U.S. Environmental Protection Agency (EPA) have published vastly improved measurements of mine radon emission rates and radon flux from tailings (U.S. Nuclear Regulatory Commission, 1979b; Momeni, et al, 1979, among others).

Thus the estimates of future health impacts, which could be only approximated in the SJBRUS draft, can now be made with greater confidence. The greatest uncertainties remaining are in the projections of future development and population.

Assuming the most recently developed average values for radon emission rates from mine vents and mill tailings, no improvement in radon controls, and very stringent lung dose conversion factors (so as to present the worst case), it is estimated that radon emissions associated with uranium development at the Moderate level might produce an increase in lung cancer risk within the San Juan Basin of approximately one percent in the year 2000. The High growth projection might increase the risk by 1.5 percent. The incidence of lung cancer in the major uranium area, McKinley and Valencia Counties, is well below the national average. The possible increase in lung cancer of approximately 5 to 7 cases incurred in 2000, which the range of 1 to 1.5 percent increased risk would entail, would leave the uranium belt population still below the national average for lung cancer incidence and would not be detectable from a statistical standpoint. In any case, the study verified the urgent need for more reliable data on dose conversion factors and on health impact estimates. It also made clear the need for careful attention to air quality, food chain, and health aspects on a site-specific and subregional scale.

Other Pollutants. Anticipated emissions of other pollutants such as sulfur dioxide, nitrogen oxides, carbon monoxide and hydrocarbons are so low that insignificant concentrations result. Any significant new sources of these pollutants will be required to comply with new source performance standards.

EXISTING ENVIRONMENT

Climate

The San Juan Basin and vicinity are mainly semiarid. They receive much sunshine and little precipitation. The precipitation varies with altitude, which ranges from about 5,000 to 8,000 feet except for crests as high as Mount Taylor's 11,000-plus feet. Winters are relatively dry, with most moisture coming during summer thunderstorms. Mean precipitation ranges from above 27 inches per year in the northeast highlands to 8 inches per year on the southern plateaus. Most of the area, in which annual precipitation averages less than 18 inches, is defined as arid or semiarid by water experts. Typical of the average ranges of precipitation are those shown in Table IV-1 (Geomet, 1978, No. 18).

As one would suspect after comparing precipitation with temperatures (Table IV-2), much snowfall is expected in the winter. The basin receives an estimated average of 26 inches. The cycle of snow and thaw occurring throughout the winter translates into impassable roads in much of the region.

Table IV-1

Mean Precipitation Data

	Albuquerque		Farmington		Gallup	
	Inches	cm	Inches	cm	Inches	cm
January	0.36	0.91	0.58	1.47	0.71	1.80
February	0.36	0.91	0.50	1.27	0.56	1.42
March	0.42	1.06	0.60	1.52	0.56	1.42
April	0.56	1.42	0.53	1.34	0.69	1.75
May	0.63	1.59	0.53	1.34	0.50	1.27
June	0.60	1.52	0.35	0.88	0.52	1.31
July	1.44	3.65	0.81	2.05	1.98	5.02
August	1.32	3.35	1.14	2.89	1.40	3.55
September	0.90	2.28	0.79	2.00	0.59	1.49
October	0.79	2.00	1.18	2.99	0.94	2.38
November	0.42	1.06	0.42	1.06	0.48	1.21
December	0.48	1.21	0.69	1.75	0.51	1.29
Annual Average	8.25	20.90	8.12	20.60	9.44	23.90
Years of Record	85		20		13	

Source: U.S. Department of Commerce, National Climatic Center.

Table IV-2

Mean Monthly Temperatures

	Albuquerque		Farmington		Gallup	
	F°	C°	F°	C°	F°	C°
January	34.5	1.4	29.7	-1.3	29.2	-1.6
February	39.5	4.2	35.0	1.7	32.0	0.0
March	46.3	7.9	40.9	4.9	38.3	3.5
April	54.8	12.6	51.2	10.9	47.1	8.4
May	63.8	17.6	59.8	15.4	55.0	12.2
June	73.4	22.9	69.1	20.6	64.4	17.9
July	77.1	25.0	75.2	23.9	70.0	21.1
August	75.1	23.9	73.2	22.8	68.1	20.0
September	68.3	20.1	65.5	18.6	62.6	16.9
October	56.7	13.7	53.5	11.9	51.2	10.9
November	43.9	6.6	38.8	3.8	36.9	2.7
December	35.1	1.7	30.9	-0.6	29.7	-1.3
Annual Average	55.7	12.6	51.9	11.0	48.7	9.3
Years of Record	85		19		13	

Source: U.S. Department of Commerce, National Climatic Center.

Air Sheds

Air quality in the San Juan Basin is affected by the existence of air sheds. These are collection basins over which air masses flow. High terrain of an air shed forms the boundary for downslope drainage of cool air. Thus local topography influences wind flow, and local wind and weather conditions in air sheds can vary drastically from the general west to east weather patterns aloft.

The study area contains three air sheds--the San Juan, Zuni, and Middle Rio Grande (Map IV-1). The Continental Divide forms most of the upwind boundary of the San Juan Basin air shed, by far the largest of the three. The nighttime air flow is generally toward the northwest along the San Juan River and past the town of Shiprock. The Middle Rio Grande, second largest air shed, is east of the Continental Divide. Local topography, including Mount Taylor and the San Mateo Mountains and Mesa, complicates the nocturnal air drainage patterns. Depending on locality, the air flow is variously toward Albuquerque, Grants, or the center of a localized topographic bowl near White Mesa, a few miles north of Ambrosia Lake. Nightly air drainage in the Zuni air shed west of the Continental Divide and southeast of the Chuska Mountains is toward Gallup from all directions (Figure IV-2).

The existence of air sheds influences pollution. Six stability categories describe typical air shed conditions in the irregular mountainous terrain of northwest New Mexico (Table IV-3).

Stable nighttime air conditions near the surface characterize the three air sheds, particularly the San Juan from Shiprock to Farmington and Bloomfield. Here, wind speeds of less than 5-10 miles per hour, unchanging wind direction, and relatively low mixing depths* are likely to result in high concentrations of pollutants from both ground level (e.g., automobiles) and elevated (e.g., industrial stacks) sources. Conditions unfavorable for pollution dispersion exist in the Shiprock/Farmington area more than 40 percent of the time. Good dispersion conditions occur more than 50 percent of the time (Geomet, 1978, No. 18).

Air Quality

Map IV-2 shows air monitoring stations in the basin. In recent years, 14 of these monitoring stations have recorded total suspended particulate concentrations that exceeded state and/or federal 24-hour average standards (Table IV-4). Natural dusts comprise a major part of these concentrations. One basin station (Farmington) and a station near the basin (Albuquerque) reported readings exceeding the state and federal carbon monoxide standards. Albuquerque exceeded the state ozone standard also. Sulfur dioxide

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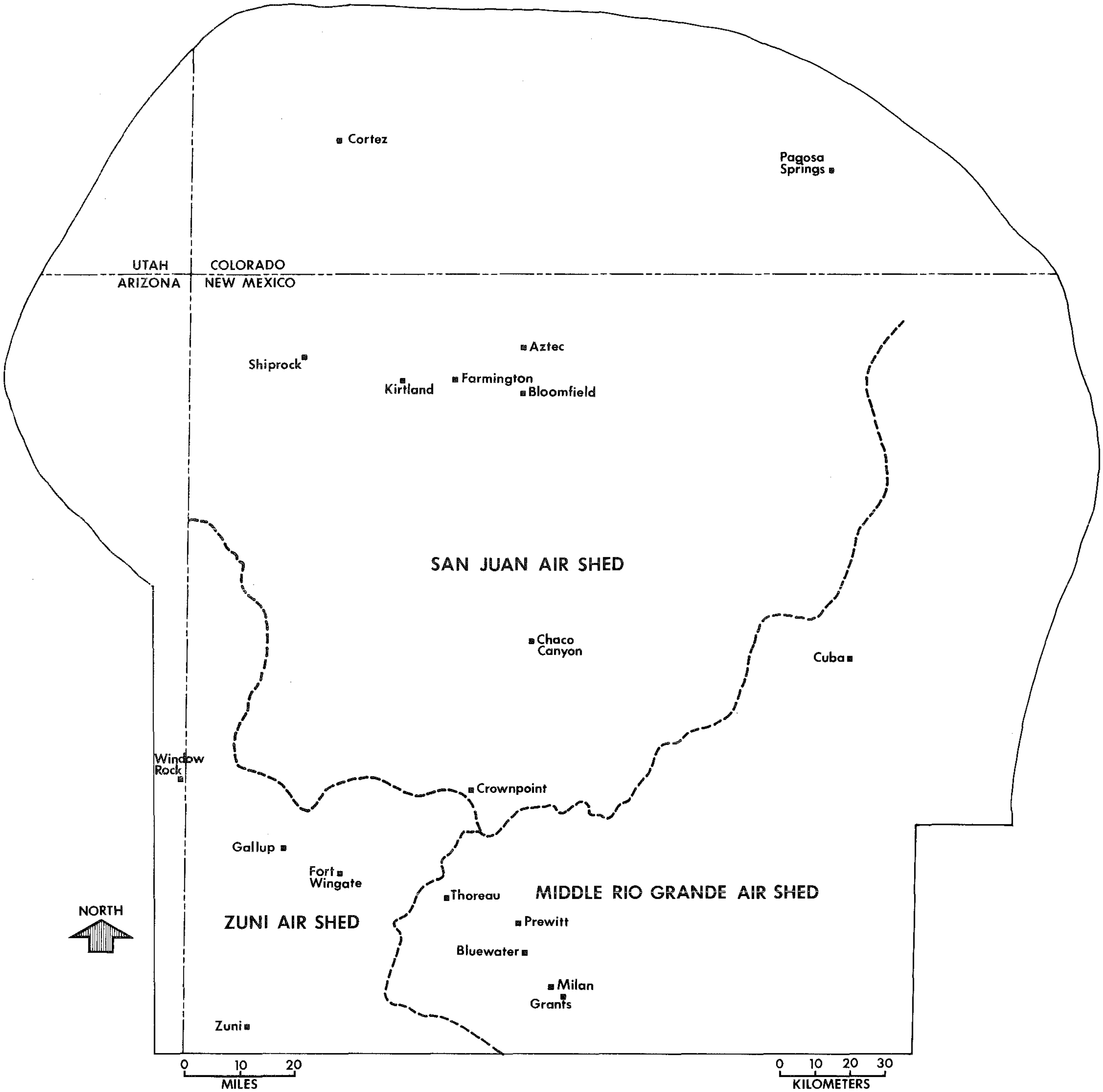
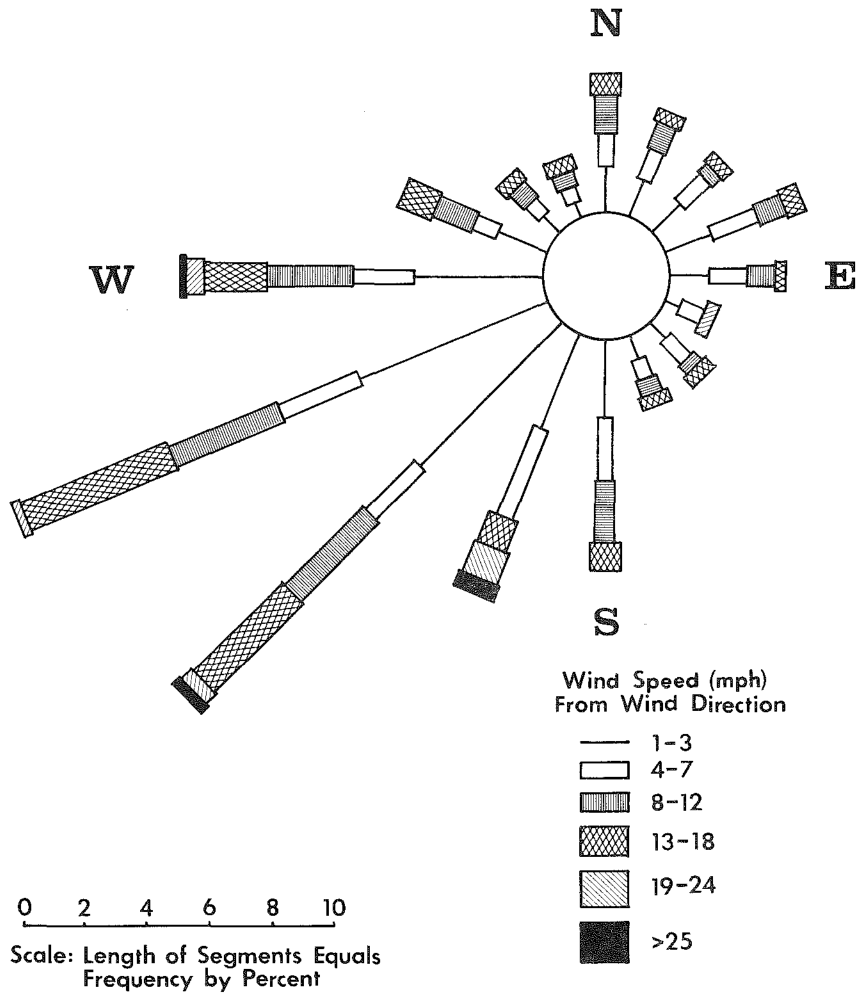
* Mixing depth is the distance from the ground to the upward boundary of pollution dispersion. If all other conditions are equal, the higher the mixing depth, the better the dispersion.



AIR SHED MAP

Map IV-1



WIND ROSE FOR GALLUP, NEW MEXICO
Average Annual Conditions (1974-1975)

Figure IV-2

(SO_2), the oxides of nitrogen, and other pollutants such as hydrocarbons are routinely monitored in the basin only in the Farmington-Shiprock corridor. The readings indicate that state and federal standards are being met except in a few areas near the power plants where SO_2 does not meet standards.

The state is revising its implementation plan for submission to EPA. The revised plan will present a strategy for bringing non-compliance areas into compliance with federal clean air standards by 1982. The plan addresses five areas in Bernalillo County (Albuquerque and vicinity) which do not meet standards for total suspended particulates (TSP). The plan also addresses standards for the automobile-related pollutants--carbon monoxide and ozone--in the county.

The Farmington area is listed as an "attainment" area for TSP, indicating standards are met. Attainment there relative to SO_2 standards is

Table IV-3

Percent Frequency Distributions
by Pasquill Stability Classes
for Zuni, Farmington, and Albuquerque

Stability	Zuni (1967-1971)	Percent Farmington (1960-1968)	Albuquerque (1960-1964)
A (extremely unstable)	2.4	4.8	2.4
B (unstable)	7.0	10.6	13.5
C (slightly unstable)	14.2	12.4	12.8
D (neutral)	35.2	27.8	30.0
E (slightly stable)	17.8	10.7	13.8
F (stable)	23.5	34.5	27.6

Source: U.S. Department of Commerce, National Climatic Center.

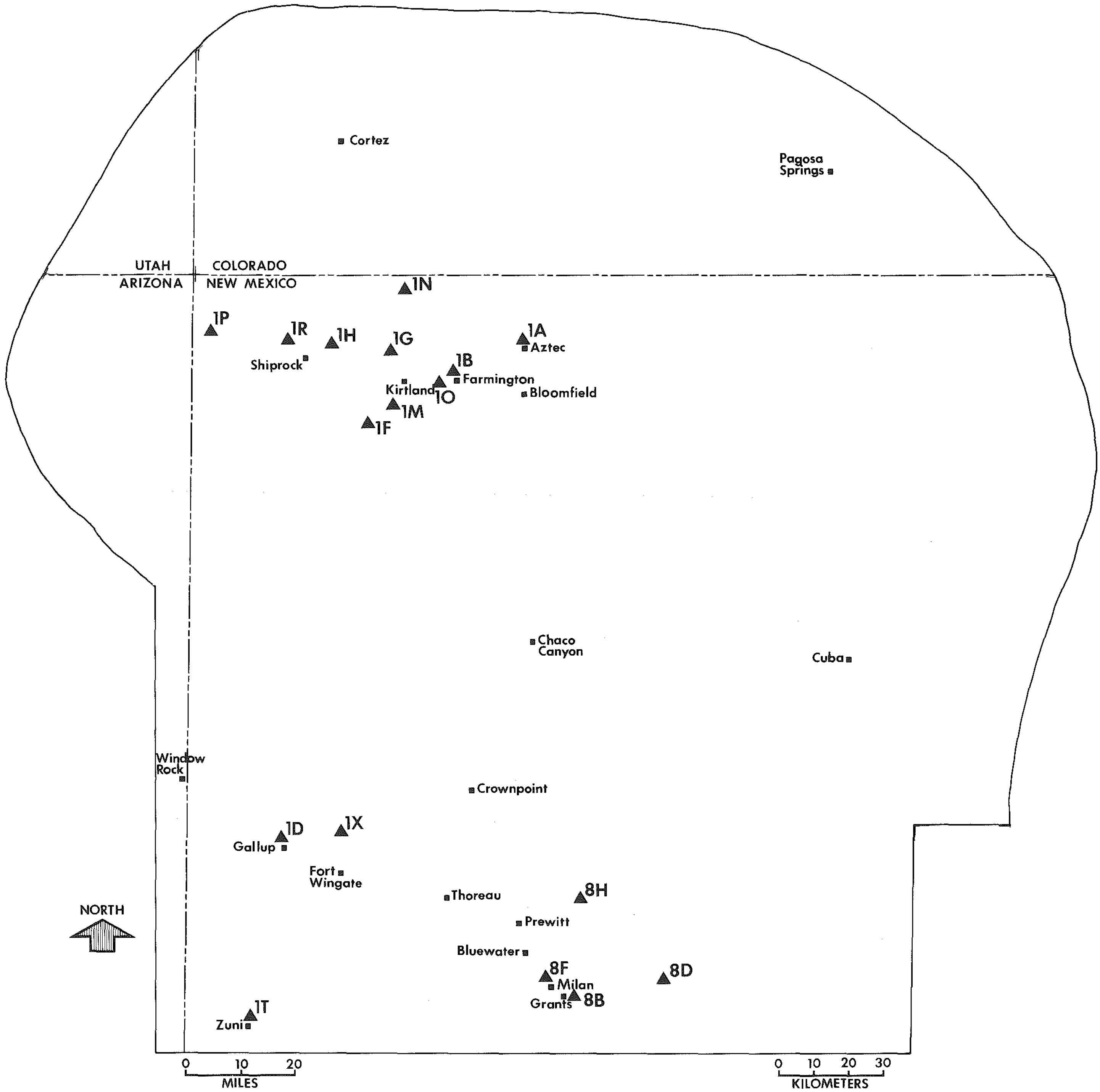
another matter, however. The plan accounts for the fact that SO_2 control equipment for the power plant units, which are the major contributors to high SO_2 concentrations, could reduce ambient SO_2 levels enough to place the area in compliance with present, stringent state regulations. The matter is under litigation, however, and the extent and timing of compliance are still to be determined. The Public Service Company of New Mexico is upgrading its pollution control equipment, but the Arizona Public Service Company has questioned several requirements in court. In the meantime, numerous complaints have been received by various agencies about pollution from the power plants west of Farmington. Pollution is visible for many miles up and down the San Juan River valley.

Any significant new sources must comply with new source performance standards.

To meet requirements of the Clean Air Act, states must inventory significant pollution sources and are required to document all sources of emissions above specified annual rates for each pollutant. Table IV-5 indicates 1975 and 1978 estimates of the point, area and total emissions for northwest New Mexico. The information requires modeling by dispersion models to permit its translation into an actual measure of pollution at a point downwind; nevertheless, these data are useful in themselves. They indicate that a problem may exist in San Juan County but that air quality is excellent for the region overall.

Radon-222, the Most Significant Pollutant

Radon-222, a gaseous daughter of uranium-238 formed by disintegration of radium-226, is the most significant airborne radionuclide involved in a study of the basin's air quality. The data available on atmospheric concentrations show that the natural background in the San Juan Basin varies widely. Not only does it vary with meteorological conditions and the time of day, as do the levels of other pollutants, but the base level of ambient radon-222 varies with the local level of the parent radium-226 in rock



(Note: Station designations are according to EID coding system.)

AMBIENT AIR MONITORING SITES

Map IV-2

Table IV-4

Ambient Air Quality Standards
(In micrograms per cubic meter ($\mu g/m^3$) or parts per million (ppm))

	New Mexico Standard	Federal Secondary Standard
Total Suspended Particulates (TSP)		
1. 24-Hour Average	150 $\mu g/m^3$	150 $\mu g/m^3$
2. Annual Geometric Mean	60 $\mu g/m^3$	60 $\mu g/m^3$
Sulfur Dioxide (SO_2)		
1. 24-Hour Average	0.10 ppm	---
2. Annual Arithmetic Mean	0.02 ppm	---
3. 3-Hour Average	---	0.50 ppm
Carbon Monoxide (CO)		
1. 8-Hour Average	8.7 ppm	9 ppm
2. 1-Hour Average	13.1 ppm	35 ppm
Photochemical Oxidants (Ozone)		
1. 1-Hour Average	0.06 ppm	0.08 ppm
Hydrocarbons		
Maximum 3 hour (6-9 a.m.)		0.24 ppm
Nitrogen Dioxide		
Annual Arithmetic Mean	0.05 ppm	0.05 ppm
Beryllium		
1. 30-Day Average	0.01 $\mu g/m^3$	
Asbestos		
1. 30-Day Average	0.01 $\mu g/m^3$	
Heavy Metals (Total)		
1. 30-Day Average	10 $\mu g/m^3$	

Source: Geomet, 1978, No. 18.

outcrops or near-surface formations. Radon is usually associated with uranium in the ore bodies.

Major Man-induced Release Sources. The major technologically enhanced sources by which radon-222 is released are mine vents, open pit mines, and tailings piles and ponds. Underground mines require ventilation to remove radon and its daughters, along with some particulate matter and water vapor. The tailings ponds and piles contain the waste from the uranium milling process. The waste includes all but one of the radioactive elements in the mined ore body at practically their original concentrations. The exception is uranium, which is reduced to 5 to 10 percent of its original concentration.

The tailings are described as follows by the Department of Energy:

> The principal solid wastes requiring disposal are the tailings solids that, along with barren leach solutions and other mill effluents, are disposed of in tailings ponds. The tailings solids contain all the ore constituents not solubilized in the leaching circuit and some that have been solubilized and reprecipitated or flocculated. The tailings contain the insoluble ore matrix of silicates and aluminosilicates, which contain insoluble trace elements and radionuclides. The carbonaceous material in many ores may also be present in an insoluble form containing other trace constitutents. Of the ore mill feed, about 97 percent remains as a solid requiring disposal. Most of the radionuclides, including residual amounts of uranium, are contained in the tailings solids. About 85 percent of the total alpha and beta activity of the ore input is sent to the tailings pond in soluble or insoluble forms (U.S. Department of Energy, 1979a).

The principal radionuclide of concern is thorium-230, which decays with a half life of 77,000 years to produce radium-226. This in turn produces radon-222. Because of the long half-life of thorium-230, the problem of radon-222 exhalation from the tailings piles will continue for tens of thousands of years after the mines are played out. Stabilization of the tailings piles and reduction of radon exhalation to an acceptable level are, therefore, very long-term operations.

The EPA reported that tailings from uranium mills contained average radiation from radium-226 of about 360 picocuries per gram (pCi/g) of mill waste. This contrasts with potential radiation of up to 900 pCi/g in older tailings piles. (A curie is defined as the rate of disintegration of one gram of pure radium, or 3.7×10^{10} disintegrations per second. One picocurie, in turn, is 10^{-12} curies or one-trillionth of a curie (Kennedy, 1978, No. 6)). On the assumption of secular equilibrium, the thorium-230 activity should be approximately the same. Haywood, et al, (1977) reported that slimes within the tailings piles contained a much higher radium activity, approximately 3,000 pCi/g. Other radon sources related to mining include barium precipitates resulting from the removal of radium from mine water discharges.

Table IV-5

Emissions Data for Five Counties

	Total Suspended Particulates (TSP)	Sulfur Dioxide (SO_2)	Nitrogen Oxides (NO_x)	Hydro-Carbons (HC)	Carbon Monoxide (CO)
Emissions for San Juan County, NM (Tons/Yr)*					
Total:					
Point Sources	72,352	148,292	132,323	12,316	6,016
Area Sources	766	427	5,293	4,125	19,125
Total Emissions	73,118	148,719	137,616	16,441	25,171
Emissions for Sandoval County, NM (Tons/Yr)*					
Total:					
Point Sources	1,850	69	172	173	1,560
Area Sources	340	206	3,090	3,441	16,142
Total Emissions	2,190	275	3,262	3,614	17,702
Emissions for McKinley County, NM (Tons/Yr)*					
Total:					
Point Sources	3,352	2,272	13,595	8,152	320
Area Sources	488	253	4,445	4,645	20,043
Total Emissions	3,840	2,525	17,040	12,797	20,363
Emissions for Valencia County, NM (Tons/Yr)**					
Total:					
Point Sources	949	33	5,500	930	529
Area Sources	587	243	3,763	4,235	20,638
Total Emissions	1,536	276	9,263	5,165	21,167
Emissions for Rio Arriba County, NM (Tons/Yr)**					
Total:					
Point Sources	1,129	35	3,679	967	2,303
Area Sources	259	144	2,234	2,250	9,647
Total Emissions	1,388	179	5,913	3,217	11,950

* Source: 1972 National Emissions Data System Emissions (NEDS) Inventory for San Juan, Sandoval, and McKinley Counties with updates through 1975 for the area sources, and NEDS updates through April 1978 for point sources.

** Source: 1975 National Emissions Data System Emissions Inventory for Valencia and Rio Arriba Counties for area sources, and April 1978 NEDS data for point sources.

NOTE: The above NEDS data is the most recent available as of July 1978.

Although the half life of radon-222 is only 3.8 days, the half lives of its daughters (decay products) such as isotopes of polonium, lead, and bismuth range from less than a second to several years. Thus the airborne radiation may extend for many miles from the source. It will, however, disperse to concentrations discussed below. (Note: for convenience, when the term radon is used hereafter, it also refers to the daughter products.)

Present Concentrations in the San Juan Basin. There is no regulatory limit on Rn-222 emissions at present. The MPC for exposure of individuals in unrestricted areas is 3 picocuries of radon activity per liter of air (pCi/L); for a representative population group, the MPC is 1 pCi/L. These MPCs refer to annual averages from uranium mills and tailing piles over and above the annual average background radon concentration. These concentration limits are imposed by the New Mexico Environmental Improvement Division (EID) and are the same as those promulgated by the NRC in 10 CFR 20. The EID also strives to maintain exposures as low as reasonably achievable (ALARA), and this concept should be even more important in future regulations.

Information on radon emissions from specific sources and on long-term average concentrations had been inadequate for performing a quantitative assessment of potential health impacts incurred by the people in the San Juan Basin. Most of the measurements made in the past were of concentrations in the general vicinity of mines, mills, surface mineralization, and so on. Consequently, it was not clear to what extent such measurements reflected mine vents, mill tailings, natural background, or combinations of these sources. A number of measurement programs are now underway in the basin to rectify this situation. The results of these studies are being followed closely by the EID, which has the primary responsibility for environmental health impact assessment and control. This is particularly important in view of the public's concern about the hazards of radiation.

High concentrations of background radon have been recorded in the basin. Sampling stations near San Mateo have recorded measurements ranging from 0.008 to 0.90 pCi/L, under varying meteorological conditions (Geomet, No. 18, 1978). The 0.90 pCi/L reading was recorded on flat terrain during an inversion. While the overall mean was 0.19 pCi/L, the winter high monthly mean was 0.59 pCi/L. A winter sampling program nearer Crownpoint showed readings ranging from 0.05 pCi/L to 2.8 pCi/L, with a mean value of 0.65 pCi/L. Five stations in the Grants-Ambrosia Lake area, closer to active uranium mining and milling, had an overall mean of 0.72 pCi/L with a high reading of 2.8 pCi/L.

Readings were taken from five other stations in the heart of extensive mining and milling activity (Map IV-3). The means were 2.2, 2.1, 3.1, 3.6 and 1.9 pCi/L. The first two sites were within a mile of mill tailings ponds, while the next two not only were near mill tailings ponds but were also adjacent to mine ventilating ducts. The maximum readings for sites three and four were 5.4 and 6.6 pCi/L, respectively.

The interpretation of the fifth site, with a mean of 1.9 pCi/L and a maximum of 3.4 pCi/L, has been the subject of controversy. It is 3 to 6 miles downstream along the night wind drainage pattern from the numerous mines and several mills in the Ambrosia Lake area. (The wind flows are described in Los Alamos Scientific Laboratories Report LA-7628-MS.) The EID reports it is in an area containing inactive mines and mine wastes. However, this site is also in an area of considerable surface and near-surface mineralization, as sketched in Map IV-3 and described by the EPA in a 1976 report (U.S. Environmental Protection Agency, 1976). This report, in which the radon measurements are recorded, includes extensive

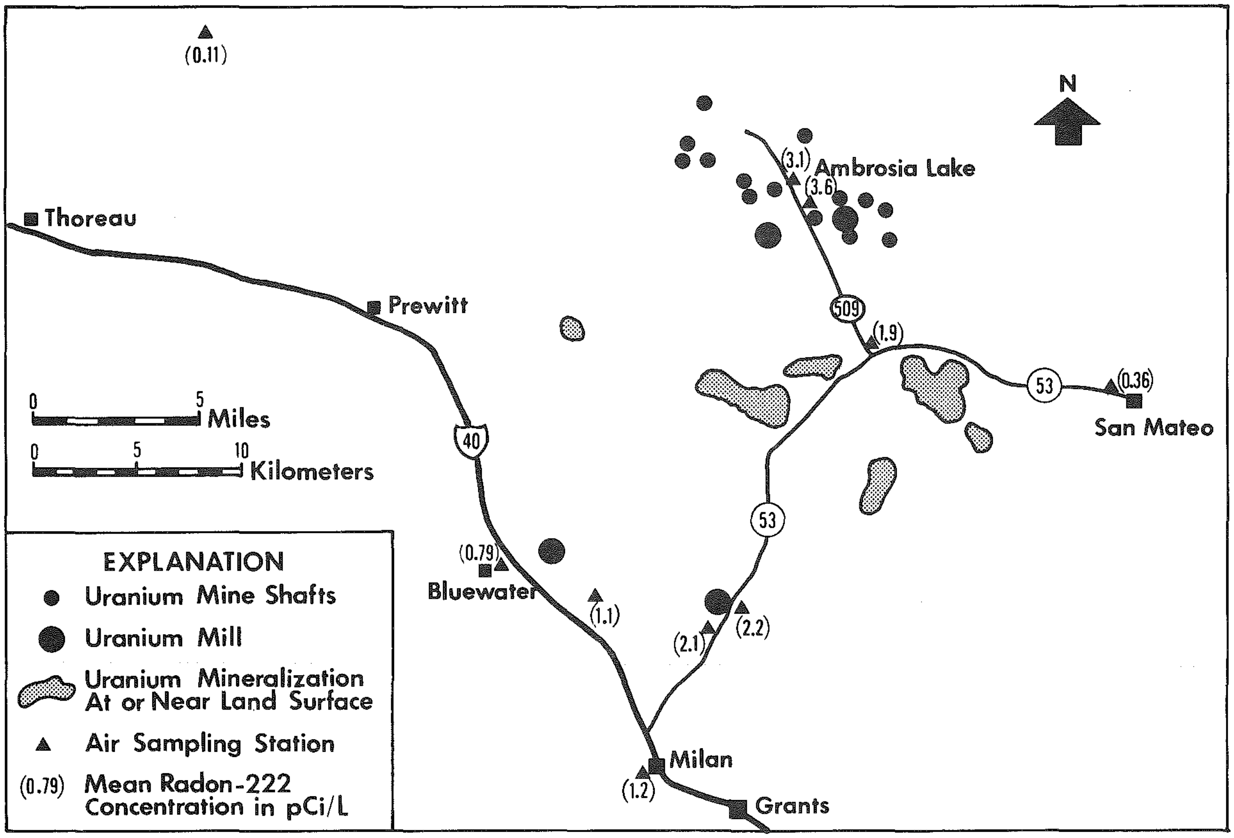
discussion of the geology and mineralization of the area. Based on the available data, it is not possible to state with certainty the extent to which each of the three sources (night drainage from Ambrosia Lake, local inactive mines, or surface mineralization) contributes to the measured radon concentration at this station, and opinions differ. It is the opinion of the SJBRUS scientists who analyzed the situation that the nearest extensive source, widespread local surface mineralization, is probably the major contributor.

The difficulty in separating the values of radon concentrations emanating from open pit mines from background readings was also apparent. A January 1979 EPA report (Technical Note ORP/LV-79-2) gives measured values taken during June 1976 in an area extending outward about 7 miles from the Jackpile-Paguate open pit uranium mine. Quoting the findings, the average radon level for seven background locations was 0.50 $\pm$ 0.033 pCi/L, with a maximum of 1.7. A site in the immediate proximity of the mine showed an average of 1.1, maximum 1.8 pCi/L, and two sites along the railroad had averages of 0.99 and 1.3 (maxima 2.1 and 2.7) pCi/L. The latter two were considered possibly attributable to ore spillage or the use of mine overburden material along the right-of-way. An average of 0.63 (maximum 1.6) pCi/L at a site 7 miles southwest of the mine was attributed to the natural variability of radon emanation from uranium bearing minerals in the local geologic structure.

It is obviously difficult to relate these short-term radon concentration measurements to the maximum permissible annual average concentration of 3 pCi/L above the natural background. The mean background concentration in areas of near-surface uranium mineralization may exceed 1 pCi/L (Table IV-6). In such cases, total concentrations of at least 4 pCi/L near mine vents and mill tailings might be interpreted as being within the MPC. Concentrations of 5.4 and 6.6 pCi/L, however, almost certainly exceed the MPC. Limited monitoring suggests that the MPC might be exceeded at stations in areas of intense mining and milling activities approximately 25 percent of the time (Geomet, 1978, No. 18). Nevertheless, if the reported measurements are assumed to be representative, the annual average concentration did not exceed the MPC at any of the monitored locations. It appears that natural background radon concentrations in highly mineralized areas may exceed 3 pCi/L as much as 20 percent of the time (Geomet, 1978, No. 18).

AIR QUALITY WITHOUT FURTHER URANIUM DEVELOPMENT

If the decision were made to delay or suspend further uranium development, beyond that now existing or under construction, overall growth would slow in the southern part of the basin but would continue unabated to the north. As pointed out in Chapter II, there will be significant industrial growth in the basin in any event. While it will not match the economic potential of uranium production, as Table IV-5 indicated, this industrial growth may produce an even greater impact on air quality than would uranium mining and milling.



AMBROSIA LAKE MINING DISTRICT AND VICINITY

Map IV-3

Table IV-6

Summary of Background Radon-222 Concentrations

	Concentration (pCi/liter)	
	Mean	Maximum
Non-mineralized areas	0.2	0.9
Mineralized areas	0.7	2.8
Mineralized areas with near-surface and surface mineralization	1.9	3.4

Note: Because of a dearth of measuring stations, the limits of the mineralized areas and near-surface or surface mineralization cannot be plotted with accuracy. In general, the region from west of Crownpoint to near Laguna contains mineralization, while areas of near-surface or surface mineralization are scattered in the region, particularly around Laguna and Ambrosia Lake.

Source: Geomet, 1978, Nos. 18 and 20.

Air Quality and the Winding Down of Uranium Development

The direct impact on air quality from the two greatest pollutants of uranium development, radionuclides and particulates, would lessen as mining slowed and tailings ponds were reclaimed. The consequence to air quality would be limited, however.

Because of dust storms common to the region, particulate levels often exceed the 24-hour national ambient air quality standard (NAAQS). Monitoring stations in more remote areas of the basin generally report an annual average background concentration of approximately 20-30 $\mu g/m^3$. Since the NAAQS for the annual average TSP concentration is 75 $\mu g/m^3$, the standard would be unlikely to be exceeded except when soil disruptions by man contributed dramatically to increased particulate emissions.

A similar analysis holds for airborne radon-222. Concentrations of radon-222 are considerably less than allowed in the federal and state regulations (annual average of 3.0 pCi/L above background) except within the vicinity of mine vents or tailings ponds, where measurements above 5.0 pCi/L have been recorded. However, radon emanating from outcrops and near-surface uranium-bearing rock would continue to cause high background levels in the region, and a decrease in uranium mining would not affect this. As pointed out later in this chapter, the health hazard from exposure to radiation caused by uranium mining and milling is much lower than that from exposure to natural background radiation.

The indirect increases in carbon monoxide, hydrocarbons, and oxides of nitrogen are caused by cars and trucks. These contributors of air pollutants would for the most part remain, and even continue to grow, as uranium mining cut back. As detailed in the socioeconomic section, the population and number of vehicles driven would increase but at a slower pace. The levels of other emissions from uranium mines and mills, such as SO_2, are insignificant, and a slowdown in mining should have little effect on them.

Air Quality and Other Development

Most industrial development over the next two decades will be north of the Grants mineral belt. Exceptions are the Plains Electric plant near Prewitt and the Santa Fe rail spur to Star Lake. Geomet (No. 20, 1978) analyzes the two extant studies of the effects of continuing development on air quality. The pollutants it anticipates for the region are viewed from three standpoints in Tables IV-7, IV-8, and IV-9, taken exclusively from the two studies by Radian Corporation, 1977, and R.W. Beck and Associates, 1975. The Beck study analyzes emissions from the proposed Wesco gasification plants as well as the El Paso Burnham plants. The SJBRUS team assumes that one Burnham plant, about 20 miles southeast of the Wesco site, is likely to be in operation by 2000. Wesco has dropped its plans.

El Paso Burnham's stack emission may interact with the proposed Bisti power plant to a certain extent. The cumulative impact of these two industrial complexes has not been studied. They are sufficiently far from the San Juan River power plants, however, that the cumulative effects may not

Table IV-7

Total Emissions (Tons/Year) for Non-Uranium Proposed Actions in Region

Emission Sources	Total Emissions (Tons/Year)											
	1985				1990				2000			
	TSP	SO_2	NO_2	OTHER	TSP	SO_2	NO_2	OTHER	TSP	SO_2	NO_2	OTHER
Alamito Coal (TC & E)	N/A											
Amcoal (Amcoal)	1,225	-	-	-	-	-	-	-	-	-	-	-
Arch Minerals (Arch Minerals)	9,964	-	-	-	9,964	-	-	-	9,964	-	-	-
Arrayo No. 1 (Albert Firchau)	N/A											
Eastern Bisti Mine (Eastern Coal)	N/A											
Gamerco Mine (Carbon Coal)	5,836	-	-	-	-	-	-	-	-	-	-	-
Gallo Wash Mine (Chaco Energy Co.)	N/A											
Star Lake Mine (Chaco Energy Co.)	11,183	-	-	-	12,954	-	-	-	12,954	-	-	-
La Ventana Mine (Ideal Basic Cement)	N/A											
Salazar Mine (Freeman-United)	4,818	-	-	-	4,818	-	-	-	4,818			
Star East Lake (Peabody)	N/A											
Gallo Wash Pits 3 and 4 (Peabody)	N/A											
McKinley Mine (Pittsburg & Midway)	N/A											
Salt River Project Mines	-	-	-	-	559	-	-	-	559	-	-	-
South Haspah Mine (Chaco Energy)	N/A											
Western Bisti Mine (Western Coal Co.)	2,523	-	-	-	5,246	-	-	-	5,246	-	-	-
San Juan Mine (Western Coal Co.)	270	-	-	-	270	-	-	-	270	-	-	-
Conpaso Mine	N/A											
Navajo Mine	N/A											
Four Corners Power Plant												
PNM - New Mexico Generating Station (Public Service Co. of NM)									3,394	11,212	34,356	-
San Juan Generating Station (Public Service of NM)												
Plains Electric Generating Plant (Prewitt)	11,103											
El Paso Coal Gasification Plant												
Conpaso Railroad (Gallup to Shiprock) N 100 miles	88	201	1,305	N/A	88	201	1,305	N/A	9	20	130	N/A
Santa Fe Railroad (Prewitt to Pueblo Pintado with branch to Bisti and Star Lake) N 157 miles	5,228	11,948	77,385	N/A	5,228	11,948	77,385	N/A	5,228	11,948	77,385	N/A
PNM 730 KV Transmission Line (Bisti to Star Lake to Ambrosia Lake)	-	-	-	-	-	-	-	-	-	-	-	-

N/A = Not Available
Emissions calculated by Radian Corporation and are scaled where appropriate
Source: Geomet, 1978, No. 20.

Table IV-8

**Possible Cumulative Effects of Facilities Over Flat Terrain
Northerly and Southerly Wind Directions
(Assuming Pasquill-Gifford Stability Class E)**

Case No.	Upwind Source	Downwind Source	Direction	Separation Distance (km)	Other Source(s)	Total Distance (km)	Possible[1] Interaction
1	San Juan	Four Corners	17°	14	-	-	Yes
					Wesco I	40	Yes
					Wesco II	45	No
2	San Juan	Burnham II	3°	59	-	-	No
3	Four Corners	Burnham II	1°	46	-	-	No
4	Wesco II	Burnham II	325°	19	-	-	Yes
5	Wesco II	Four Corners	197°	32	-	-	Yes
					Wesco I	32	Yes
					San Juan	45	No
6	Burnham II	San Juan	183°	59	-	-	No
7	Burnham II	Four Corners	181°	46	-	-	No
8	Burnham II	Wesco II	145°	19	-	-	Yes

[1] Possible interaction was rejected whenever source to source distance exceeded 43 km (3 hours of travel at 4 m/sec.).

Source: Geomet, 1978, No. 20, taken from R.W. Beck and Associates, 1975.

exceed the increments allowed in the EPA Class II designation (19 μg/m^3 particulates and 20 μg/m^3 SO_2, annual average).

Average concentrations thus remain within standards. However, as pointed out earlier, several problem spots exist. Meteorological conditions in the Farmington area impede pollution dispersion more than 40 percent of the time. Impaction of elevated plume sources against nearby topography and limited dispersion of plumes due to temperature inversions can be expected to continue in the future. If additional generating capacity is added, the nighttime air drainage along the San Juan River westward will retain pollutants in the vicinity and westward past the town of Shiprock. Similarly, Gallup would lie in the downwind path of the normal nightly airflow from the planned Prewitt plant, which is scheduled for construction in a scenic area that now has no significant longterm air quality problems of a manmade nature. Construction of a coal gasification plant, as assumed for purposes here, would further increase the potential for increased pollution to the north.

Coal fired power plants also release radionuclides. Western coal contains from 0.001 percent to 0.1 percent uranium. The stack effluent of a 1,000 MW(e) plant could contain an individual dose of 5 mrem to 70 mrem per year from radium-226 and thorium-230. Figures are not available on radon (U.S. Environmental Protection Agency, 1977).

Table IV-9

Maximum Predicted Annual-Average Surface Concentrations

Source	Distance (km)	Direction	SO_2	NO_x	P
				($\mu g/m^3$)	
San Juan	6	W	13	21	2
Four Corners	5	W	20*	44	3
Wesco I	4	N	2	3	1
Wesco II	7	N	3	6	1
Burnham I	2	SE	3	3	1
Burnham II	2	ENE	5	6	1

Note: When background air quality values representative of 1986 are added to these impacts, no compliance problems with the New Mexico annual standards will result.

*Predicted concentrations should be reduced somewhat due to the higher control efficiency requirement effective 7/31/79.

Source: Geomet, 1978, No. 20, taken from R.W. Beck and Associates, 1975.

Offsetting the possible adverse effects would be imposition of more stringent environmental controls and operation of increasingly effective pollution control equipment. The net impacts on air quality in affected areas would be influenced by future decisions and technological developments and cannot be predicted with assurance at this time. New Mexico and Colorado air quality plans are designed to bring about compliance with existing standards where they are not now met.

To summarize, the gradual cessation of uranium development would lessen concentrations of particulates and radionuclides locally, but for the most part air quality would not improve. In fact, because of industrial development and population growth the opposite would be true. Nevertheless, though the change would be for the worse for the region, air quality would remain better than it is in most parts of the country.

AIR QUALITY WITH MODERATE URANIUM DEVELOPMENT

Methodology

Density. Density of expected Moderate uranium development was projected on the basis of locating the mines and mills needed to meet the assumed demand in areas of known reserves (Gibson, 1978, No. 5). The density is important in air quality studies because sources of pollution located close together tend to combine emissions. This results in higher

total concentrations than would occur if they were separated. The Moderate development assumption calls for the numbers of mines and mills shown in Table IV-10. The density expected is shown in Table IV-11 and is depicted for 1990 and 2000 on Maps IV-4 and IV-5.

Table IV-10

Assumed Number of Mines and Mills, Moderate Scenario*

Year	Mines	Mills
1977	30	4
1985	38	10
1990	48	11
2000	72	15

*All uranium extraction facilities are assumed to be standard uranium mills to present a worst case.

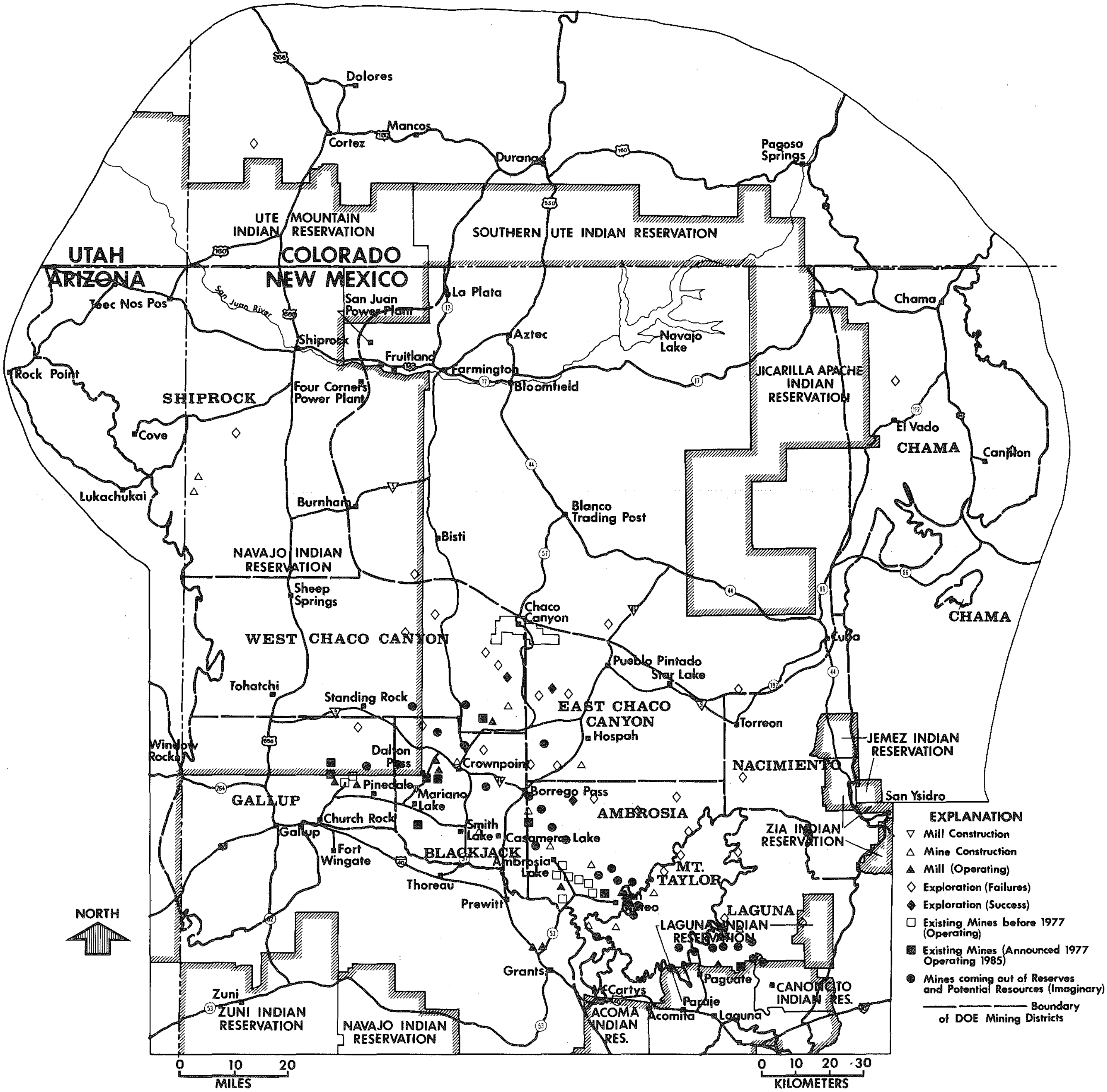
Table IV-11

Density of Mine/Mill Combinations

Scenario Year/development	Number within: Cluster area	10 mile diameter mills	10 mile diameter mines	15 mile diameter mills	15 mile diameter mines	20 mile diameter mills	20 mile diameter mines
1990/Moderate	1	1	7	1	8	1	10
	2	1	9	2	13	2	16
	3	2	5	2	5	2	8
2000/Moderate	1	2	6	2	9	2	12
	2	1	7	1	13	2	16
	3	2	5	2	5	2	8

Source: Geomet, 1978, No. 20, revised 1979.

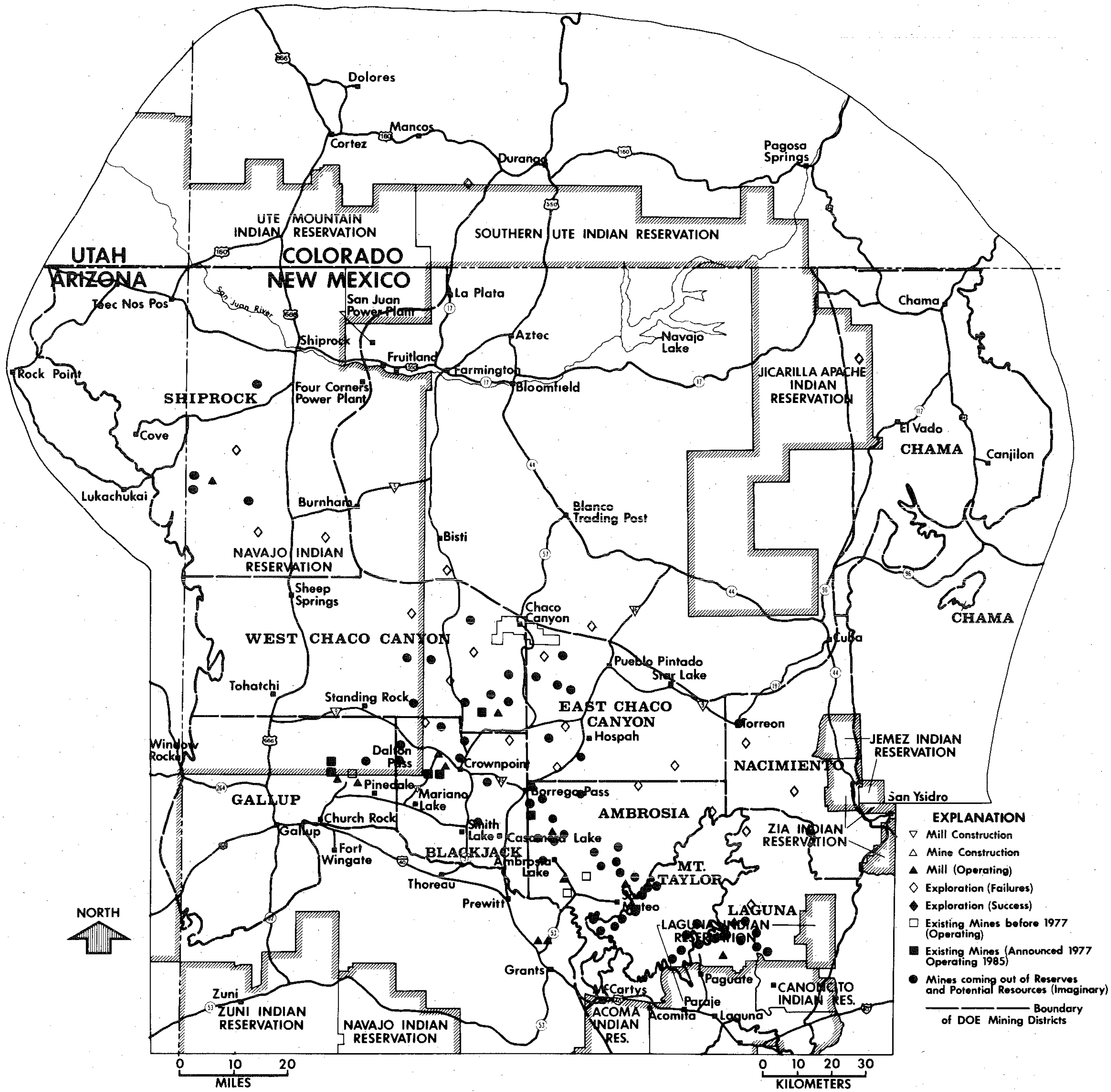
Three cluster areas in the San Juan Basin region are conspicuously projected as most likely to experience the greatest uranium development under conditions envisioned here. They are 1) Northeast Valencia County, taking in the Laguna area northward; 2) Ambrosia Lake area; 3) Crownpoint area.



URANIUM MINING, MILLING AND EXPLORATION IN NORTHWESTERN NEW MEXICO 1990

MODERATE

Map IV-4



URANIUM MINING, MILLING AND EXPLORATION IN NORTHWESTERN NEW MEXICO 2000

MODERATE

Map IV-5

The greatest density of mines and mills projected under the Moderate scenario occurs in the 1990 period in a circle 10 miles in diameter centering at Ambrosia Lake. As shown in Table IV-11, the rough projections indicate this area would have one mill and nine mines then. This would average 0.13 mine or mill per square mile.

Possible Pollutants. Several types of pollutants are emitted to the atmosphere during mining and milling operations. Pollutants studied were those for which air quality criteria have been established, called criteria pollutants, and radionuclides, a noncriteria pollutant. The criteria pollutants are sulfur dioxide (SO_2), suspended particulates (TSP), nitrogen oxides (NO_x), carbon monoxide (CO) and hydrocarbons (HC). State regulations cover the source and byproducts of criterion pollutants and limited amounts of special nuclear material. The EPA is studying air quality-related aspects of radioactive pollutants, as directed in the Clean Air Act Amendments of 1977, and may promulgate standards in the future.

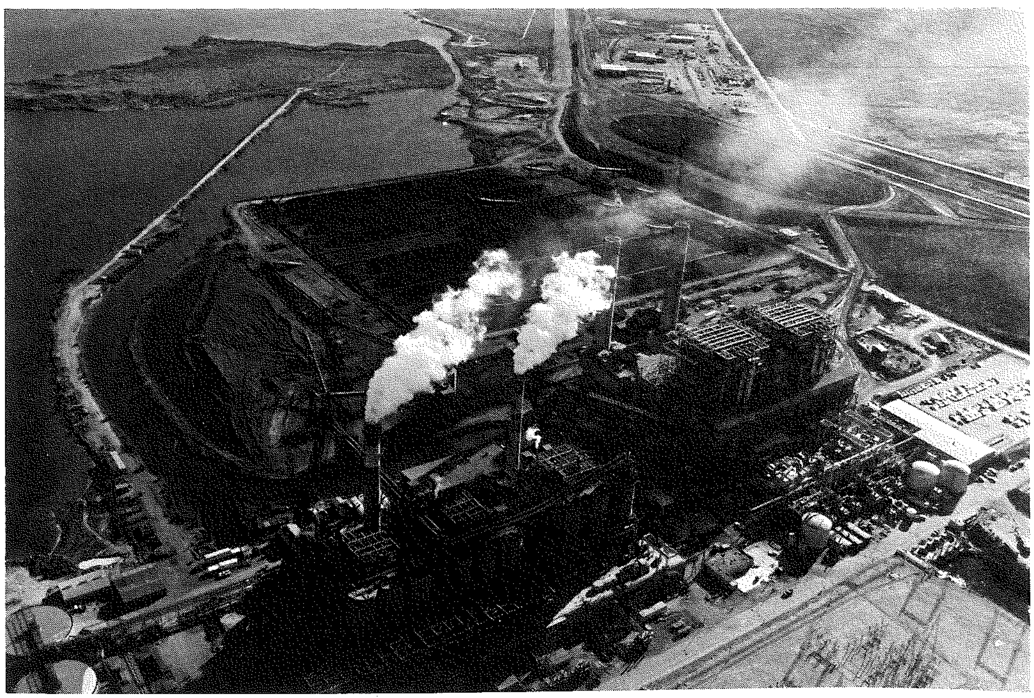


Figure IV-3.--Four Corners Power Plant

Dust may contain certain toxic non-radioactive contaminants such as molybdenum (Mo), selenium (Se), and arsenic (As). Data on the quantities of these elements in the ore are not available, and no estimate of the impacts can be made. They are believed to be minimal, however.

Tables IV-12 and IV-13 showing expected emissions from a typical uranium mine or mill are based on present or probable emission rates at existing or proposed developments (Geomet, 1978, No. 20). It should be noted that the existing data on emissions of most of these potential

Table IV-12

Emissions Due to Engines and Mining Operations

Diesel Engine ($g\ sec^{-1}$)		Underground Mine (with 3 Diesel Engines Operating) ($g\ sec^{-1}$)
SO_2	0.017	0.051
NO_x	0.253	0.756
CO	0.055	0.165
HC	0.020	0.060
		^{222}Rn 18 Ci day^{-1} (range 4 to 40 Ci day^{-1})

NOTE: Latest data on radon-222 emanations from mines are from NUREG/CR-0627, March 1979 rev. August 1979.

Source: Geomet, 1978, No. 20, revised 1979.

pollutants are scarce. The information that is available indicates that the quantities of SO_2, NO_x, CO and HC released from large scale development are not large enough to cause violations of air quality standards on a regional basis, whether conditions are typical or adverse. The effects of particulates and radionuclides, however, are less clear. Radon-222 emissions in Table IV-12 are based on an average of projections taken from a new study using sophisticated measuring techniques.

Data on the rates of particulate emissions from mines were not available. However, measurements of particulate concentrations--as contrasted to emission rates--in the atmosphere around mine vents (listed in Geomet, 1978, No. 20), were used to calculate downwind concentrations. (See "Analysis" below.)

The emissions shown in Table IV-13 are estimated for a mill with a 3,000 ton daily ore capacity. Emissions for a mill with a capacity of 5,000 tons of ore per day, assumed for future mills in the study area, would be higher by a factor of 1.67 on the assumption that emissions would increase in proportion to the increase in mill capacity. Emissions from active tailings ponds are not included but appear in Table IV-14, which compares radon emanation rates from the vents of a mine with those from three elements of the milling operation. Using the fine ore bin as the basic

Table IV-13

Emissions from Uranium Mill

Pollutants	lb yr^{-1}	g sec^{-1}
Particulates		
Crusher and ore bin dust collector	12,500	0.18
Yellowcake dust collector	1,940	0.03
Boiler	2,630	0.04
Sulfur dioxide		
Leach tank vents	426	0.006
Boilers	88	0.001
Kerosene		
Solvent extraction	547	0.008
Organic acids	17,300	0.25
Nitrogen dioxide	17,500	0.25
Carbon monoxide	2,480	0.03
Radionuclides *		
(Rn-222) crusher		1.25×10^{-4} $\mu Ci\ sec^{-1}$
(Rn-222) fine ore bin		1.33×10^{-6} $\mu Ci\ sec^{-1}$
(U-238) yellow cake drier		6.73×10^{-3} $\mu Ci\ sec^{-1}$

*The above values for radionuclides were taken from readings made at the Exxon Highland Mill in Wyoming. The GEIS study indicates that for the average mill these figures are very low.

Source: Navajo-Exxon, 1976, Final EIS, Uranium Development, BIA.

unit of comparison with a factor of 1, Table IV-14 shows, for example, that the fine ore bin in the mill issues only 1/156-millionth the radon emanating from the mine's vents.

Any future plant that used on-site generated sulfuric acid would be constrained to an emission rate of 4 lb/ton of sulfuric acid produced. No such plant is known in the area at present, but some are contemplated.

Pollutant Concentrations. Digital modeling using existing data determined the concentrations of particulates and radionuclides that could result under varying wind and atmospheric conditions, including the most

Table IV-14

Comparison of Radon-222 Emanation Rates

Source	Rn-222 Emanation Rates pCi Sec^{-1}	Factor Times Fine Ore Bin
Tailings (Active Pond, 250 acres)	100,000,000	75,188,000
Mine Vents (per mine)	207,000,000	156,000,000
Mill - Crusher	125	94
Mill - Fine Ore Bin	1.33	1.0

Source: Geomet, 1978, No. 20, revised 1979.

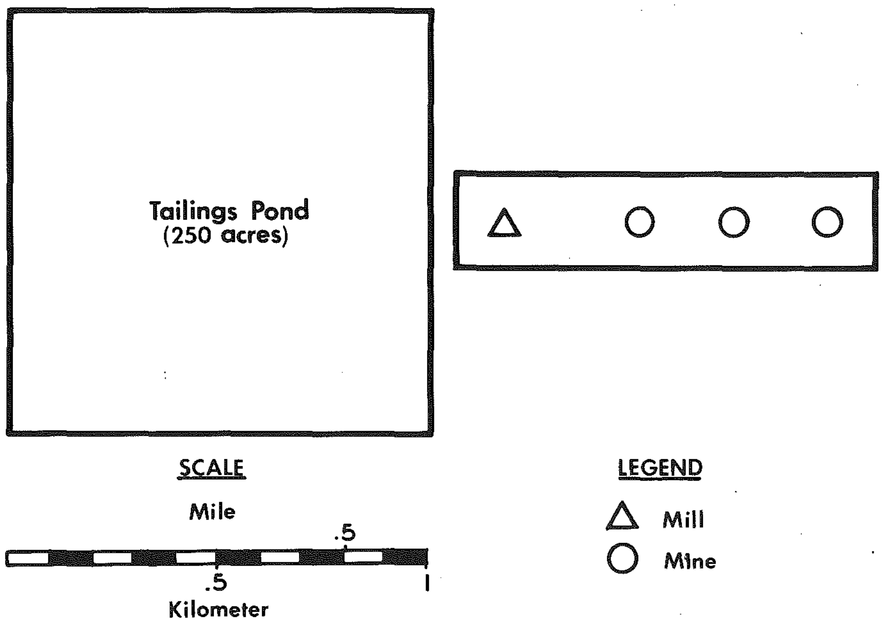
adverse (Geomet, 1978, No. 20). Modeling for conditions under which the greatest pollution could occur made it possible to single out the pollutants most likely to create an air pollution problem.

It should be noted that alignment of mines and mills to one another, as well as the distance between them, influences air quality. For example, sources placed along a line could generate maximum concentrations of pollution if the wind were to blow parallel to the alignment, permitting clouds from the various sources to reinforce one another. Figure IV-4 shows the hypothetical combination of source density and configuration used to give maximum concentrations with the wind parallel to the source line.

Analysis

Particulates. The study showed that a single mine vent would emit about 5 $\mu g/m^3$ of particulates--or dust. This is 3 percent of the allowable 24-hour standard (150 $\mu g/m^3$) for particulates contributed to a point one-half mile distant from the source. This standard assumes a day with nominal dispersion conditions and a more persistent than usual wind direction. At the mill, increased levels of dust would result from ore crushers, yellowcake bagging operations, and dusts blown from ore stock piles, ore haulage roads, and mill tailings disposal areas. Fugitive emissions of dust from employee traffic on unpaved roads around mines or mills are expected to be nominal, because these are intermittent and near the ground (Geomet, 1978, No. 20). A monitoring station downwind from a mill could expect to record 15 to 100 $\mu g/m^{-3}$ intermittently from these sources, depending on the controls in the mill.

The NRC's Draft Generic Environmental Impact Statement on Uranium Milling (GEIS) (U.S. Nuclear Regulatory Commission, 1979a) referring to single-mill impacts, stated: "the increase in suspended particulates that



MINE/MILL ALIGNMENT FOR
MAXIMUM AIRBORNE RADIONUCLIDE CONCENTRATION

Figure IV-4

would result from the tailings pile, the ore pads and the yellowcake drier is estimated to be less than 10 micrograms/m^3 at 1,000m from the center of the tailings pile, in addition to the present 35 micrograms/m^3 (assumed as) background concentration."

Radioactive Particulates. Radioactivity in airborne particulates that are raised by the wind from dry surfaces of tailings ponds (and to a lesser extent from the mill itself) is derived primarily from radium-226, thorium 230, polonium-210 and lead-210.* Preliminary analysis of the radiation doses that might be delivered through these pathways indicated that:

(1) They would be mostly localized with respect to specific individual facilities and local food utilization.

(2) During the 20 year period this study covers, improved control measures would largely eliminate such pathways in the future. These controls are required by the Uranium Mill Tailings Radiation Control Act (PL 95-604, 92 Stat. 302 (1978)). (See Chapter XII.)

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* Polonium-210 and Lead-210 are daughter products of radon and, for the most part, are discussed with radon. However, as heavy metals, they attach themselves to dust and thus are often found on particulates along with radium-226 and thorium-230.

(3) Neither individual nor collective dose commitments from these sources and pathways would be comparable to those from radon-222, in all probability. For example, the total diffusion of radon from a tailings pile is 3,154 Ci/yr. By contrast, the annual radioactivity in windblown particulates from tailings is calculated in the GEIS at just 0.014 Ci each for uranium-238 and uranium-234, 0.19 Ci for thorium-230, and 0.2 Ci each for radium-226, lead-210, and polonium-210. The difference is even greater when radon from mines is also taken into account. Each mine emits more than twice as much radon as a mill's tailings, and there could be three to five times as many mines, depending on the projection year considered. It is further assumed that control measures will be required at individual facilities to assure that no person receives a dose in excess of the EPA standard of 25 millirems per year (40 CFR 190). However, this may be contested by the industry. (For definition of millirem, see "The Health Hazard.")

Further discussion is found under "The Health Hazard" and in Chapters V and VI.

Radon-222, A General Analysis. The vents from an underground mine constitute the largest single source of radon-222 emissions in uranium production activities. Next largest individual sources are inactive dry tailings piles resulting from past uranium milling. Far behind in emissions of radon-222 are active tailings, which generally are nearly saturated below the surface although two-thirds of their area may be dry on the surface. As explained in the next section, an unreclaimed inactive pile of tailings emits much more radon than an active one, often 10 times as much.

Superimposing the emissions from a mine vent on the "plume" from a tailings area, using the values in Table IV-14, can significantly increase the concentrations over those of the tailings area alone.

Uncontrolled, this combined emanation would almost certainly cause the annual average standards to be exceeded within a mile or so of the facility. The middle column in each section of Table IV-15, under the heading 500, approximates the downwind concentrations from two mine vents and one mill when the distance from the source is 6 kilometers or greater. If a 3 km/hr wind speed persisted for 10 hours, a concentration of 3 pCi/L (the MPC) would be exceeded at all locations within 30 kilometers (18 to 19 miles) downwind of the operations. At higher wind speeds, the concentrations would be much less. It is not clear what they would be on an average annual basis in a populated area (the basis for the MPC).

These potential individual violations may not be subject to existing regulations, because the regulations do not cover mine vents. The figures point up the need for vigilant monitoring on a site-specific basis.

A Further Explanation: Radon-222 from Tailings Piles. The fact that the release rate of radon-222 from inactive tailings piles is generally estimated to be much higher and more variable than that from the actively used tailings ponds is demonstrated in Table IV-16. The wide variability for radon release rates is primarily attributed to variations in the amount of moisture and radium in the tailings, the latter related partly to ore

Table IV-15

Calculated Concentrations (pCi/L) from Mine Vents and a 250-Acre Mill Tailings Site for Various Downwind Distances, Stability Classes, and Source Strengths (These emission rates taken from Table IV-16)*

Distance from Upwind Edge of (km)	Atmospheric Stability Class								
	Neutral			Slightly Stable			Moderately Stable		
	Source Strength pCi m^{-2} sec^{-1}			Source Strength pCi m^{-2} sec^{-1}			Source Strength pCi m^{-2} sec^{-1}		
	13.4	500	2200	13.4	500	2200	13.4	500	2200
1.1	0.16	6	26	0.4	33	146	1.3	48	212
1.3	0.11	4.1	18	0.3	24	104	1.0	36	158
1.4	0.10	3.7	16	0.3	21	94	0.9	32	142
1.5	0.09	3.3	15	0.3	19	85	0.8	30	130
1.7	0.08	2.8	13	0.2	17	74	0.7	26	114
1.9	0.07	2.5	11	0.2	15	66	0.6	23	102
2.0	0.07	2.4	11	0.2	14	63	0.6	22	97
3.0	0.05	1.7	7	0.1	10	46	0.4	16	71
4.0	0.04	1.4	6	0.1	9	38	0.4	14	60
6	0.03	0.9	4	<0.1	6	29	0.3	11	48
10	0.01	0.5	2	<0.1	4	18	0.2	8	36
15	<0.01	0.3	1	<0.1	3	11	0.2	6	26
20	<0.01	0.2	0.8	<0.1	2	8	0.1	5	20
30	<0.01	0.1	0.5	<0.1	1	5	<0.1	3	16
40	<0.01	0.1	0.1	<0.1	0.8	3	<0.1	2	10
50	<0.01	0.1	0.1	<0.1	0.6	3	<0.1	2	8
60	<0.01	0.1	0.1	<0.1	0.5	2	<0.1	1	6
70	<0.01	0.1	0.1	<0.1	0.4	2	<0.1	1	5

* Note: The table may be read as follows: a wind speed of 3 km/hr might be expected under moderately stable conditions. After 10 hours the radon daughters would drift downwind 30 km. For a source strength of 500 pCi m^{-2} sec^{-1}, the calculated radon concentration would be 3 pCi/L. For more than one source, values at distances of less than 6 kilometers are not accurate.

Source: Geomet, 1978, No. 20, revised 1979.

grade, and in the porosity of tailings material. An actively used tailings pile is normally almost saturated. Although at the surface it may vary from very dry to water-covered (i.e., a pond), subsurface conditions control radon emission. The EID in 1979 reported 66 percent of the area covered by active tailings was dry on the surface, the rest covered by water.

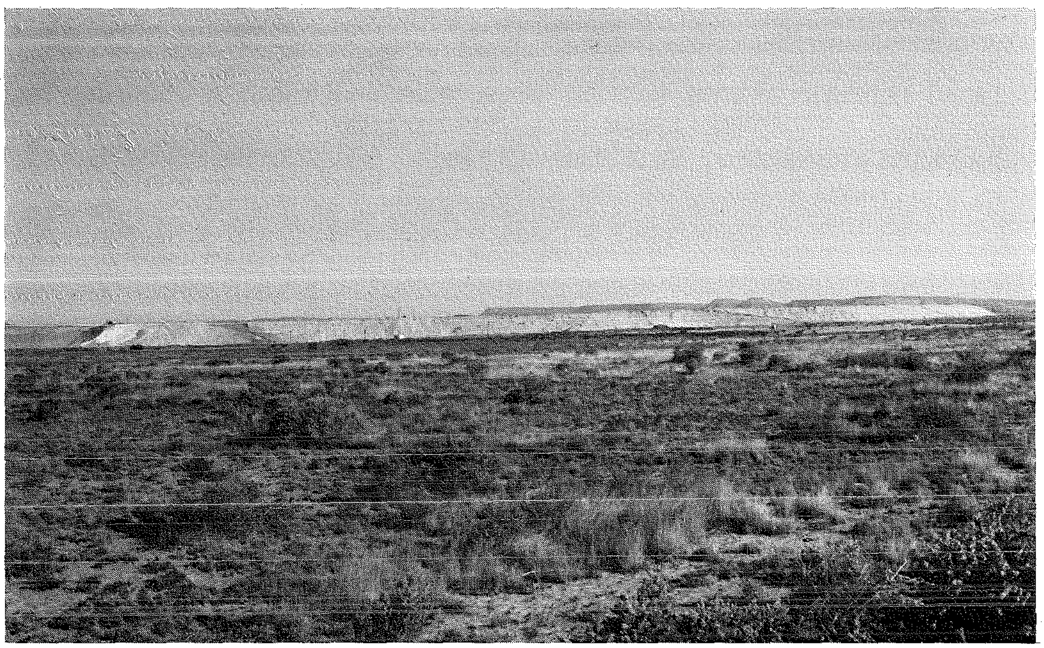

Figure IV-5.--Abandoned uranium mill tailings pile near Ambrosia Lake, N.M.

An active tailings pond with an average emanation rate (100 pCi m^{-2} sec^{-1} (the latest data) for a 250 acre pond, giving 10^{-4} Ci sec^{-1}), under adverse short term conditions can be expected to cause concentrations above the annual average MPC for a distance of about 1 to 3 kilometers from the downwind edge of the tailings. Under more usual conditions, and thus for the entire year, modeling (described in Geomet, No. 20, revised 1979) shows that the annual average MPC would probably not be exceeded by the tailings pond alone. The results for this calculation, while not shown directly in Table IV-15, would be represented by a column in that table headed "100," falling between the "13.4" and "500" headings.

Windblown tailings deposited on the ground around a tailings site have been shown to effectively increase the size of the radon-emitting area; the added area is much larger in size than the tailings pile but emits radon at a much lower rate. Recent measurements (U.S. Nuclear Regulatory Commission, 1979c) have shown that, for an active tailings area, windblown tailings can fall on the ground within 2 to 4 miles of the pile in sufficient quantities to increase the total radon emission rate from the entire area by 10 to 30 percent over that for the tailings itself. The total emanation rates used in later calculations are for an active tailings area in the projected future, where the blowing of tailings dust will be prevented by mitigation measures.

Emanations from the dried-out tailings piles vary widely in time and in location on a pile. Radon release is reduced when the surface is wet or snow covered. Emanation rates at a medium level (500 pCi m^{-2} sec^{-1}) under the most adverse conditions could produce radon-222 concentrations exceeding the MPC for a distance of many miles (or kilometers, Table IV-15). Under the highest levels (2200 pCi m^{-2} sec^{-1}) combined with the

Table IV-16

Radionuclide (Rn-222) Emissions from Tailings Pile and Ponds

Emission Rate pCi m^{-2} sec^{-1}	Emanation Source*	Reference
22.4	Pond	Navajo-Exxon Environmental Impact Statement (1976)
13.4	Pond	SJBRUS (1977)
36	Pond	U.S. NRC, undated
53 to 157	Pile	Ford, Bacon, and Davis, Utah, Inc. (1977)
11.2 to 220	Pile	Bernhardt, Johns and Kaufman (1975)
580	Pile	Witherspoon, Sears and Blanco (undated)
11.4 to 2200	Pile	Clements, Barr and Marple (1978)
100	Active Tailings	Momeni, et al (1979)

* The terminology "pond" and "pile" derives primarily from the original data sources. The terms "active" and "inactive" tailings are more appropriate. See the text for a discussion of the water content factor.

Source: Geomet, 1978, No. 20, revised 1979.

most adverse conditions, and for the short periods that these conditions would exist, the annual average MPC would be exceeded by a greater amount. The distance, however, would be about the same as for the medium level. This is because the most adverse conditions are approximately limited to the hours of darkness when the most stable atmospheric conditions can occur (Geomet, 1978, No. 18).

Thus the dry tailings probably often exceed the annual average maximum permissible concentration of radon-222 for as much as a mile or so from the pile and may occasionally register high readings for as much as 30 kilometers (18 miles) from the pile.

The dry tailings piles, in short, present significant air quality problems which call for mitigating actions. Through enactment of the

Uranium Mill Tailings Radiation Control Act, Congress laid the legislative groundwork for stabilizing tailings piles so as to reduce emanations of radon-222 to acceptable levels. (See "Mitigation of Air Quality Problems" and Chapter XII.)

While these air modeling studies indicate that the active tailings sites pose little problem, additional data are desirable on emanation rates for these wastes. A measuring program currently conducted for the NRC has provided the most recent information on tailings emanations. Any new information which might be obtained in the future should be incorporated in future analyses.

Surface Works and Radon-222. Radiation within and around structures such as mill buildings, process tanks, ore bins, and mine headworks is relatively low, as shown in Table IV-14. These sources could pose a problem, however, to workers exposed for long periods or in structures with poor ventilation. Therefore, this exposure must be monitored by the state's Environmental Improvement Division (mills) and the Mine Safety and Health Administration (mine headworks). This is a localized problem that would be studied in site-specific environmental impact statements. The regional effect, and thus the effect of interest to this study, is minimal.

Regional Impact. The total impact of emissions from all sources may be assessed by comparing with present emissions the additional emissions from all mines and mills projected in the Moderate scenario through 2000. Table IV-17 presents the total emissions of radon-222 and particulates calculated for these development levels using emanation rates from Table IV-14. The emission rates used for the total emission estimates presented there are shown in Table IV-18.

Table IV-17

Particulate and Radon Emissions from Mines and Mills for 1990 and 2000

Source	1990			2000		
	Number	Particulate ton/yr	Radon Ci/yr	Number	Particulate ton/yr	Radon Ci/yr
Mine	48	800	315360	72	1200	473040
Mill	11	89	2	15	122	3
Tailings Pond	11	---	34694	15	---	47310
Total		889	350056		1322	520353

Source: Geomet, 1978, No. 20, revised 1979.

When compared with the present inventory in Table IV-5, the total particulate emissions from mines and mills are projected to increase present emissions by 17 percent and 25 percent for the years 1990 and 2000, respectively, in McKinley and Valencia counties where nearly all of the projected development would take place. While the increase in terms of percentages is significant, the total quantities would remain low and air quality would remain good. These percentages would become insignificant if particulate figures from San Juan County or in dust storms were included (Geomet, 1978, No. 20).

The Health Hazard

Presupposition. As Schiager (1979, No. 40) states, "For the control of any environmental pollutant for which there is no recognized threshold level for biological effect, it is necessary to establish an acceptable level of health risk. Within the United States whole body doses from all natural sources (i.e. terrestrial, cosmic and internal radionuclides) range from about 65 mrem* per year in the Atlantic and Gulf coastal plain areas to as high as 125 mrem in Denver, Colorado (NCRP-75). These values are averages for very large population groups (i.e., greater than 1 million persons in each group). However, within each area surveyed, variations above and below the average were observed. Thus the variation of doses from natural sources of radiation to small population groups or individuals ranges from approximately 50 mrem per year to 250 mrem per year. Since there is no evidence that individuals move from Colorado to Mississippi or other Gulf Coast areas specifically to avoid radiation exposures, it must be concluded that variations in radiation doses, at least in the order of 200 mrem per year, are considered to be acceptable risks of normal living.

"The ICRP (1977) and the NCRP (1971) have both recommended radiation dose limits of 170 mrem per year averaged over appropriate population groups and not to exceed 500 mrem per year to any individual. [All doses are above background.] Due to the variability of environmental radiation exposures the average dose to any significant population group cannot exceed 170 mrem per year if all individual doses are less than 500 mrem per year. These recommended dose limits are obviously not much different from the variations observed in natural radiation doses and as such are taken to be levels that do not present unacceptable risks to individuals." (The ICRP is the International Commission on Radiological Protection; the NCRP is the National Council on Radiation Protection and Measurements.)

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* mrem=one millirem or 1/1000th of a rem.

rem--The amount of ionizing radiation that, when absorbed by man, is equivalent to one Roentgen of X-ray or gamma radiation. (From Roentgen Equivalent Man).

Roentgen--A primary unit of radiation exposure. Technically, it is defined as that quantity of X-radiation or gamma-radiation that produces one electrostatic unit of electrical charge per 0.001293 gram of air.

Table IV-18

Emission Rate Values Assumed for Mine and Mill Emissions

Source	Particulates g/s	Particulates ton/yr	Radon-222 Ci/s	Radon-222 Ci/yr
Mine	.48	16.67	2.07×10^{-4}	6570
Mill				
Crusher	0.170	5.9	1.25×10^{-10}	3.9×10^{-3}
Fine Ore Bin	0.027	0.94	1.33×10^{-12}	4.0×10^{-5}
Yellow Cake Dust Collector	0.037	1.28	6.73×10^{-9}	2.1×10^{-1}
Mill Total		8.12		2.2×10^{-1}
Tailings Pond 250 Acre			10^{-4}	3154

Source: Geomet, No. 20, 1978, revised 1979.

Radiation Effects Controversy. The dose limiting recommendations of the ICRP and the NCRP are based on linear extrapolations down to natural background levels of health effects observed in populations exposed to high levels of radiation. All of the large scientific committees* that have addressed the issue of effects of low levels of radiation on population groups have agreed that this is a conservative approach, that is, an approach that is much more likely to overestimate than to underestimate the actual health effects.

In recent years, several individual scientists have cited findings of much higher risks from low levels of radiation exposure than would have been predicted from the linear response model. In the analysis that follows, however, SJBRUS follows the lead of the great majority of scientists and advisory committees by using the generally accepted dose-response models and calculational procedures.

Pathways into Human Body. Radiation may enter the human body in three ways: exposure or absorption through the skin, ingestion by eating or drinking contaminated food or water, and inhalation of gases or airborne

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* NAS-NRC BEIR Committee (National Academy of Sciences-National Research Council, Biological Effects of Ionizing Radiation Committee); ICRP; NCRP: UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation); and the Interagency Task Force on Low-Level Radiation, sometimes referred to as the Libassi Committee.

particulates. Absorption is a problem with certain reactive gases and vapors not found in the San Juan Basin. This type of exposure will not be discussed further.

External gamma radiation exposes the entire body, including the gonads. Also, some radioactive isotopes when taken internally may concentrate in the reproductive system and cause genetic defects. However, such exposures from uranium mining and milling in the San Juan Basin are not considered as prevalent as the exposures which might lead to cancer induction. This discussion, therefore, concentrates on cancer, the most important health impact in a situation in which the major doses would be to non-reproductive organs.

Ingestion of radioactive isotopes, the second of the three pathways into the human body, is being studied intensely in the basin. The studies are necessary because of the complexities associated with this pathway. Its effects are dependent upon the uptake rate of various plants, the ability of the plant cells to store or concentrate the isotopes, the plant's palatability to animals, the storage of the isotopes in various animal organs, and many other factors. As explained in following sections, this pathway is not believed to have caused measurable cancer problems among basin inhabitants and is not expected to do so in the future. This will particularly apply if the mitigating measures prescribed by law and discussed in these pages are followed.

"The most significant potential radiation exposure of a population from uranium mining and milling activities is due to the inhalation of airborne radon decay products," Schiager states. "This is also one of the manmade environmental radiation sources for which the U.S. Environmental Protection Agency has not established limits..." (Schiager, 1979, No. 40).

The translation of environmental concentrations to doses received by organs in the human body is complicated by uncertainties in distribution and retention patterns within the body. These are often dependent upon the physical and chemical forms in which the radionuclides enter the body. For example, organ doses from inhaled particulate materials depend upon deposition in the lung. This varies with particle size and the uptake to blood, which in turn is affected by both particle size and solubility of the material.

Other uncertainties arise. For example, the critical organ for inhaled insoluble uranium is the lung, whereas for soluble uranium the critical organ is the kidney. However, the exposure limit for soluble uranium is based on chemical toxicity and there are no data indicating a potential for cancer induction in the kidney. The maximum permissible intake specified only for occupational exposures is 2.5 milligrams (mg) in one day by inhalation (International Commission on Radiological Protection, 1964).

This gives some indication of the uncertainties and variables involved in interpreting how the exposure pathway affects human health.

The Cancer Risk. As could be inferred above, the use of accepted practice and adequate data does not answer all questions. Even when the organ dose can be estimated with some reliability, the probability of a deleterious health effect, such as cancer, may not be readily calculable. This is particularly true for dose-effect relationships which are non-linear, as in the case of the induction of bone sarcoma by deposited Ra-226 (UNSCEAR, 1977). For dose-effect relationships which are believed to be linear, the total number of health effects in a population is predicted on the basis of the average individual dose within the population multiplied by the total number of individuals. That is, the total probability equals the sum of the individual probabilities, which in turn are all equal. In the case of non-linear dose-effect relationships, the collective probability of health effect is equal to the sum of individual probabilities, but these cannot be calculated on the basis of average doses; in fact, some effects may exhibit an apparent threshold dose below which the effect is never observed. However, as yet the EPA has not recognized a threshold dose.

The Health Hazard from Particulates. Dust blown from the dry surface of a tailings pile could contain radium-226, thorium-230, polonium-210, and lead-210. The dust could be inhaled directly or it could settle on the earth, enter the food chain, and be ingested with foods.

Maximized transfer of radionuclides through food chains might occur in the case of Navajo Indians who live near a uranium mill and eat sheep raised in the area. There are no data available that apply specifically to this situation, and this potential food pathway should be thoroughly investigated.

The only data available that are potentially relevant to the analysis of exposures via food pathways are contained in a recent report by Holtzman, et al (1979). Unfortunately, the data are meager and the conclusions are necessarily speculative. The authors postulate that individuals could receive, under the worst conditions, an annual dose several times larger than the EPA standard of 25 mrem per year (40 CFR 190). However, the conditions required to produce such an exposure are extremely unlikely and the authors say "the actual exposure to the residents in this area is probably substantially less than the above figures ..." (Holtzman, et al, 1979).

Radium-226 in Particulates. A major radionuclide in dust or particulates is radium-226. The cancer risk from internally deposited radium is an example of a non-linear dose response and apparent threshold. In spite of the intensive study and long term follow-up of a relatively large number of individuals with internal Ra-226 contamination, no bone sarcomas have been observed following mean bone doses of less than 1160 rads or endosteal surface doses of less than 760 rads. If releases from uranium mills and tailings piles are controlled so as to comply with the limits established by the EPA in 40 CFR 190 (25 mrem/year), the maximum lifetime dose commitment to any individual would be many orders of magnitude lower than the minimum doses at which bone sarcomas have been observed (25 mrem = 2.5 mrads for alpha radiation). This apparent threshold effect is adequately explained by the non-linear response model suggested by

UNSCEAR, 1977; it combines a quadratic term (the value squared) which applies at relatively low doses (i.e., less than a few hundred rads to bone) and an exponential term which corrects the quadratic at high doses (a few thousand rads).

The use of any generally accepted risk factor for radium-226, whether it is inhaled or ingested, produces calculated risks that are much smaller than those from inhalation of radon and its progeny. In keeping with the intent of the SJBRUS to analyze the significant impacts, the remainder of this analysis is devoted to the potential health impact of radon. All dose-effect relationships used in the radon analysis are assumed to be linear and without thresholds.

The Health Hazard from Radon-222. All of the data on the risk of lung cancer resulting from the inhalation of radon decay products have been derived from the experience of underground miners for uranium or other products. The radiation doses to these miners resulted from occupational exposures to radon daughter concentrations that were often orders of magnitude higher than those to which the general public might be exposed. Because of the large uncertainties in the conversion factors used in dose calculations, correlations are more reliable when the exposures are retained in the original cumulative concentration units: working level months (WLM)*. The epidemiological risk index is then the incidence of lung cancer per unit exposure (WLM) (Schiager, 1979, No. 40).

For lifetime occupation exposures, the risk may be estimated as $4x10^{-4}$ cancers per WLM x 15 years lost life per cancer or approximately $6x10^{-3}$ years (2 days) lost per WLM. For population exposures involving individuals of all ages exposed for most of their lifespan, the risk may be estimated as $8x10^{-4}$ cancers per WLM or approximately $12x10^{-3}$ years (4 days) lost per WLM. The annual average radon concentrations converted to annual average radon daughter concentrations using an average equilibrium factor for radon daughters indoors or outdoors near the ground surface resulted in a value of 0.006 WL per pCi/L (National Council on Radiation Protection and Measurements, 1975; UNSCEAR, 1977). The conversion factor of 27 WLM per annual average WL concentration is applied to estimate annual exposures in WLM (Schiager, 1979, No. 40).

The Impact on Health in the San Juan Basin. Cancer studies and statistics for isolated groups or population segments particular to the San Juan Basin are meager at best. To further complicate the analysis of future health risks, such factors as population density, population mix, and the average levels of criteria air pollutants (sulfur dioxide, nitrogen

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* Working Level - An atmospheric concentration of radon (Rn-222) daughters which will deliver $1.3 x 10^5$ MeV of alpha energy per liter of air.

Working Level Month - An exposure equivalent to 1 working level of radon daughters for 173 hours. The Mine Safety and Health Administration's maximum standard for uranium miners is 4 WLM per year.

oxides, and others) will change as industrialization increases. Therefore, for the purpose of approximating the risk factors, calculations were made based on national lung cancer statistics applied to the basin environment. Where insufficient data were available worst cases were assumed.

Two sets of calculations were made: one for background radiation, the other for radiation caused by uranium development. Since the results were for comparative purposes only, just the year 2000 was selected for complete analysis. The limitations of this analysis are fourfold: (1) It assumes that background radiation will remain constant. More data on background radiation would be helpful. (2) It assumes that radiation from uranium development will not diminish as a result of technological advances or regulations. Data are available on current technology and current radon emissions from mine vents and tailings ponds in the basin. (3) The analysis assumes that population will grow and be distributed as described in Chapter VII. Additional data could not guarantee accuracy on this assumption. (4) The analysis assumes that the SJBRUS projection of mines and mills is valid. Again, no amount of additional data could foretell the future with certainty.

Natural background concentrations of radon-222 occur in three ranges, according to the land category as shown in Table IV-6 (Geomet, 1978, No. 18). The mineralized areas referred to above included no mining or milling facilities, and the population distribution among the three concentration ranges was not reported. Consequently, the assumption must be made that the high concentrations occur in very small areas and that a natural background concentration of 0.2 pCi/L occurs over most of the region. This average radon concentration would result in annual radon progeny inhalation exposures of:

$$(0.2 \text{ pCi/L})\ (0.006 \text{ WL/pCiL}^{-1})\ (27 \text{ WLM/WL - yr}) = 0.03 \text{ WLM/yr}.$$

This value is used for making comparisons of the incremental increases from uranium development with natural background (Schiager, 1979, No. 40).

Calculations based on possible uranium development projected the expected magnitudes and distributions of annual average concentrations of radon-222 for 1990 and 2000. The EPA-developed and approved Climatological Dispersion Model (CDM) was used. (For details, see Geomet, 1978, No. 20, revised 1979.) In this calculation mines and mills were distributed according to the projections in Table IV-10.* For emanations from tailings the value used was 10^{-4} Ci sec^{-1}, based on the latest data. For total emissions from all vents of each mine, the value cited in Table IV-12 (18 Ci/day) was used.

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* Emanations from the Jackpile and the small St. Anthony open pit mines were not considered in this analysis of 1990 and 2000 regional effects. It is anticipated that they would add, at most, the equivalent of one additional mine's emissions.

Two additional sets of calculations were made, one using a figure for the mines of 4 Ci/day (the lower limit shown in Table IV-12), and the other a lower figure from earlier data (0.4 Ci/day). The purpose here was to examine how sensitive the results were to changes in the mine vent value, due to the uncertainty involved. The calculated annual average concentrations represent those that would be added to any natural background already present.

Conclusions

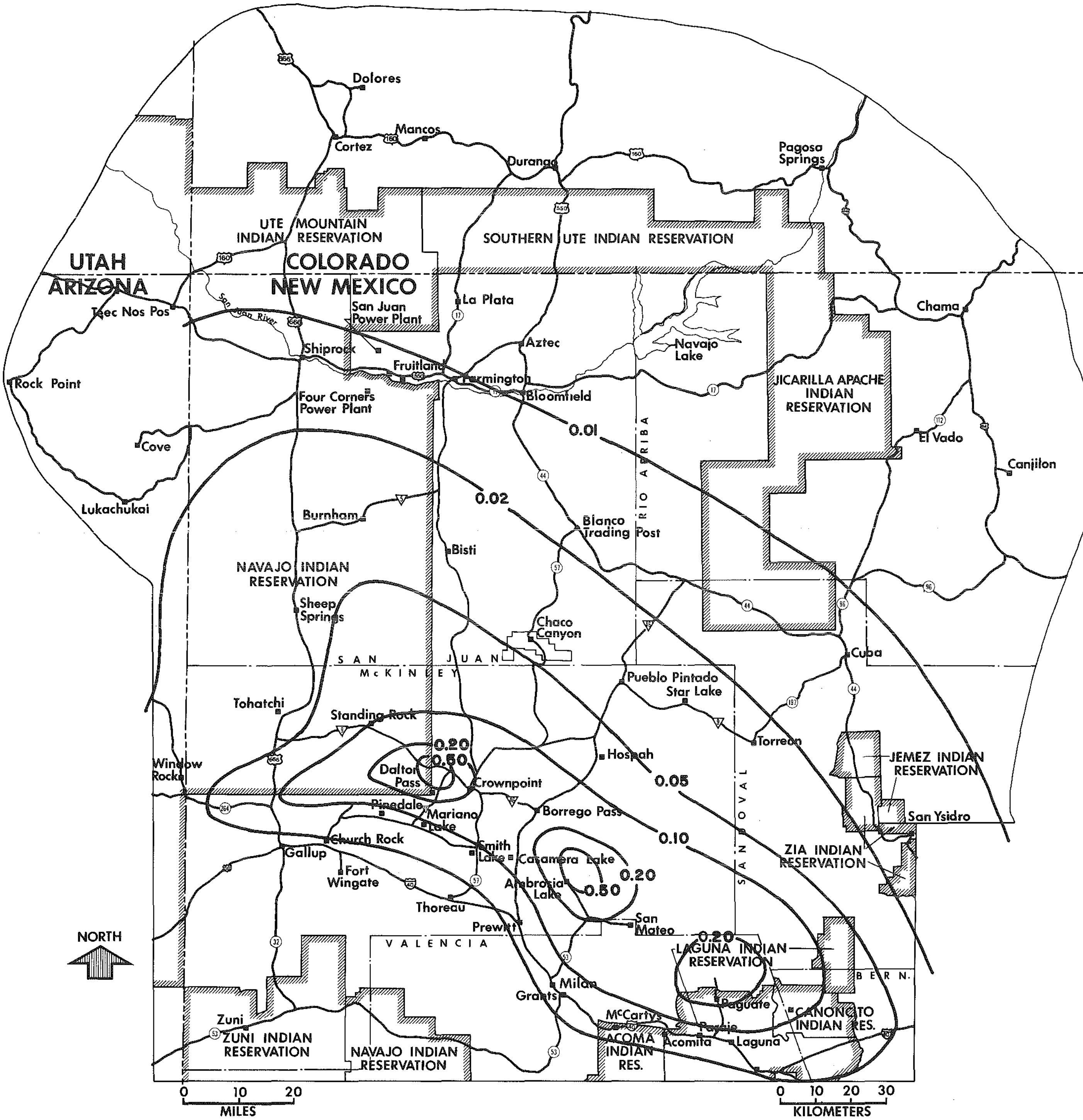
In the 1990 scenario, with 48 mines emitting radon at the rate of 18 Ci/day each, and 11 mills, the highest annual average calculated was 0.50 pCi/L, one-sixth the maximum permissible annual average. This occurred in the general area of Ambrosia Lake. The next highest value was 0.47 pCi/L at Dalton Pass. The contours of the concentrations are shown in Map IV-6.

When the same calculation was made for 2000 (Map IV-7), assuming 15 mills and 72 mines, the peak in the Ambrosia Lake area was reduced to 0.31 pCi/L, while the Dalton Pass value increased slightly to 0.50 pCi/L. The reduction in one of the maximum values and the expansion of the area covered by the lower values reflect the shifting of mines and mills toward the north in the later period. With regard to the calculation using a mine emission figure set at 4 Ci/day, the concentrations averaged about one-third those shown in Maps IV-6 and IV-7. At 0.4 Ci/day, the general effect was to reduce the concentrations to about one-half those at 4 Ci/day.

Only a few of the calculated annual averages with the 18 Ci/day mine vent rate are as much as one-sixth of the annual average radiation standard specified in 10 CFR 20. A study was also made to examine the health impact of such small incremental increases in the annual average figures. The annual average radon-222 concentrations were converted to annual exposures in working level months per year, and these were related to projected population distributions.

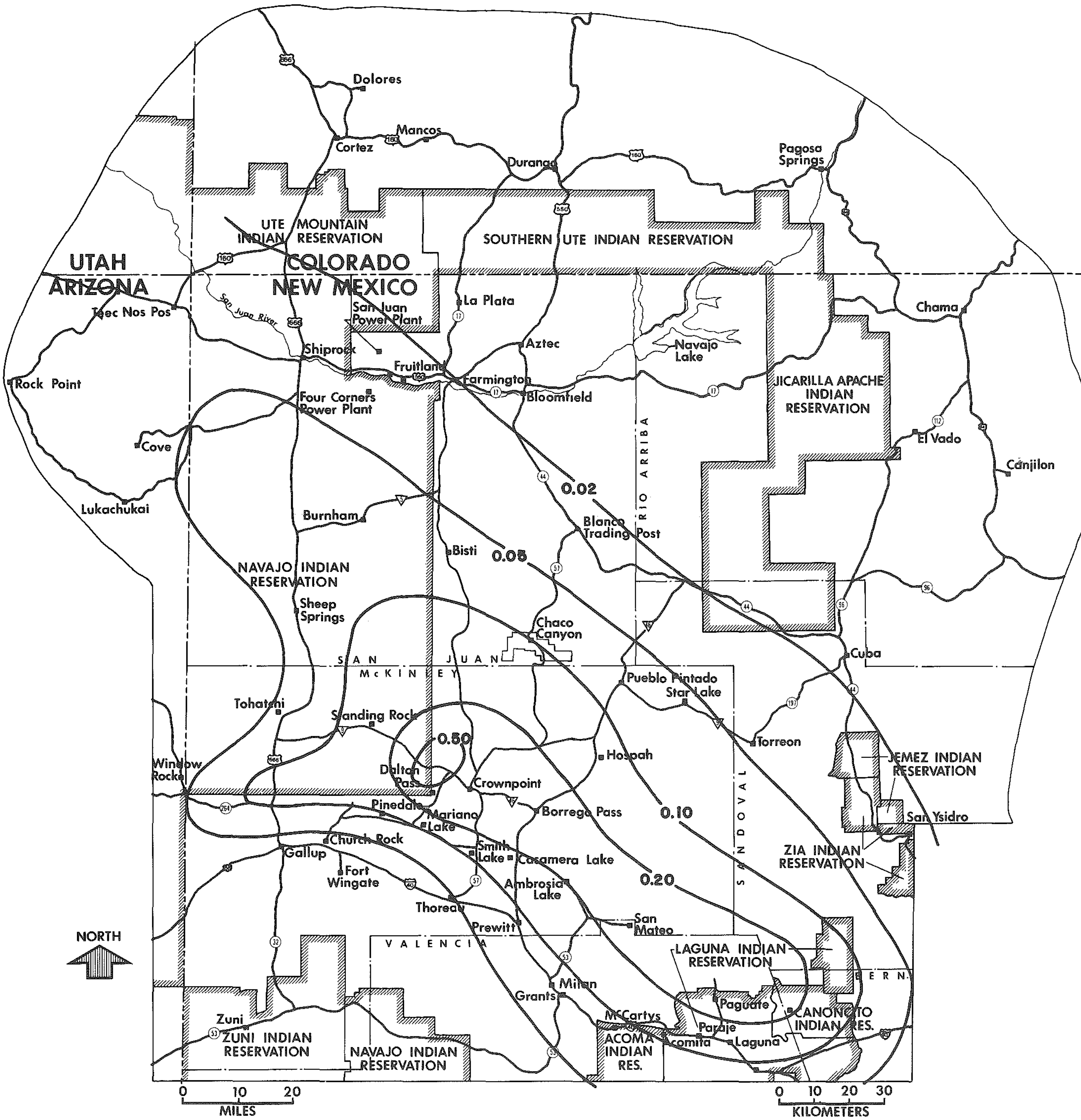
The projected incremental increases in radon concentrations by locations for 1990 and 2000 that would result from Moderate uranium development, with population estimates for five groups, are shown in Table IV-19. The incremental increases in radon progeny inhalation doses as a percentage of doses due to natural background are listed in Table IV-20. Also included in Table IV-20 are the postulated number of cases of lung cancer based on national statistics.

Based on the available estimates of radon source terms and on lung cancer statistics from other population groups, a crude estimate of the general health impact is obtained. Cases of lung cancer may be postulated to result from uranium development at the Moderate level during the year 2000. These cases would not be expected to be manifested until many years later. However, they can be compared with the natural incidence of cases that would occur in the year 2000. It must be remembered that the figures in the table are for one year and the accumulative totals would be the sums of all years considered.



CONTOURS OF ANNUAL AVERAGE RADON CONCENTRATIONS in pCi l^{-1} for the Uranium Development Projections for 1990, with an emanation rate of 18.0 Ci day^{-1} for each mine

Map IV-6



CONTOURS OF ANNUAL AVERAGE RADON CONCENTRATIONS in pCi l^{-1} for the Uranium Development Projections for 2000, with an emanation rate of 18.0 Ci day^{-1} for each mine

Map IV-7

Table IV-19

LUNG DOSES FROM RADON PROGENY INHALATION ESTIMATED FOR POPULATIONS IN THE YEARS 1990 AND 2000 AS A RESULT OF MODERATE URANIUM DEVELOPMENT

	1990			2000		
		Person-WLM/year			Person-WLM/year	
Communities	Population	Background	Uranium Develop.	Population	Background	Uranium Develop.
Municipalities (14) in the San Juan Basin	148,672	4,460	1,085	181,217	5,437	1,718
Navajo Reservation	126,209	3,786	533	155,815	4,674	1,443
Villages (14) in the Eastern Navajo Agency	27,356	821	337	33,779	1,013	574
Other residents of the San Juan Basin	71,981	2,159	236	91,189	2,736	640
Sub-Total, SJB	374,218	11,226	2,191	462,000	13,860	4,375
Albuquerque	461,772	13,853	793	568,202	17,046	1,459
TOTAL	835,990	25,079	2,984	1,030,202	30,906	5,834

Source: Schiager, 1979, No. 40, revised 1979.

Table IV-20

ESTIMATED LUNG CANCER RISK IN THE YEAR 2000 FROM MODERATE URANIUM DEVELOPMENT SAN JUAN BASIN

		Postulated lung cancer cases*		
Communities	Lung Dose Increase as % of Background	Annually from all causes ($4x10^{-4}$/person-yr)	Annually from nat. bkgd. radon conc. ($8x10^{-4}$/pers-WLM)	Commited from 1 yr of uranium develop. ($8x10^{-4}$/pers-WLM)
Municipalities (14) in the San Juan Basin	31.6%	72.49	4.35	1.37
Navajo Reservation	30.9%	62.33	3.74	1.15
Villages (14) in the Eastern Navajo Agency	56.7%	13.51	0.81	0.46
Other residents of the San Juan Basin	23.4%	36.48	2.18	0.51
Sub-total, SJB	-	184.81	11.08	3.49
Albuquerque	8.6%	227.28	24.72	1.17
TOTAL	-	412.09	35.80	4.66

* Calculations are based on national statistics; they provide a basis for comparisons but should not be construed as applying specifically to the population of the San Juan Basin.

Source: Schiager, 1979, No. 40, revised 1979.

An estimated 5 cases, or slightly more than one percent, would be added to the 412 cases of lung cancer expected to occur normally. Thirty to forty cases, almost 10 percent, would result from natural background radiation. Because of population mobility and uncertainties in statistical data, the excess lung cancer cases theoretically induced by uranium development would not be distinguishable from the other 412 cases. The 412 cases would represent .089 percent of the projected 462,000 basin population in 2000; the 5 cases that might result from uranium activity would represent about .001 percent of the population.

In other words, normal lung cancer cases might affect close to one-tenth of one percent of the population, compared with about one-one thousandth of one percent affected by uranium-related cases.

Before these figures are taken at face value, it must be emphasized that they are derived from dose conversion factors that may be overestimated because of the lack of reliable data. Wherever large uncertainties existed in reported data or assumptions, values on the high or conservative side of the uncertainty have been used to avoid any serious underestimation of impacts.

These initial calculations indicate, however, that the potential health impact of uranium development on the general population of the San Juan Basin would be quite small compared to that from other cancer causing factors.

A final caveat is in order. The foregoing analysis is based on a regional perspective, with dispersed or aggregated effects. A site-specific analysis could disclose local problems, perhaps indicating serious concentrations of radon exposure at some locations. For example, if a mine vent were located adjacent to a home the inhabitants could be exposed to a much higher risk. In cases where the concentration limit for radon is exceeded at particular locations, the current alternatives are to close down uranium operations temporarily or to evacuate the people who are subject to exposure. Several trailers which had been located adjacent to a mine vent in the Ambrosia Lake area were recently moved. This subject should be carefully explored in site-specific and subregional environmental analysis work.

AIR QUALITY WITH HIGH URANIUM DEVELOPMENT

Impacts. In the unlikely event of High uranium development, air quality would be affected more adversely in some places than it would with Moderate development. Nevertheless, existing air quality standards would continue to be met. Dispersion modeling using estimated emission rates from mines and mills shows that the concentrations reached by even the most pervasive pollutants would be only a fraction of applicable standards.

Overall, the results are similar to those for the Moderate projection. Mine and mill emissions would temporarily exceed annual average air quality standards only in the event that several mine vents issued radionuclides affecting a single location at the same time. Heavy traffic on unpaved

roads without control measures would produce temporary excesses of particulates.

Mines and mills projected with High development are shown in Table IV-21 and on Maps IV-8 and IV-9. Density calculations indicate the mines would be no closer together than with Moderate development. The greatest density would still occur in the Ambrosia Lake vicinity, in 1990, with 11 mines and 2 mills possibly operating within a 10-mile diameter area (Table IV-22).

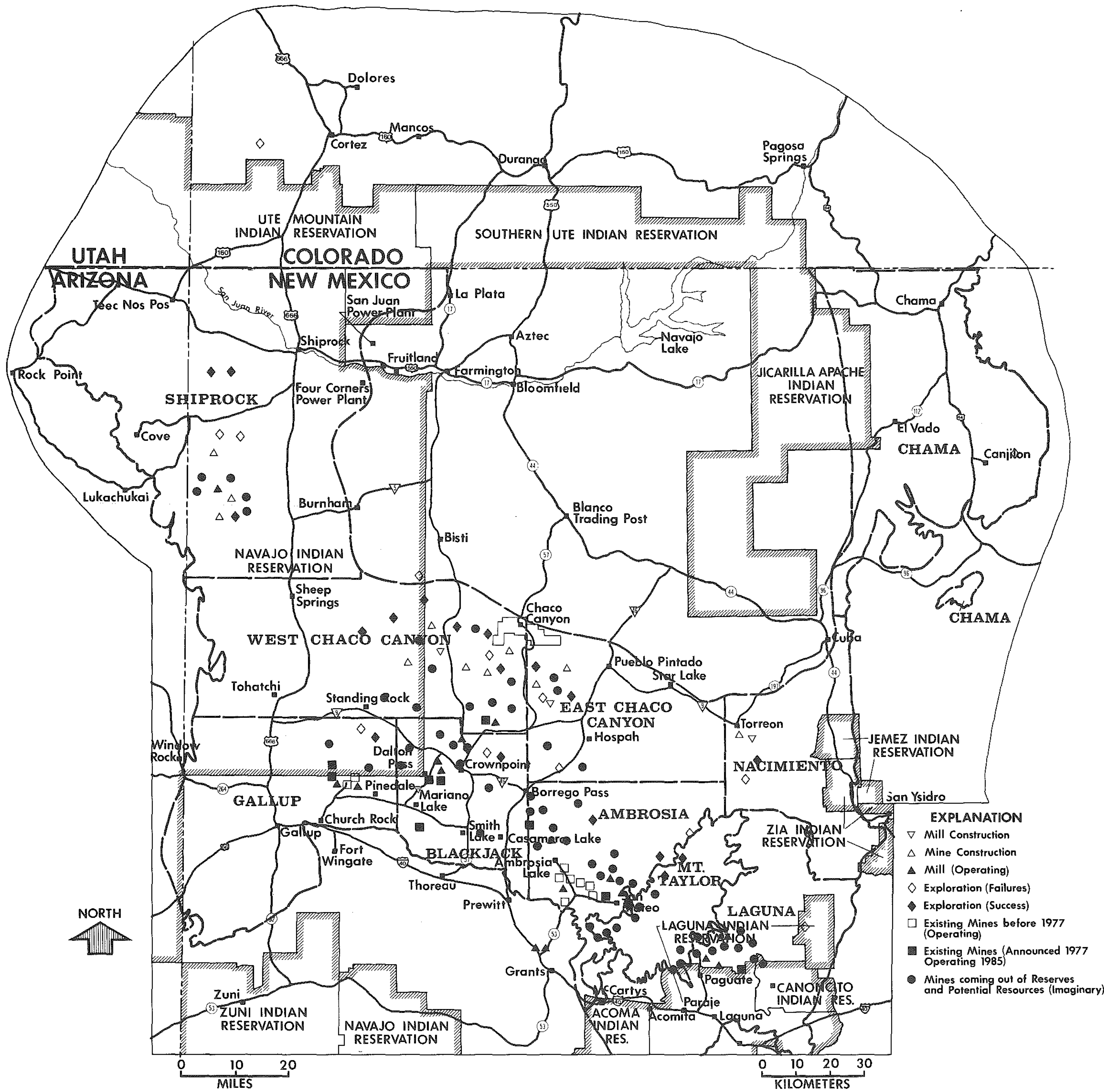
Table IV-21

Assumed Number of Mines and Mills, High Scenario

Year	Mines	Mills
1977	30	4
1985	57	12
1990	80	16
2000	105	22

Emissions at the highest projected uranium production level are shown in Table IV-23. Increased particulate emissions for various time periods can be compared with existing emissions in the five New Mexico counties shown in Table IV-5 and with those for the Moderate level in Table IV-17. Mines and mills are expected to center in McKinley and Valencia counties which currently have a combined total of 5,376 tons per year of particulate emissions (Table IV-5). With High development, increases of 27 percent and 36 percent could be expected in mine and mill particulate emissions above the 5,376 ton annual base for the years covered. This compares with increases of 17 percent and 25 percent with Moderate development. Radionuclides have not been inventoried in past years, so there are no background values against which to compare the expected yearly emission rate shown.

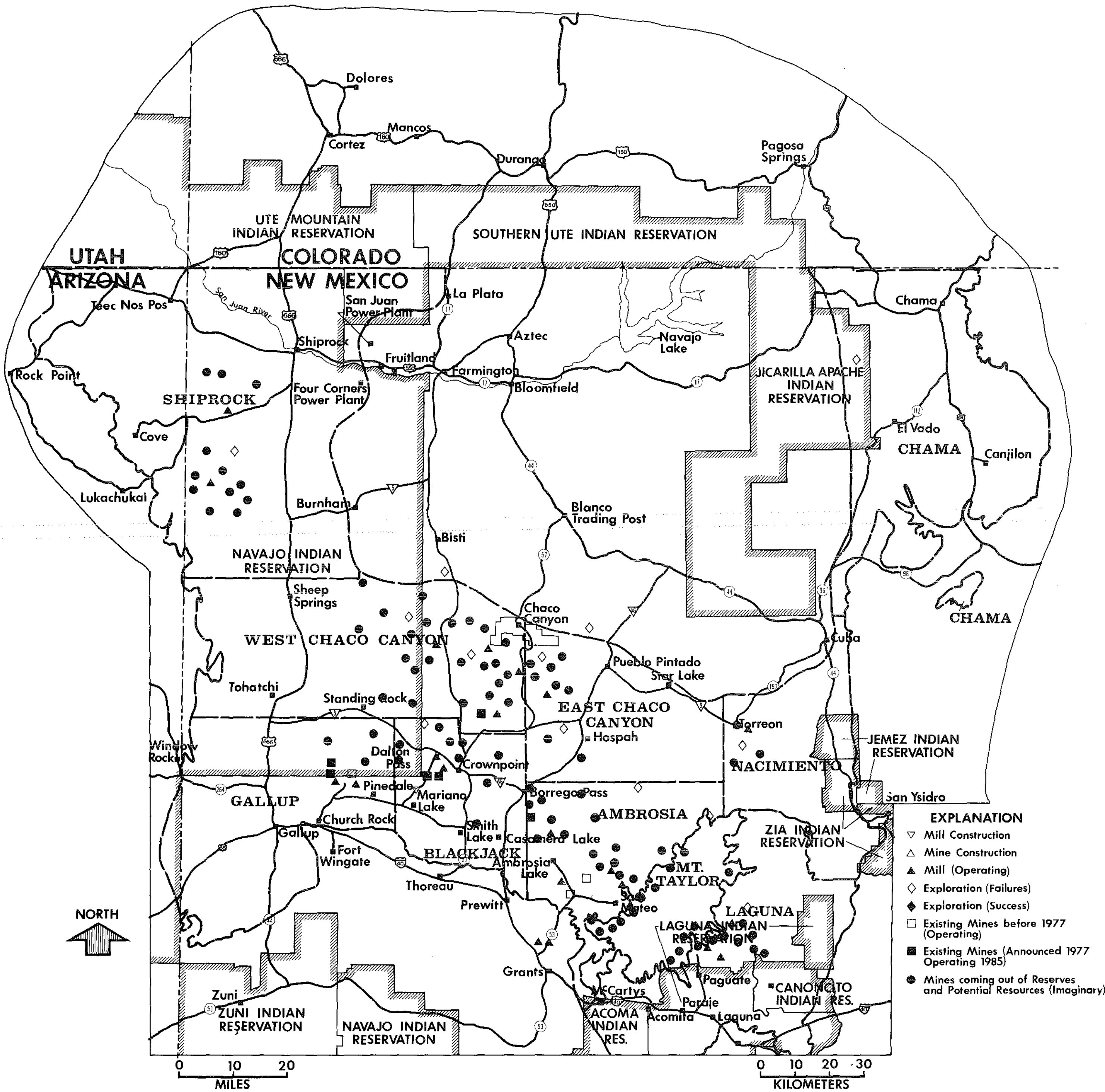
The earlier discussion on the health impacts of radon-222 emission from 1990-2000 uranium development applies here as well. While the High scenario was not modeled, the sensitivity study permits approximation of the health effects of an increase in radon-222 emission for the year 2000 (about half again as much for the High scenario of Table IV-23 as under the Moderate scenario of Table IV-17). Based on this, the estimate of 5 possible cases of lung cancer with Moderate development--or slightly above one percent of the approximate 400 cases expected from all causes in 2000--becomes with High development an estimate of a possible 7 cases. This would mean a possible increase of slightly above 1.5 percent over the expected number of lung cancer cases from all causes.



URANIUM MINING, MILLING AND EXPLORATION IN NORTHWESTERN NEW MEXICO 1990

HIGH

Map IV-8



URANIUM MINING, MILLING AND EXPLORATION IN NORTHWESTERN NEW MEXICO 2000

HIGH

Map IV-9

Table IV-22

Density of Mine/Mill Combinations

Scenario Year/development	Cluster Area	Number within 10 mile diameter mills	10 mile diameter mines	15 mile diameter mills	15 mile diameter mines	20 mile diameter mills	20 mile diameter mines
1990/high	1	3	7	3	10	3	16
	2	2	11	2	18	3	21
	3	3	6	3	18	3	9
2000/high	1	3	6	3	10	3	12
	2	2	5	3	13	3	14
	3	3	6	3	12	4	15

Source: Geomet, No. 20, 1978.

Table IV-23

Emissions of Radionuclides (Rn-222) and Particulates from
Uranium Mines and Mills in 1990 and 2000
with High Demand for Uranium

Source	1990 Number	1990 Radon Ci/yr	1990 TSP ton/yr	2000 Number	2000 Radon Ci/yr	2000 TSP ton/yr
Mine	80	525,600	1,334	105	689,850	1,750
Mill	16	4	130	22	5	179
Tailings Pond	16	50,464	--	22	69,388	--
Total		576,068	1,464		759,243	1,929

Source: Geomet, 1978, No. 20, revised 1979.

THE NRC DRAFT GENERIC ENVIRONMENTAL IMPACT STATEMENT

Subsequent to most of the effort devoted to the preparation of this overall report, the NRC released its Draft Generic Environmental Impact Statement on Uranium Milling (U.S. Nuclear Regulatory Commission, 1979a), referred to hereafter as the GEIS. The differences between the GEIS and the SJBRUS in assumptions and methodology are noteworthy.

1) The GEIS analyzes a hypothetical model mill which possesses very specific characteristics and is located in a hypothetical environment. The SJBRUS bases its analysis on groups of both mills and mines. Their characteristics are not so well defined, but they are located in a specific, real environment.

2) The GEIS attempts to address, from a single facility, all impacts including those that may occur remotely in time or space, as well as several that appear to be negligible. The SJBRUS, on the other hand, is concerned primarily with the significant impacts on the population and environment of the San Juan Basin region.

3) The GEIS strives to build a common foundation from which to address the alternatives for controlling emissions from uranium mills and mill tailings disposal sites. The generic model was developed in only enough detail to yield generally applicable rules on uranium milling and tailings disposal (44 FR 50015). These rules, when approved, would be applied to the impact analysis for all of the NRC's mill licensing actions. The SJBRUS is an analysis of cumulative impacts from many actions in a specific region. The SJBRUS will be used to accompany site-specific environmental reports.

4) The GEIS demonstrates modeling methodology that can be used to develop EIS's for specific facilities in support of license applications. In an apparent attempt to identify potentially serious impacts from individual facilities, the GEIS uses conservative values for most calculational parameters. The SJBRUS contributes little to the methodology for modeling impacts from individual facilities, although it contains much background information that is valuable as input data for modeling of facility impacts in the San Juan Basin. The modeling included in the SJBRUS utilizes parametric values that are considered realistic and representative, in order to derive conclusions as to what is most likely to occur.

In spite of the differing purposes and methods, it is gratifying to note that general conclusions by the two studies are in basic agreement that possible health impacts are extremely small. The fractional increase in risk to a regional population from operation of a single hypothetical uranium mill is estimated in the GEIS to be 0.0013 percent for cancer induction from radon emissions (GEIS, p. 5). In the SJBRUS (Table IV-20), the increase by 2000 in percentage of risk for all uranium mines and mills in the San Juan Basin region is estimated at 4.66/412, or 1.13 percent.

Although this SJBRUS figure of risk is considerably higher than that of the GEIS, the numbers are subject only to the most generalized

comparison because of the important differences between the studies and the inclusion of mines in the SJBRUS work.

MITIGATION OF AIR QUALITY PROBLEMS

Current Regulations. All development in the San Juan Basin region must conform to the requirements of the Clean Air Act of 1970. This act covers all pollutants expected from uranium development except radionuclides. The EPA is charged with enforcing the act and has set up standards that must be followed (Table IV-4). The State of New Mexico generally follows EPA standards but in a few cases has more stringent standards or standards covering contaminants for which no federal standard exists. The Clean Air Act is normally interpreted to include state standards when they are more stringent than, or augment, federal standards.

The 1977 amendments to the Clean Air Act addressed future deterioration of air quality. To maintain control, the legislation required that the nation be divided into air quality control regions (AQCR) and that each region fall within one of three classes. The classes allow increases in pollutant concentrations up to a point. These are shown in Table IV-24. The Four Corners states have cooperated in setting up AQCR's, as shown on Map IV-10. The San Juan Basin has been designated Class II, except for Mesa Verde National Park which is Class I. The State of New Mexico is revising its permit regulation to address "Prevention of significant deterioration" (PSD). If the revised regulation is approved by the EPA, the State will receive authority to grant PSD permits.

While the State does not have clear jurisdiction, the New Mexico EID enforces compliance over private operations on Indian lands. Here compliance presumably could eventually be enforced by the Tribe with advice from EPA. However, the question has not arisen. Because air pollutants from Indian lands follow prevailing winds into air quality control districts regulated by the State, the State's EID has exercised jurisdiction.

Thus, statutes and regulations exist which should restrict the degradation of air quality in the region. As stated previously, mining and milling in the basin will not produce enough non-radioactive air pollutants to violate the standards set forth in the Clean Air Act of 1970.

The federal EPA has issued a regulation (40 CFR 190) which limits the radiation dose to any individual from nuclear fuel cycle facilities to 25 mrem/year. This standard becomes effective for uranium mills on December 1, 1980 and will ultimately apply to mines, as well. The standard applies to all radionuclides contained in airborne emissions from mines and mills except radon and its decay products. Until environmental standards for radon concentrations or doses are adopted, and until substantial improvements are made in radon control technology, exposures from radon and its progeny from uranium mines and mills will continue to be of great concern.

The present concentration limit for Rn-222 in unrestricted areas, as specified by the New Mexico EID and the U.S. NRC, is 3 pCi/L for the annual average exposure of one or a few individuals and 1 pCi/L for representative population groups. These limits are in addition to the natural background.

Table IV-24

Federal Prevention of Significant Deterioration Increments

Pollutant	Allowable Increases in Pollutant Concentrations Over Baseline ($\mu g/m^3$) Class I	Class II	Class III*
Particulates:			
Annual geometric mean	5	19	37
24-hour maximum	10	37	75
Sulfur Dioxide:			
Annual arithmetic mean	2	20	40
24-hour maximum	5	91	182
3-hour maximum	25	512	700

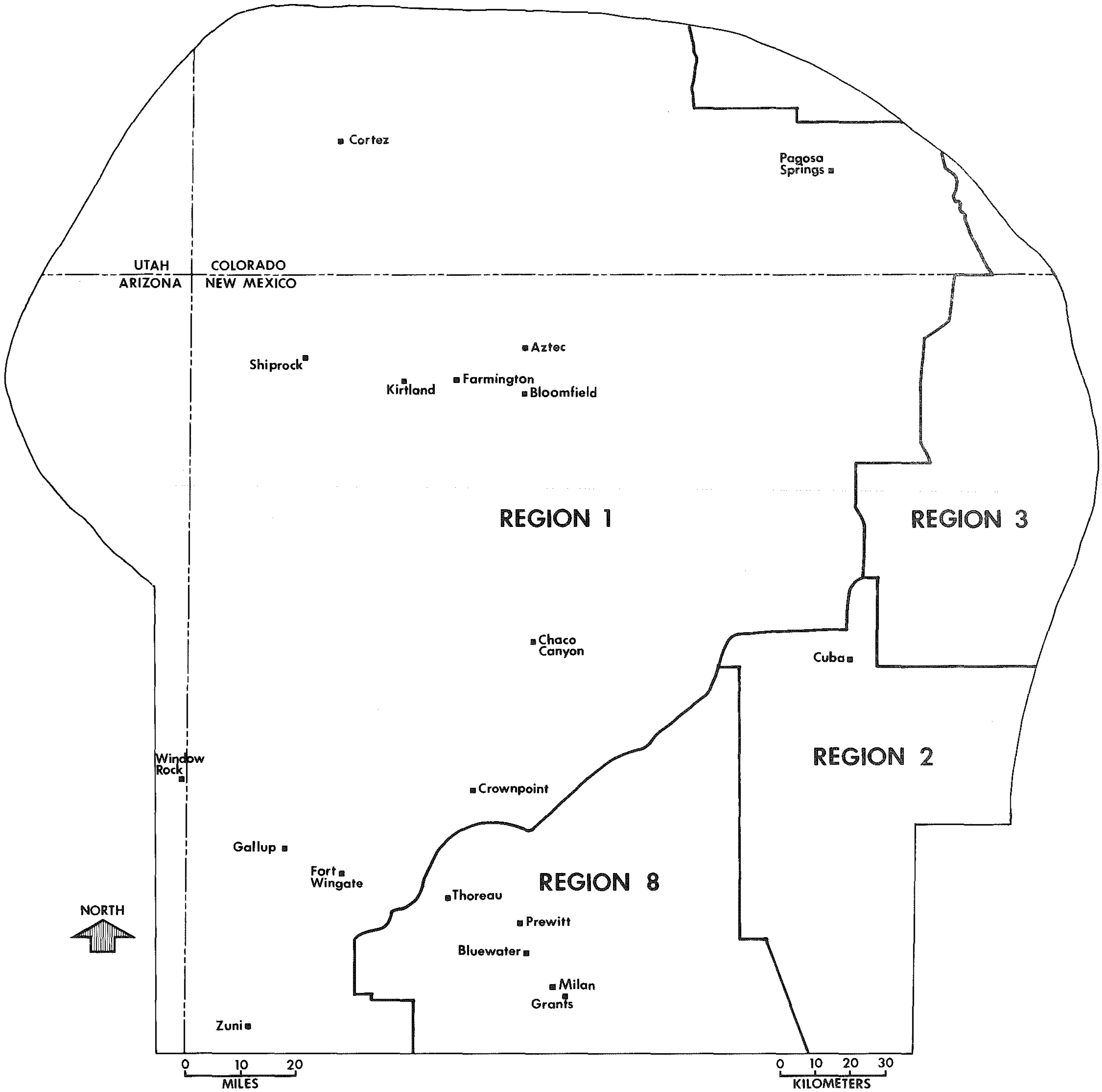
* Increases up to the national ambient air quality standards are allowable in Class III areas.

Source: Clean Air Act Amendment, August 1977.

Under the High uranium development scenario, this concentration limit could be exceeded on a short term basis in many locations near mines and mills. However, it is unlikely that this limit would be exceeded on an annual average basis at many, if any, permanently occupied locations.

Inactive tailings piles have been large sources of radon emanation, but this problem has been addressed by recent legislation. Since the passage of the Uranium Mill Tailings Radiation Control Act of 1978, the EPA has proposed radiological and nonradiological standards to be implemented by the NRC and "agreement" states.

Section 203, Title II of the act requires among other things: "an adequate bond, surety or other financial arrangement...be provided...by a licensee...for the decontamination, decommissioning, and reclamation of sites, structures, and equipment used in conjunction with byproduct material (mill tailings)." The act emphasizes decontamination and reclamation such as deep burial that will not require long-term monitoring. Title I provides for federal funds to dispose of inactive tailings piles dating back to the 1950's and 1960's when the AEC purchased yellowcake. The Department of Energy has established a Uranium Mill Tailings Remedial



AIR QUALITY CONTROL REGIONS

Map IV-10

Action Project Office and initiated contacts with contracting firms to carry out the provisions of the act. The NRC's GEIS supplied data and recommendations. The GEIS recommended a final emission rate from reclaimed tailings not exceeding 2 $pCi/m^2/sec$ above natural background. One alternative being strongly considered is below ground placement of tailings.

A probable mitigation measure for the future is modification of the "maximum permissible concentration" value to include use of exposure to concentration values "As Low as Reasonably Achievable" (ALARA). The EPA, NRC, and state will issue regulations for ALARA when current studies are completed. These would tend to be lower than the MPC value.

In Situ Leaching. If the Mobil and subsequent pilot projects prove that in situ leaching (Chapter III) is feasible in the San Juan Basin, air quality will be affected. Presumably this method would be especially useful to extract uranium from small isolated ore bodies or low-grade concentrations. With success, possibly as many as one-third of the region's ore deposits could be mined in situ by 2000.

This would eliminate the need for mine vents on 25 to 35 mines, depending on the development level. In place of these vents, the process would emit much lower concentrations of radon from surge tanks and ion exchange columns. Estimated at approximately 650 Ci/yr per in situ site, these emissions would amount to about one-tenth those from an underground mine. They would disperse rapidly and would not be easily detectable in the off-site environment. Therefore, air quality at each in situ mine site would be appreciably better than that in the vicinity of the underground mines.

While most liquid is recirculated, some waste from the process would remain. It would be pumped to a pond a fraction the size of a tailings pond. The solid waste could amount to as little as one one-thousandth (by weight) that from a conventional mine and mill process. Thus waste disposal would be much simpler. Although measurements of radon concentrations from the small in situ site pond were not available, they should be considerably lower than from a tailings pond. The problem of dry tailings piles would not arise. The liquid waste could be pumped into non-potable aquifers and the solids buried.

Monitoring. Until recently, continuous monitoring in the basin was pretty much limited to the measurement of particulates. The only measurements over lengthy periods have involved SO_2 and the oxides of nitrogen along the San Juan River near Farmington. The lack of monitoring stemmed mainly from authorities' view that air quality in New Mexico was generally excellent except during wind storms and near the power plants in the San Juan River valley.

Environmental regulations have brought changes, however, in the perception of monitoring. The New Mexico EID is requiring new or relicensed industrial plants to set up comprehensive monitoring programs as required by the Clean Air Act, and the EID itself has begun an extensive monitoring program in the Grants mineral belt. These programs include measurements of both radionuclides and criteria pollutants. The EPA and NRC have programs underway to monitor radon emissions. Mill license provisions require com-

panies to maintain continuous monitoring stations which are inspected by the State.

The various programs should determine background radiation levels and concentrations near mines and mills under all meteorological conditions more accurately than ever before.

On Indian lands continuous monitoring programs are conducted only by the companies at present.

A list of current monitoring efforts appears in Table IV-25.

THE SPECIAL RADIATION RISKS OF MINERS

Miners run a much greater potential health risk from exposure to radiation than does the general public. This is due to the fact that the concentration of radionuclides is higher near the rock face in a mine tunnel than it is above ground. Even the mill employee does not face these high radon concentrations. As noted below, however, new enforcement measures have been taken since the early 1970's aimed at significantly reducing the health hazards found in some mines in the 1950's and 1960's.

Two kinds of exposure exist: 1) penetrating gamma radiation, and 2) alpha emitting radon daughters which are inhaled and enter the bronchial passages. The latter exposure is by far the more serious. Radon released from the ore decays through several short-lived nuclides to long-lived radioactive lead-210. Three alpha particles are released in the decay sequence. The daughter radionuclides become attached to atmospheric dust particles and a certain percentage of these are trapped in the respiratory system. This is especially the case with particulates in the "respirable size range," 0.5 to 5 micrometers. Excessive accumulation of radioactive particulates in the lungs increases the risk of cancer.

Studies of cancer occurrence among uranium miners led to recent stringent limitations on exposure to radon and its daughters. The effect of the new limitations on uranium miners is being studied by several groups but is as yet unknown. The discussion that follows summarizes the impacts which took place before the new exposure limitation went into effect.

In the early days of uranium mining, high grade ore was often found close to the surface. Small operations of 2 to 30 men proliferated; anybody with a Geiger counter or pickax could stake and open a claim. The risks were mostly unsuspected by those who worked these mines. Shafts and drifts were small, tunnels often dry and dusty, and radiation monitoring practically nonexistent. As a result, the incidence of lung cancer was extremely high among the miners of these so-called "dog" or "coyote" holes.

The larger operations conducted by major corporations, by contrast, often monitored radiation and maintained records. Based on these records, a study covering the period from 1950 to 1968 compared the respiratory cancer deaths of uranium miners with those expected by other hard-rock miners. For the study sample of 3,366 non-uranium, hard rock Caucasian miners, 11.71 deaths caused by respiratory cancer could be expected. Among

Table IV-25

AIR QUALITY MONITORING IN THE SAN JUAN BASIN AREA

ORGANIZATION	TYPE STATIONS	APPROXIMATE LOCATIONS AND QUANTITY	MONITORING INTERVAL	TYPE EQUIPMENT	TYPES OF POLLUTANTS MONITORED
New Mexico Public Service Company	Both temporary and permanent	(1) Farmington area (1) Bisti area (1) Ambrosia Lake area	Sulfur dioxide measured continuously 24 hrs/day. Particulates measured twice a week.	Varies	Sulfur dioxide, particulates, nitrogen dioxide
Mobil Oil Corp.	Sec. 12 and 15, temporary; Section 9, permanent	T17NR13W Sec. 9, 12, 15	Daily		Sec. 12 and 15, particulates measured. Sec. 9, radon measured.
U.S. Environmental Protection Agency	Monitoring Program Temporarily Completed				
N.M. Environmental Improvement Division (Air Quality Dept.)	Permanent	(1) Farmington (1) Zuni (5) Milan (1) Gallup (1) Church Rock	Twice a week	Carbon monoxide measured by infrared screening method. Sulfur dioxide measured by Phillips continuous meter. Particulates measured by high-volume type vacuum cleaner.	Carbon monoxide, sulfur dioxide, particulates
Navajo Protection Agency	N/A	N/A	N/A	N/A	N/A
United Nuclear	Temporary	(1) Church Rock area	Monthly	Radon gases measured by Lucas Chamber. Particulates measured by high-volume test chamber.	Radon gases, radioactive dust particles, particulates.
N.M. Environmental Improvement Division (Radiation Dept.)	Temporary station Field laboratory	(1) Grants (1) Ambrosia Lake	Twice a week.	Air bag sampling	Radon gases (intensive) Radioactive dust particles Particulates Radon Radionuclides

N/A -- Not available

3,366 Caucasian uranium miners, by contrast, 70 died of respiratory cancer, six times as many (Lundin, et al, 1971). Among non-Caucasian miners, the impact was less conclusive (1.76 deaths expected, 3 observed). The study also showed that the longer the exposure, the greater the chance of cancer. A related paper mentioned that most of the deaths occurred 10 years or more after exposure began (Lundin, et al, 1969). This report also contained the interesting observation that smoking uranium miners could expect to contract lung cancer at a rate 10 times greater than that of non-smoking miners.

These dangers cannot be projected to the miners who will work the basin's mines in the future, however. The exposure to radiation has been limited by the standards adopted by the Mining Enforcement and Safety Administration (MESA) in 1971. The concentration of radon and its daughters in a mine is measured in terms of working levels and working level months ("The Health Hazard from Radon-222"). Today, the Mine Safety and Health Administration (MSHA), successor to MESA, monitors and enforces strict uranium mine exposure limits (4 working level months per year) that are a fraction of previous working level tolerances. Since the average month is defined as 173 hours, 4 WLM means the miner can work at an exposure of one WL for 692 hours per year, or at an exposure of 0.5 WL for 1,384 hours per year. If the working level exceeds one, corrective action must be taken or the area cleared.

The Public Health Service data indicated low lung cancer mortality among miners exposed to less than 120 WLM. Even assuming 30-year employment, no miner would exceed this cumulative exposure if he was limited to 4 WLM per year (MESA, 1975). Therefore, the impact on the health of miners is projected to be much less than it was in the past.

The miners themselves seem reluctant to talk about the matter. Two social workers who work with miners and their families were asked about the feeling toward risk. One replied: "It never comes up. They never talk about it or discuss it. Once in a while I hear a young person joking about how he glows in the dark, you know, covered with radiation all the time. I don't know if that's actually true. I never did see anyone glow in the dark, I've heard that joke. I think most think (that they) will do it for a few years and then get out (of mining) so they're not worried about a health problem. I think they ought to be worried about a health problem." (Gibson, 1979, No. 44)

The second social worker told an interviewer: "They are all afraid of becoming sterile because of being exposed to too much radiation, that's one of the fears. The general saying out here has been you really shouldn't spend more than 20 years in the mine because of the radiation problem and also because of the cancer problem. A lot of the guys even if they fear it won't talk about it." (Ibid)

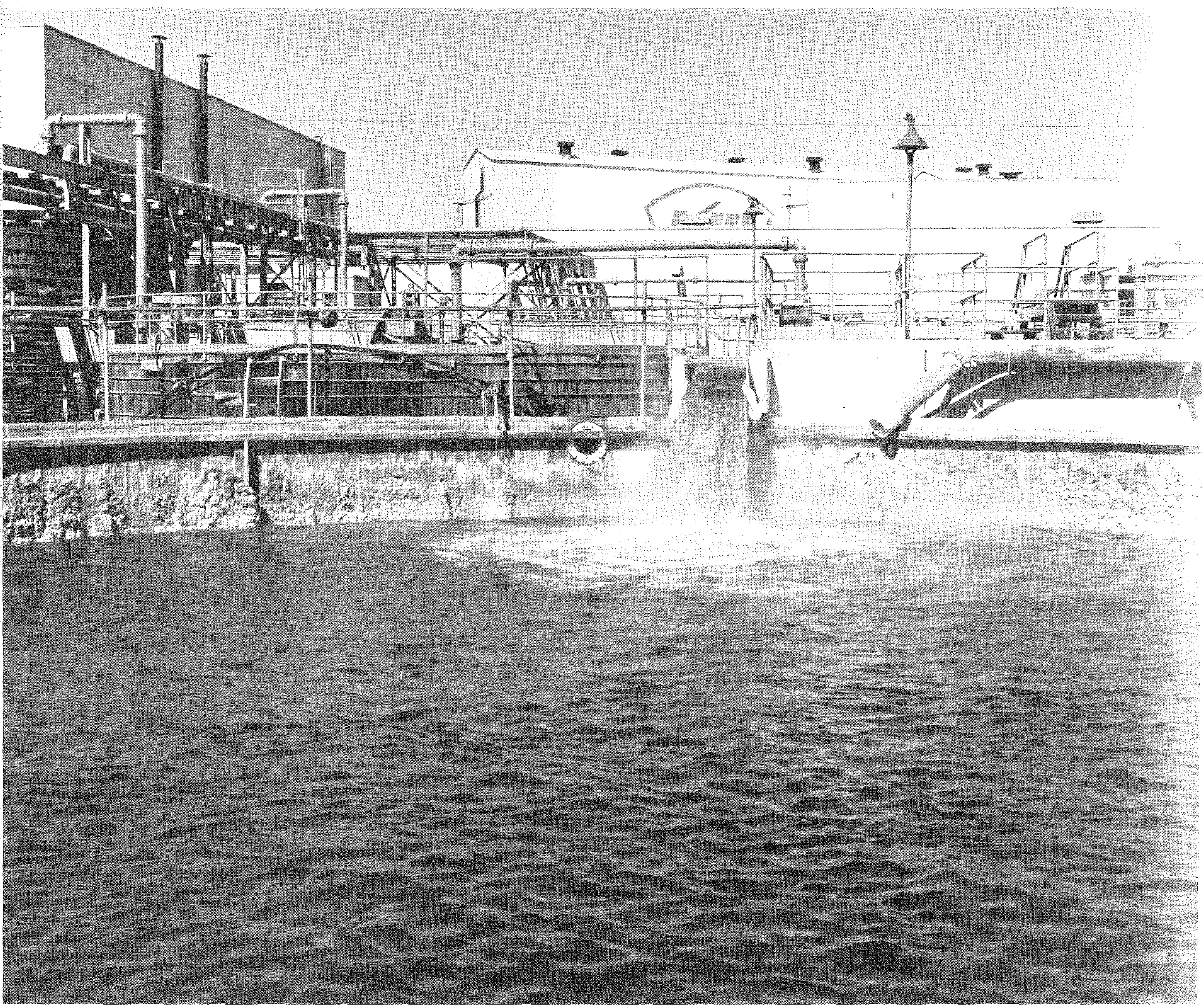
Ongoing studies of the cancer risks from radiation are expected to reduce the uncertainties in calculations of health effects. Additional data are also being acquired on the relative contributions to radiation doses from natural as well as manmade sources. All of these data, taken together, will make it possible for the regulatory agencies to determine

whether or not additional controls of radiation sources and exposures would be appropriate.

Concurrent with the studies of radiation sources and health risks, more advanced or sophisticated control measures are being investigated. For example, investigations are underway to develop methods for removing radon from the mine exhaust stream or for retaining radon underground in unoccupied areas. Although it appears possible that substantial improvements in radon control will be made in the near future, it would be premature to attempt to predict the exact nature or magnitude of the controls that might be achieved.

CHAPTER V

IMPACTS ON WATER SUPPLIES



Chapter V

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Chapter V

Summary

The San Juan Basin is largely a water-deficient area. Surface water is relatively abundant only in the mountains along the northern and northeastern border. In the lower elevations comprising more than 85 percent of the area, most streams are intermittent or ephemeral. (Intermittent streams flow only part of the year; ephemeral streams flow only during and immediately after storms or snow melt periods.) Consequently, ground water is the only reliable source of water for increased development in the basin.

Many uranium mines discharge water from the Morrison Formation, the principal uranium producing unit and an important aquifer. If mining should develop as projected, this mine dewatering would cause even more extensive declines in water levels and yields from wells developed in this aquifer than have occurred to date. These declines, both actual and potential, raise significant questions of public policy. Legal disputes over water rights are anticipated (Chapter XII).

At places, exploration and mining can rupture overlying formations and mix water of varying qualities unless adequate precautions are taken. Field evidence suggests that the mine effluent can be consumed by animals and plants without short term toxic effects. The long term effects are unknown and should be studied.

Chapter V

Impacts on Water Resources

EXISTING ENVIRONMENT

Surface Water

Rivers and Streams. The study area is within both the Rio Grande and the Upper Colorado River Basins. The eastern and southeastern part of the area is drained by tributaries of the Rio Grande, the central and northern part by the San Juan River and its tributaries, and the southwestern part by a tributary of the Little Colorado River. The principal streams are listed by tributary rank in downstream order in Table V-1.

Table V-1

Major Streams in the San Juan Basin Region

Rio Grande Basin:	Rio Chama (P)1/		
	Jemez River		
	Rio Puerco:	Arroyo Chico	
		Rio San Jose (P)2/	
Colorado River Basin:			
	San Juan River (P):		Navajo River (P)
			Piedra River (P)
			Los Pinos River (P)
			Gobernador Canyon (P)
			Canon Largo
			Animas River (P)
			La Plata River (P)
			Chaco River (P)
			Mancos River
			McElmo Creek
	Little Colorado River Basin:		
			Puerco River (P)3/

1/ (P) designates perennial streams. All others are intermittent or ephemeral.
2/ Perennial for a portion of its length.
3/ Perennial in the study area due to mine dewatering.

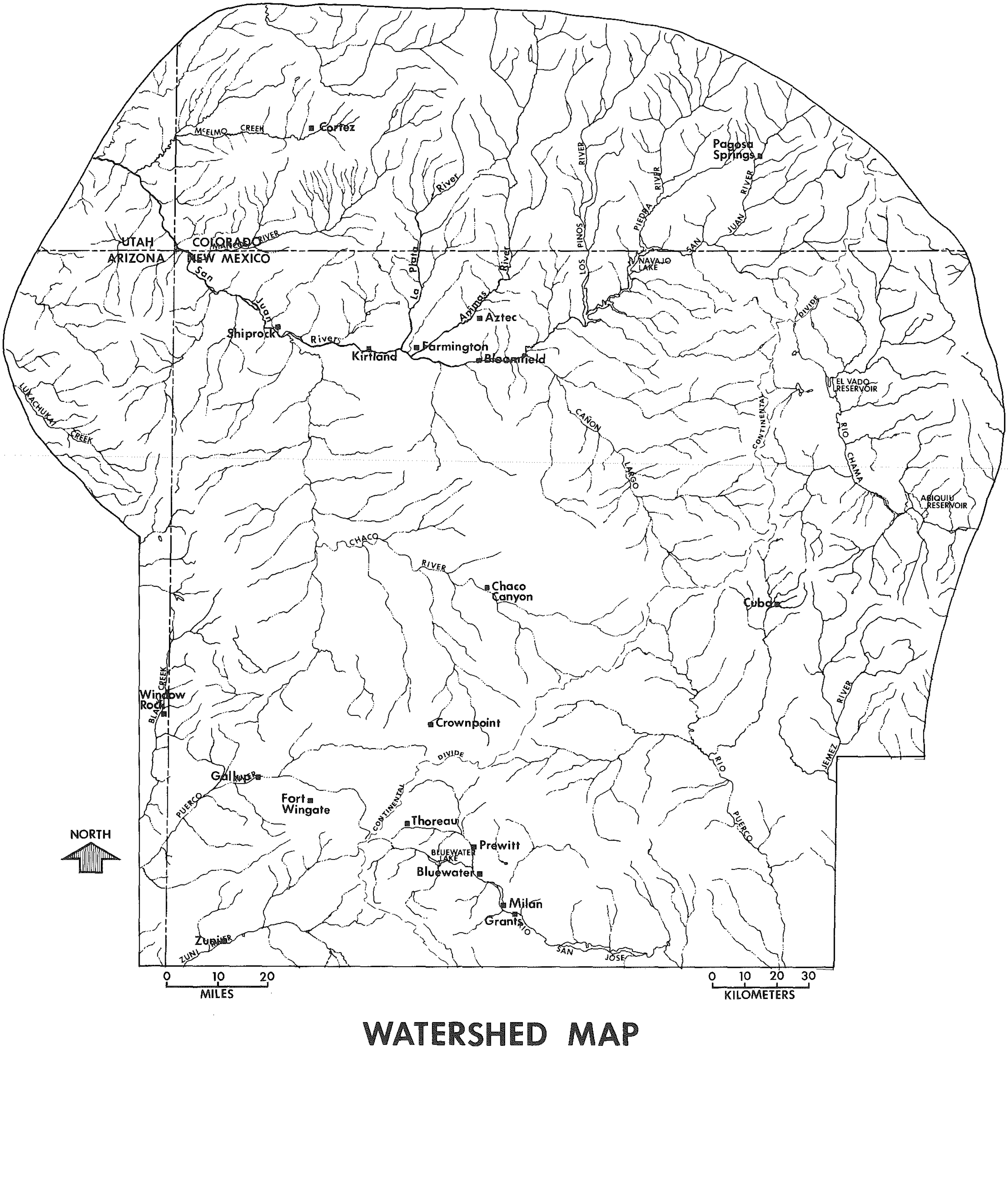
Source: Busby, 1978, No. 32.

Figure V-2.--The Puerco River, which receives mine water discharge from mines near Church Rock

The surface drainage pattern is shown on Map V-1. The larger streams shown are perennial in the mountains above 7,000 or 8,000 feet and are continuously fed by melting snow, springs, or both. Below 7,000 feet, most streams are ephemeral. While winter storms produce little runoff at these lower elevations, local flash floods are common after brief but heavy summer thunderstorms. Watersheds of only a few square miles can produce discharges, or runoff, ranging from several hundred to several thousand cubic feet per second.

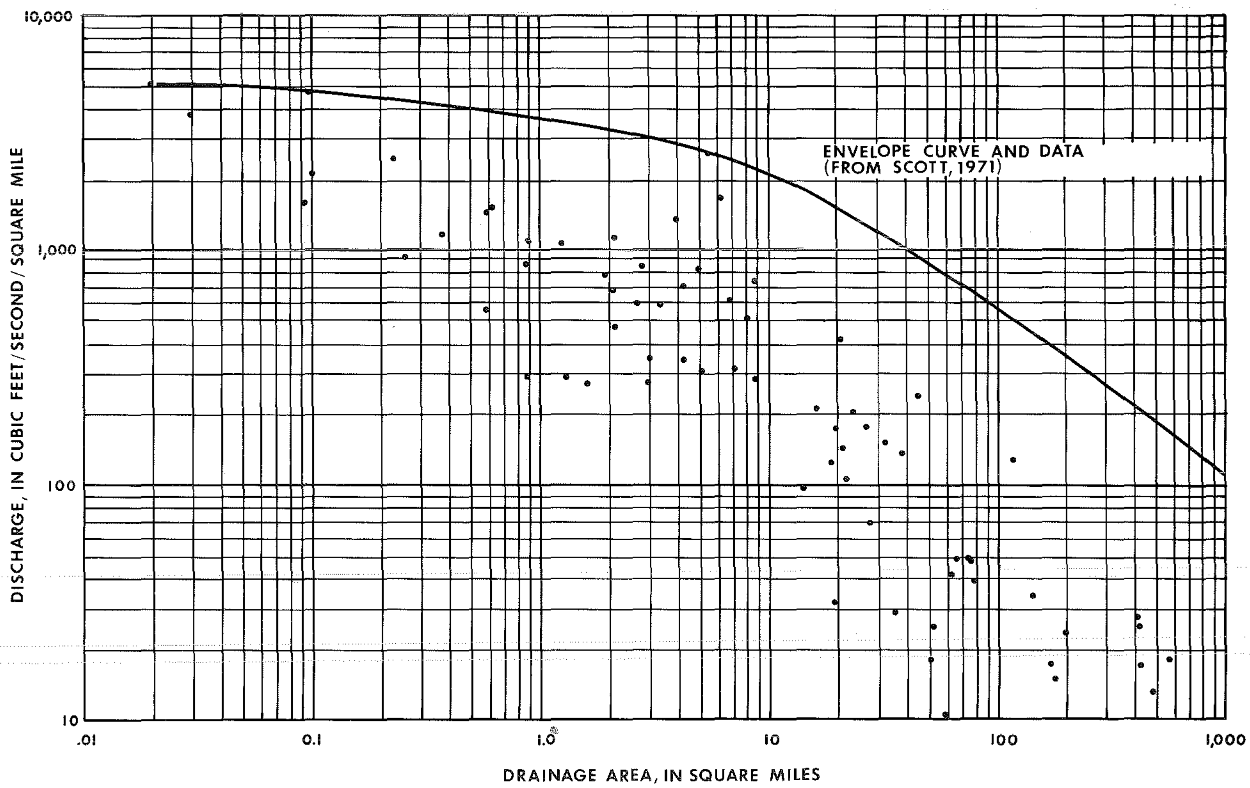
Because of the ephemeral nature of most San Juan Basin streams, flood-peaks are the most important feature of the streamflow. Figure V-3 (modified from Scott, 1971) gives maximum observed peak discharges for northwest New Mexico. These data show the large floods that have been observed in recent years. The envelope curve connects only the largest events and gives no indication as to the frequency of such flood peaks. Flood data for most of the basin are scarce, but these discharge rates are probably representative of the area. Data on mean annual flow, range of annual minimum daily discharge, and peak flow characteristics for selected streams are given by Busby (1978, No. 32).

Sediment. As might be expected, the floods can yield very large quantities of sediment, depending upon terrain, soils, ground cover, drainage conditions, and other variables. The Rio Puerco (Map V-1), considered one of the muddiest streams in North America, yields 75 percent of the sediment discharges to Elephant Butte Reservoir and only 5 percent of the water, according to 20 years of records.



WATERSHED MAP

Map V-1



MAXIMUM OBSERVED DISCHARGES IN NORTHWEST NEW MEXICO

Figure V-3

The Chaco River and Canon Largo are the major contributors of sediment to the San Juan River immediately above Shiprock. The Chaco River and several smaller arroyos yield approximately 2,880,000 tons of sediment per year from the 4,350 square miles of the Chaco Basin. Arroyo Chico, a tributary of the Rio Puerco, and the Rio San Jose at Correo southeast of Grants show average yields of 2,750,000 and 837,000 tons per year, respectively. Table V-2 lists suspended sediment concentrations and suspended sediment discharges recorded for selected streams (Busby, 1978, No. 32). (For related material, see "Erosion" in Chapter VI.)

Lakes. Major multiple-use water projects have created some sizable lakes since the mid-1950's. The largest (Figure V-4) is the Navajo Reservoir (1,708,600 acre feet), the source of water for the Navajo Indian Irrigation Project. Others include Heron Reservoir (401,300 AF), El Vado Reservoir (196,500 AF), Vallecito Reservoir (126,300 AF), Lemon Reservoir (40,100 AF), Bluewater Lake (38,500 AF), and Jackson Gulch Reservoir (10,000 AF). The effect these reservoirs, lakes, and ponds have on river flows ranges from complete control to minor regulation of flow (Busby, 1978, No. 32).

Man-made ephemeral lakes and many stock watering ponds exist within the basin. Generally covering less than 50 acres each, these are often

Table V-2

Suspended Sediment Concentrations and Discharges for Selected Streams in New Mexico and Colorado (For either 1976 or 1977)

Station Name	Suspended Sediment[1/] Concentration (mg/L) Minimum	Concentration (mg/L) Maximum	Discharge (ton/d) Minimum	Discharge (ton/d) Maximum	Type[2/]
Rio Chama below Abiquiu Dam, NM	0	107,000	0	214,000	O
Rio Grande at Otowi Bridge near San Ildefonso	11	47,400	3	366,000	D
Rio Puerco near Bernardo, NM	0	267,000	0	2,240,000	D
Vallecito Creek near Bayfield, CO	0	50	0	140	O
Animas River at Farmington, NM	1	36,800	0.5	337,000	D
Shumway Arroyo near Waterflow, NM	15	182,000	.01	124,000	O
Chaco Wash at Chaco Canyon National Monument, NM	0	131,000	0	417,000	O
De-na-zin Wash at Bisti Trading Post, NM	0	168,000	0	420,000	O
Hunter Wash at Bisti Trading Post, NM	0	273,000	0	280,000	O
Chaco River near Waterflow, NM	2	280,000	9.6	810,000	O
San Juan River at Shiprock, NM	2	114,000	1	200,000	D

1/ In milligrams per liter (mg/L) and tons per day (ton/d).
2/ O-Observed instantaneous.
D-Daily mean.

Source: Busby, 1978, No. 32.

scattered at about 4 to 8 per 10 square miles. Small natural lakes and ponds are found in the higher mountains.

Ground Water

Ground water is available nearly everywhere in the basin. All geologic systems from the upper Paleozoic age or younger (Figure V-5) contain at least some aquifers that yield water to wells. Unfortunately, as the

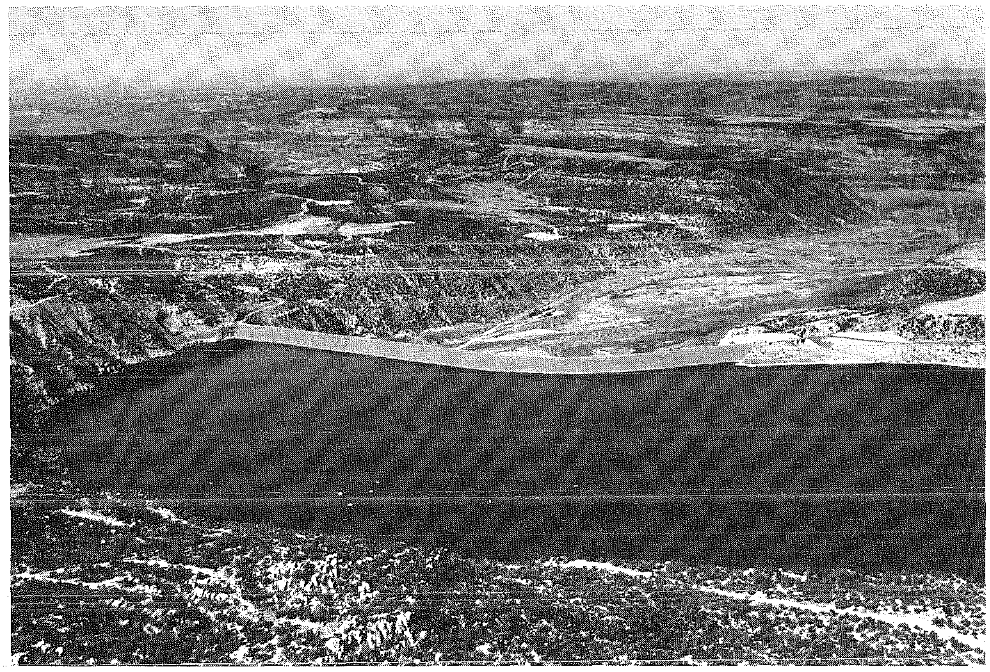


Figure V-4.--Navajo Dam and Lake

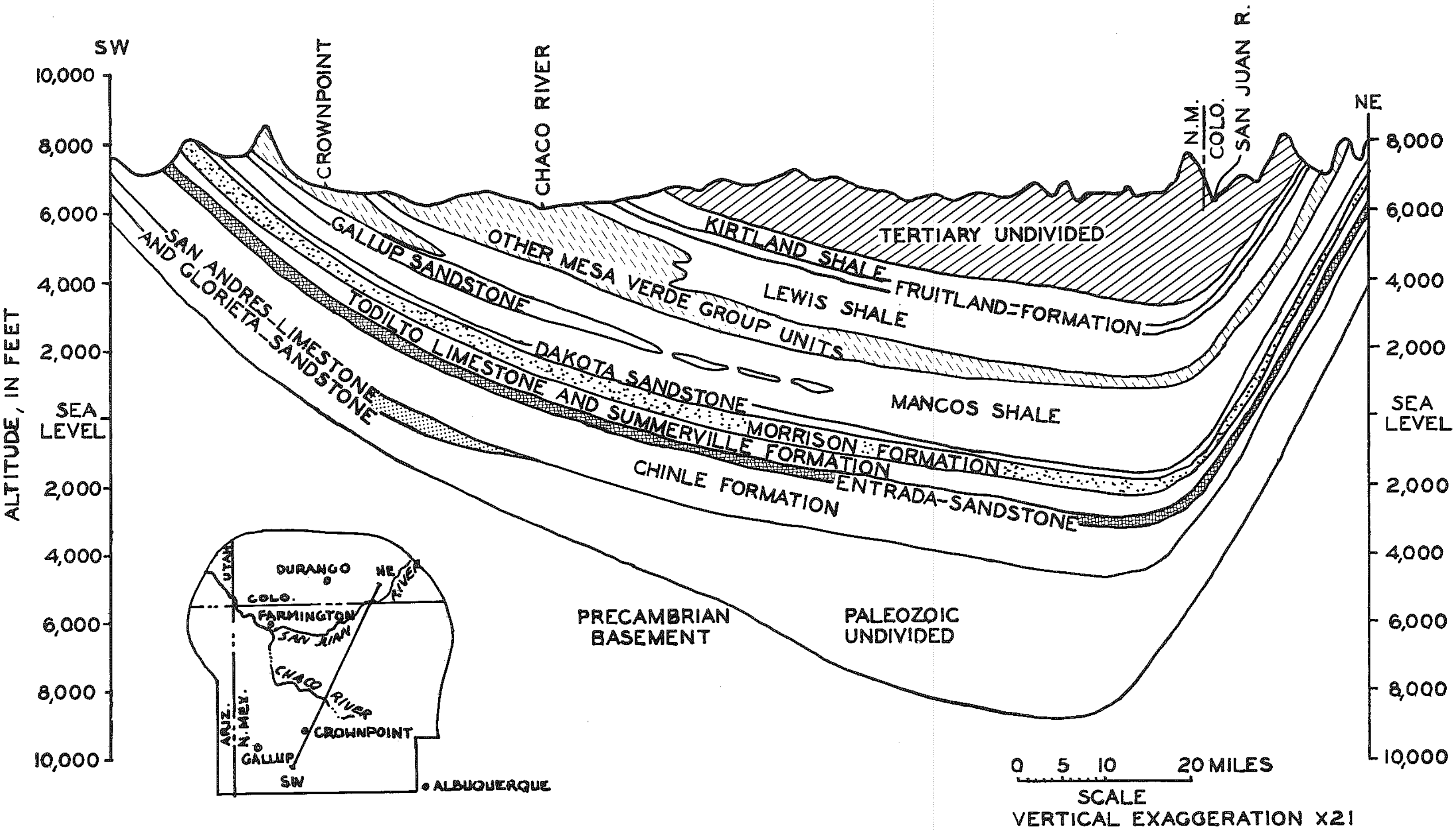
characteristics shown in Table V-3 would lead one to suspect, yields in many formations are low--less than 20 gallons per minute (gal/min), and the water frequently is of poor quality. (See "Water Quality.")

Seven formations have demonstrated the potential in many areas to yield 100 gal/min or more to properly constructed wells. They are the San Andres-Glorieta, the Entrada, the Morrison, the Gallup, and the Tertiary age Ojo Alamo, Nacimiento, and San Jose Formations.

However, there are major gaps in knowledge of the basin's geohydrology. A special study prepared for the New Mexico state engineer identified a need for more than 40 observation wells for purposes of studying drawdown, ground water flow, water quantity, and water quality. The study was ordered in recognition of increasing energy developments in the San Juan Basin (Sorenson, Marston, 1978, No. 35).

Regionally, all sedimentary strata dip inward toward the center of the basin or toward the axes of the adjoining structural sags. In general, the strata are exposed by erosion as irregularly shaped concentric rings similar to the rims of a set of nested mixing bowls. Thus, like other formations, water-bearing units that are exposed or lie at shallow depths along the margin of the basin are deeply buried in the center (Lyford, 1978, No. 23).

Most ground water flows from topographically high outcrop areas toward the San Juan River and Rio Grande Rift. Some water may move vertically to other aquifers rather than discharging directly to streams or springs. Transmissivities of the more productive water-bearing formations range from



GENERALIZED GEOLOGIC SECTION SHOWING MAJOR AQUIFERS

Figure V-5

Table V-3

Aquifer Characteristics

Aquifer	Thickness (ft)	Transmissivity (ft^2/d)	Storage Coefficient	Specific Capacity (gal/min/ft)	Total Dissolved Solids (mg/L)
Alluvium	0-100				200- 9,200
San Jose Formation	0-3,000				300- 2,400
Nacimiento Formation	800-2,000				600-14,000
Ojo Alamo Sandstone	0-400	57-165	$2x10^{-4}$-$6.7x10^{-3}$	0.2-1.02	240- 4,000
Kirtland Shale	0-1,500				700- 4,100
Fruitland Formation	0-500				
Pictured Cliffs Sandstone	75-375			0.02-0.07	310-38,000
Cliff House Sandstone	100-1,000			0.05-0.12	1,100- 4,100
Menefee Formation	100-2,000			0.03-1.38	200- 2,400
Point Lookout Sandstone	100- 350			0.07-1.12	150- 7,000
Crevasse Canyon Formation	100-1,000			0.03-0.64	240- 4,500
Gallup Sandstone	0-500	120-270	$3x10^{-3}$	0.03-4.7	300- 4,400
Dakota Sandstone	0-250			0.05-0.2	300-59,000
Morrison Formation	50-800	36-510	$1x10^{-4}$-$3x10^{-3}$	0.27-1.6	170- 5,600
Bluff Sandstone	100-400				260- 2,300
Entrada Sandstone	50-400			0.02-3.5	450-15,000
Chinle Formation	1,400-1,600			0.03-1.1	340- 2,500
San Andres Limestone	0-150		$4.2x10^{-4}$-$1.1x10^{-3}$		270- 2,300
Glorieta Sandstone	100-300				290- 1,200

Source: Cooley, et al, 1969; Shomaker and Stone, 1976; Ridgley, et al, 1978, No. 8; and unpublished data.

50 to 300 feet squared per day, a relatively low figure. The greater the transmissivity, the more rapidly ground water can flow through a formation (Lyford, 1978, No. 23).

As discussed in Chapter III, uranium is mined in the Morrison Formation. The Morrison Formation and the Entrada Sandstone beneath it and the Dakota and Gallup Sandstones above it are the aquifers most apt to be impacted by the mining. The Todilto and Summerville Formations may retard or prevent leakage from the Entrada to the Morrison, while the Mancos Shale above the Dakota prevents upward leakage into the Gallup. For the descriptions that follow, reference to Figure V-5 may be helpful.

Entrada Sandstone. Where the Entrada Sandstone crops out north of Interstate 40, in the southern part of the basin, it consists of about 45 feet of dark reddish-brown siltstone and thin-bedded silty sandstone overlain by about 160 feet of massive, reddish-orange, fine to medium-grained quartzose sandstone.

Except in the outcrop areas, the water is under artesian pressure. Throughout most of the basin, this pressure is so great that the water level in wells tapping the Entrada will rise almost to the land surface. This is true even where the top of the aquifer is 10,000 feet underground near the center of the basin. (See reference to potentiometric surface under "Morrison Formation.") Because the water level rises so far above the top of the aquifer, a large drawdown is possible without dewatering the aquifer.

Yields of as much as several hundred gallons per minute can be obtained from the Entrada Sandstone (Busby, 1978, No. 32). Recharge occurs mainly by infiltration in or near the outcrop areas or by leakage from adjacent aquifers. Much of the water may be discharged to overlying aquifers before reaching the outcrops in the discharge areas.

Todilto Limestone. The Todilto is a gray, dense, thick to thin-bedded limestone interspersed with sandy shale. In the central and eastern parts of the San Juan Basin and in the Chama Basin, the limestone sequence is overlain by a thick gypsum-anhydrite sequence. Thickness of the Todilto is variable, ranging to 33 feet in the limestone section and to as much as 100 feet in the gypsum-anhydrite section. Contact with the underlying Entrada Sandstone is gradational and continuous (Ridgley, et al, 1978, No. 8).

Summerville Formation. The Summerville Formation (Gilully and Reeside, 1928, p. 80) has about the same distribution as the Todilto Limestone along the western and southern parts of the San Juan Basin. There, the Summerville consists of massive to flat bedded, reddish-brown and gray, fine-grained, silty sandstone and sandy siltstone and ranges in thickness from 10 to 66 feet (Ridgley, et al, 1978, No. 8).

Morrison Formation. The Morrison Formation includes three members throughout most of the region. In ascending order these are the Recapture Member, the Westwater Canyon Member, and the Brushy Basin Member containing the Jackpile Sandstone. In the northwest part of the region near Four Corners, a fourth unit, the Salt Wash Member, underlies the Recapture Member.

The Westwater Canyon Member is the principal water-bearing unit within the Morrison Formation. This unit ranges from approximately 425 feet thick in the southwest part of the study area to 100 to 230 feet thick along the east side. A conglomeratic sandstone present in the Westwater Canyon Member in the southwest part of the region disappears to the north and east. The percentage of sandstone and the grain size decrease from south to north (Ridgley, et al, 1978, No. 8).

The Recapture and Brushy Basin Members consist mostly of sediments that serve as confining beds for water in the Westwater Canyon Member. The Recapture Member generally ranges from approximately 230 to 330 feet thick and consists mostly of interbedded fine to very fine-grained sandstone, siltstone, and mudstone. The Brushy Basin Member ranges in thickness from 230 to 425 feet and consists of claystone and very fine-grained sandstone. The Jackpile Sandstone is a sandstone-claystone sequence comprising the upper part of the Brushy Basin in the eastern part of the San Juan Basin. Ranging from 25 to 230 feet thick, the Jackpile yields water to wells north of Laguna and is the host rock for the major uranium deposits in that area. The uranium occurs in sandstones and is associated with carbonaceous or humate material (Ridgley, et al, 1978, No. 8).

The Salt Wash Member of the Morrison Formation reaches a maximum thickness of approximately 330 feet at the north end of the Chuska Mountains and consists of interbedded medium to very fine-grained sandstone, claystone, and siltstone.

Although the Westwater Canyon member is potentially a major source of ground water, few wells in the San Juan Basin currently obtain water from it. In the southwest part of the basin near Gallup, the overlying Brushy Basin Member is thin to absent. As a result, the Westwater Canyon Member and the overlying Dakota Sandstone form a single hydrologic unit. This unit is capable of yielding several hundred gallons of water per minute in many locations. Uranium mine shafts in this unit in the Ambrosia Lake and Church Rock areas reportedly are being dewatered at rates as large as 3,000 gal/min.

The Westwater Canyon Member is recharged chiefly by percolation from streams flowing across the outcrops and by precipitation on outcrop areas. It may also receive some water by leakage from other formations. Flow in the aquifer generally is toward the center of the basin, then essentially northwest toward the Four Corners area or southeasterly toward the Rio Grande Valley. There is some leakage to overlying and underlying formations, and a relatively small quantity moves toward the Puerco River southwest of Gallup.

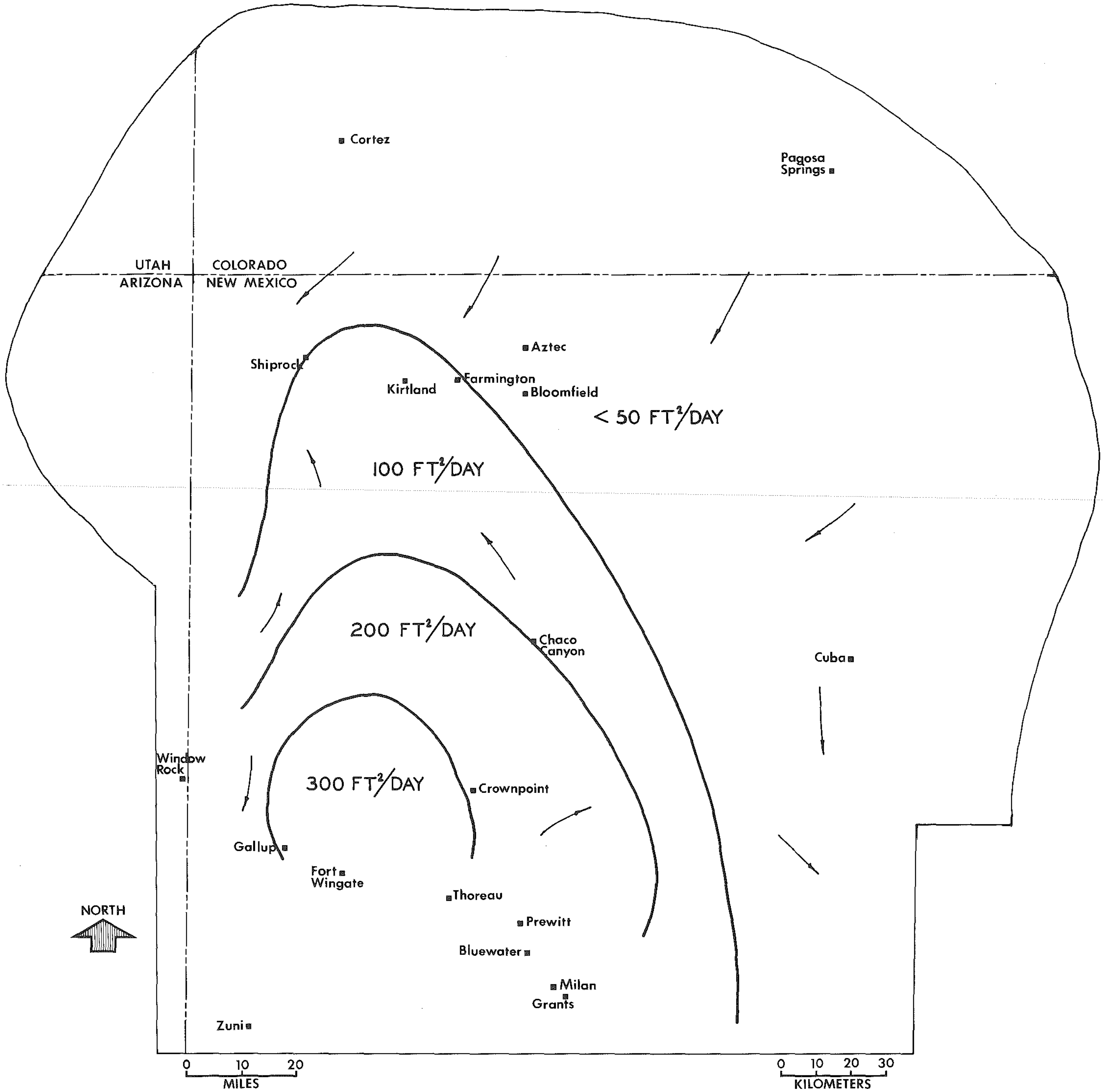
Map V-2 indicates the general direction of ground water flow in the Morrison Formation as well as the low transmissivities which often would suggest low well yields. Yields are higher here for reasons discussed below.

Except near the outcrop, water in the Westwater Canyon Member is under artesian pressure. This pressure increases as the aquifer extends northward under younger formations, and most of the wells flow without pumping. Near Star Lake the top of the aquifer is about 4,600 feet below the land surface, whereas the potentiometric surface is only 188 feet below the land surface. (The potentiometric surface of aquifers is an imaginary surface indicating the levels to which water would rise in properly cased wells.) Near Chaco Canyon National Monument, where the top of the aquifer is about 4,500 feet below land surface, the potentiometric surface is nearly 160 feet above land surface.

Consequently, as with the Entrada, a large drawdown in pumping wells is possible without dewatering of the aquifer. Even in the case of wells with a specific capacity of only 0.3 gallons per minute per foot of drawdown, yields of several hundred gallons per minute are possible (Busby, 1978, No. 32).

Dakota Sandstone. The Dakota Sandstone (Meek and Hayden, 1862) crops out around the margins of the San Juan and Chama Basins. Thickness of the Dakota varies but is generally less than 200 feet. The basal sequence generally consists of sandstone and conglomeratic sandstone, carbonaceous shale and siltstone, and thin coal beds. The upper sequence is primarily medium to fine-grained sandstone, which is locally cross-bedded and burrowed (Ridgley, et al, 1978, No. 8). Transmissivities are lower and water quality is poorer than in the Morrison Formation.

Mancos Shale. The Mancos Shale (Cross, 1899) is present throughout the San Juan and Chama Basins. The Mancos intertongues with the overlying



TRANSMISSIVITY AND DIRECTION OF GROUND-WATER FLOW IN THE MORRISON FORMATION

Source: Lyford, 1978, No. 37.

Map V-2

formations and, in the southern part of the San Juan Basin, intertongues with the Gallup Sandstone.

Because of these intertonguing relationships, the Mancos thins to the south from a maximum of about 2,180 feet in the northern part of the basin. Gray shale, siltstone, and lesser amounts of limestone, sandstone and bentonite characterize the Mancos. Invertebrate fossils indicate that the Mancos was deposited in shallow to deep marine environments (Ridgley, et al, 1978, No. 8).

Gallup Sandstone. The Gallup Sandstone consists of light-gray to buff, fine to coarse-grained sandstone with interbeds of siltstone and mudstone, and in places some coal. In some areas, the Gallup is split into two separate sandstone units by a dark-gray shale. The upper sandstone is pink to buff or light gray and forms cliffs and ledges. The lower unit is a buff to gray, fine grained, silty sandstone, commonly with a dark-brown ironstone bed at the top. The Gallup thins toward the northeast and eventually pinches out (Shomaker and Stone, 1976).

The Gallup Sandstone is the major aquifer in the vicinity of Gallup and supplies most of the city's water. Mercer and Cooper (1970) reported that a test well north of the city was capable of yielding 800 gal/min. In 1977, the city of Gallup pumped about one million gallons per day (Mgal/d) from wells tapping the Gallup Sandstone, with water levels in nearby wells declining about one foot per year.

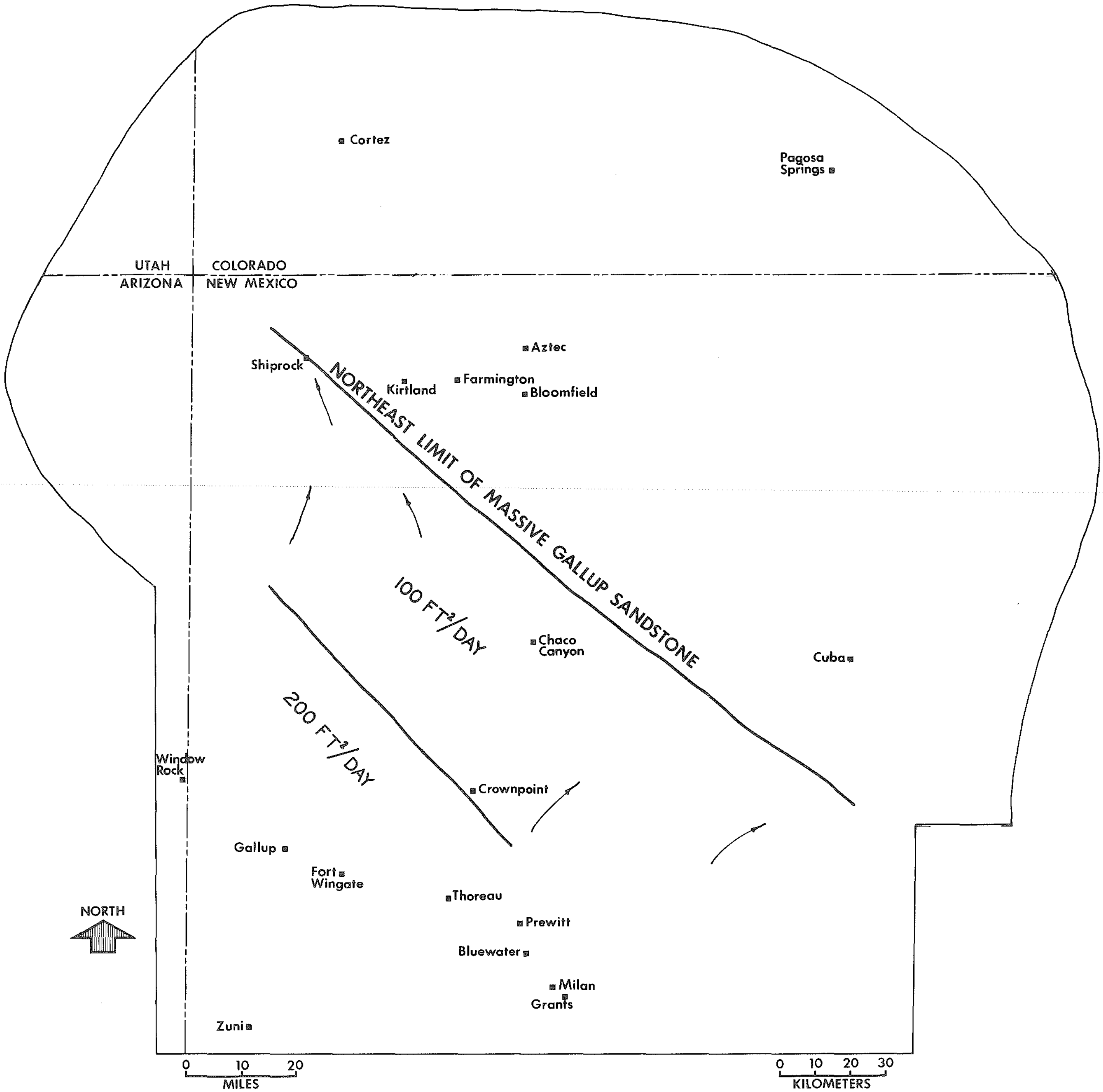
The Gallup Sandstone is recharged from precipitation and streams flowing over its outcrops. Most water moves northward and eastward, but some water moves toward the Puerco River in the Gallup area. As the Gallup does not crop out on the San Juan River, water moving toward the river must leak to adjacent aquifers. Map V-3 shows ground water flow direction and transmissivity in the Gallup Sandstone.

Water in the Gallup Sandstone, as in the Westwater Canyon Member of the Morrison Formation, generally is under artesian pressure, with many flowing wells. As the Gallup dips under younger rocks to the north, this pressure permits a large drawdown, so that several hundred gallons per minute can be obtained from a well even though the specific capacity is low (Busby, 1978, No. 32).

Water Quality

Surface Water. Except in the higher mountains, surface water in the San Juan Basin is high in dissolved solids. The predominant ions are sodium, bicarbonate, and sulfates. Quality is usually poor in the ephemeral streams immediately after thunderstorms, due to flushing of accumulations not only of sediment but also of soluble materials originating from weathered soils and rocks, animal and plant wastes, and residues from evaporation of earlier runoff.

After the initial storm runoff, the water quality improves progressively until the final stages, when bank seepage again increases the concentrations of dissolved solids. Flows early in the storm season generally are



TRANSMISSIVITY AND DIRECTION OF GROUND-WATER FLOW IN THE GALLUP SANDSTONE

Source: Lyford, 1978, No. 37.

Map V-3

of poorer quality than those later. The chemical quality of water in ponds or reservoirs changes with time, primarily as a result of evaporation which concentrates the more soluble constituents and precipitates the less soluble ones.

The EPA (U.S. Environmental Protection Agency, 1973) recommends that in drinking water the concentration of dissolved solids not exceed 500 mg/L. However, it allows up to 1,000 mg/L if no better water is available. Table V-4 lists the recorded extremes of dissolved solids content for 20 streams.

While the natural streamflow is fairly low in radiochemical constituents, uranium mineralization leads to greater concentrations of those

Table V-4

Observed Specific Conductance and Dissolved Solids for Selected Streams in New Mexico and Colorado

Station Name	Specific conductance (µmhos)		Dissolved solids (mg/L)	
	minimum	maximum	minimum	maximum
Rio Grande near Lobatos, CO	170	1,140	131	592
Rio Grande below Taos Junction, near Taos, NM	150	390	127	250
Rio Chama above Abiquiu Reservior, NM	153	1,320	--	--
Rio Grande at Otowi Bridge, near San Idlefonso, NM	165	1,310	131	1,030
Jemez River below Jemez Canyon Dam, NM	305	4,700	188	3,390
Arroyo Chico near Guadalupe, NM	3,350		2,380	
Rio San Jose near Grants, NM	1,350		829	
Rio Paguate below Jackpile Mine near Laguna, NM	1,400		1,240	
Rio Puerco near Bernardo, NM	238	11,400	258	9,060
Vallecito Creek near Bayfield, CO	41	120	17	81
San Juan River near Archuleta, NM	199	480	140	171
Animas River at Farmington, NM	146	1,980	115	1,430
San Juan River at Farmington, NM	154	2,290	103	1,720
Shumway Arroya near Waterflow, NM	1,300	16,300	1,610	12,500
Chaco Wash at Chaco Canyon National Monument, NM	265	720	162	469
De-na-zin Wash near Bisti Trading Post, NM	480	1,500	--	--
Hunter Wash near Bisti Trading Post, NM	480	2,500	309	1,230
Chaco River near Waterflow, NM	805	3,250	1,110	2,640
San Juan River at Shiprock, NM	188	4,360	115	2,980
Puerco River at Gallup, NM	562	1,370	303	820

Source: Busby, 1978, No. 32.

constituents in some areas than are found in parts of the country where uranium mineral concentrations in soils and rock are low. Variations within the basin are further accentuated in some cases by discharges from uranium mining.

The variations are suggested in Table V-5. Vallecito Creek, in the northern part of the basin, always has met the drinking water standards for radioactive constituents (U.S. Environmental Protection Agency, 1973), which are shown in milligrams/liter in Table V-6. Chaco Wash, farther south, usually meets these standards. Grants mineral belt streams that receive discharge water from uranium mining (Rio Paguate, Rio San Jose, and Puerco River), on the other hand, often exceed the standards.

Data on pre-mining concentrations of radioactive constituents in the Grants mineral belt streams, needed to quantify the effects mining has on these constituents, are not available. Radiochemical data (Table V-5) have been collected at only a few streams and may not apply to the whole basin. EPA did a preliminary study of radionuclides in surface water in 1975 which, as summarized in the technical journal Ground Water, stated in part:

> Ground-water contamination from uranium mining and milling results from the infiltration of mine, mill, and ion-exchange plant effluents containing elevated concentrations of radium, selenium, and nitrate. Available data indicate that radium concentrations in the discharge waters of a producing mine tend to increase substantially as the ore body is developed. Whereas natural background radium concentrations are generally about several picocuries/liter (pCi/L), 100 to 150 pCi/L appear in the effluents of operating mines. The discharge of such highly contaminated mine effluents to streams and seepage from tailings ponds, creates a long-lived source of ground-water contamination. Seepage of mill tailings at two active mills ranges from 126,000 to 491,000 m^3/yr and, to date, has contributed an estimated 2400 Curies of uranium, radium, and thorium to the ground-water reservoir. The shallow aquifer in use and downgradient from another mill has been grossly contaminated with selenium, attributable to excessive seepage from a nearby tailings pond.
>
> To date, no adverse impacts on municipal ground-water supplies have been observed. However, industry-sponsored environmental monitoring programs are inadequately designed and implemented, and may not define the full, long-term impact of mining and milling operations on the ground-water quality of the study area. (Kaufmann, et al, 1976)

The foregoing conclusions were based, as noted, on a preliminary study. A need exists for additional detailed studies such as this to more fully determine water quality effects from uranium development on surface water resources throughout the basin. Water quality monitoring programs

Table V-5

Observed Radiochemical Properties of Surface Water in Northwest New Mexico and Southwest Colorado

Station Name	Gross Alpha as U-nat. Dissolved (µg/L) Minimum	Gross Alpha as U-nat. Dissolved (µg/L) Maximum	Gross Alpha as U-nat. Suspended (µg/L) Minimum	Gross Alpha as U-nat. Suspended (µg/L) Maximum	Dissolved radium (pCi/L) Minimum	Dissolved radium (pCi/L) Maximum	Dissolved uranium (µg/L) Minimum	Dissolved uranium (µg/L) Maximum
Rio Grande at Otowi Bridge, NM	3.0	18	0.7	64	0.05	0.60	0.9	4.3
Jemez River below Jemez Canyon Dam, NM	25		22		0.17		4.1	
Rio San Jose near Grants, NM	17		<.4		.10		3.8	
Rio Paguate below Jackpile Mine near Laguna, NM	77	120	28	150	1.17	3.2	72	78
Rio San Jose near Laguna, NM	140		6.0		.11		91	
Vallecito Creek near Bayfield, CO	<.5	1.7	<.4	<.4	.04	.11	<.4	.46
Animas River at Farmington, NM	4.3	12	<.4	61	.06	.14	1.2	3.1
Shumway Arroya near Waterflow, NM	<29	<89	2.4	99	.06	.19	1.1	12
Chaco Wash at Chaco Canyon National Monument, NM	4.4	17	19	12,000	.02	.56	1.2	7.8
Ah-shi-sle-pah Wash near Kimbeto, NM	<6.0		880		.06		1.0	
Hunter Wash at Bisti Trading Post, NM	11	81	470	2,100	.06	.20	3.4	4.0
San Juan River at Shiprock, NM	3.0	16	1.4	470	0	.10	1.0	6.2
Puerco River at Gallup, NM	500	3,500	48	2,300	.38	.84	230	1,500

Table V-5

Table V-6

Selected Criteria for Public Water Supplies

Dissolved Constituents Parameter	Recommended Criteria mg/L
Total Dissolved Solids	500.0
Chloride	250.0
Sulfate	250.0
Nitrates	10.0
Arsenic	0.05
Selenium	0.01
Barium	0.05
Chromium (hexavalent)	0.05
Copper	1.0
Iron	.3
Lead	.05
Mercury	.002
Manganese	.05
Zinc	5.0
Uranyl Ion	5.0
Radioactive Constituents Parameter	**pCi/L**
Gross Alpha	15
Gross beta	50
Ra-226	3
Ra 226-228 (combined)	5
Sr-90	8

Source: U. S. Public Health Service, 1962 and National Interim Primary Drinking Water Regulations, EPA 570/9-76-003.

Selected Criteria for Agricultural Supplies

Parameter	Livestock (mg/L)	Irrigation (mg/L)
Molybdenum	---	0.005
Vanadium	0.1	10.0
Cobalt	1.0	0.05
Nickel	---	0.2

Source: U.S. National Technical Advisory Committee, 1968.

are now being conducted by the EID. In addition to monitoring the companies' National Pollutant Discharge Elimination System permits and mill license requirements, the EID also samples mine and mill effluents at least once a year.

A sampling program to determine surface water quality in the Grants mineral belt was conducted in 1978 and 1979 (Kunkler, Revised 1979, No. 22). The results and sample locations are shown in Table V-7 and Map V-4. The naturally occurring concentrations of many of the constituents of several samples exceed drinking water standards. Two laboratories conducted tests for selenium, with major differences in the results. Radium-226 exceeded the drinking water standard (3 pCi/L) at several sites, and in that respect the findings are somewhat in agreement with the EPA study. The largest activity of radium-226 in the samples (Table V-7) was in mine construction discharge water and was 23 pCi/L, but this water was from an aquifer that contained no ore.

The activity of dissolved radium-226 in treated mine water generally ranges from 1 to 10 pCi/L at points near its discharge from the mines. In streams, at distances of 5 miles or more from the point of effluent discharge, the activities of dissolved radium-226 are commonly 1 to 2 pCi/L (Kunkler, Revised 1979, No. 22). Further tests for radium to verify these results are in order. Tests of sediments in the stream bottoms to determine adsorption rates and other characteristics are particularly needed.

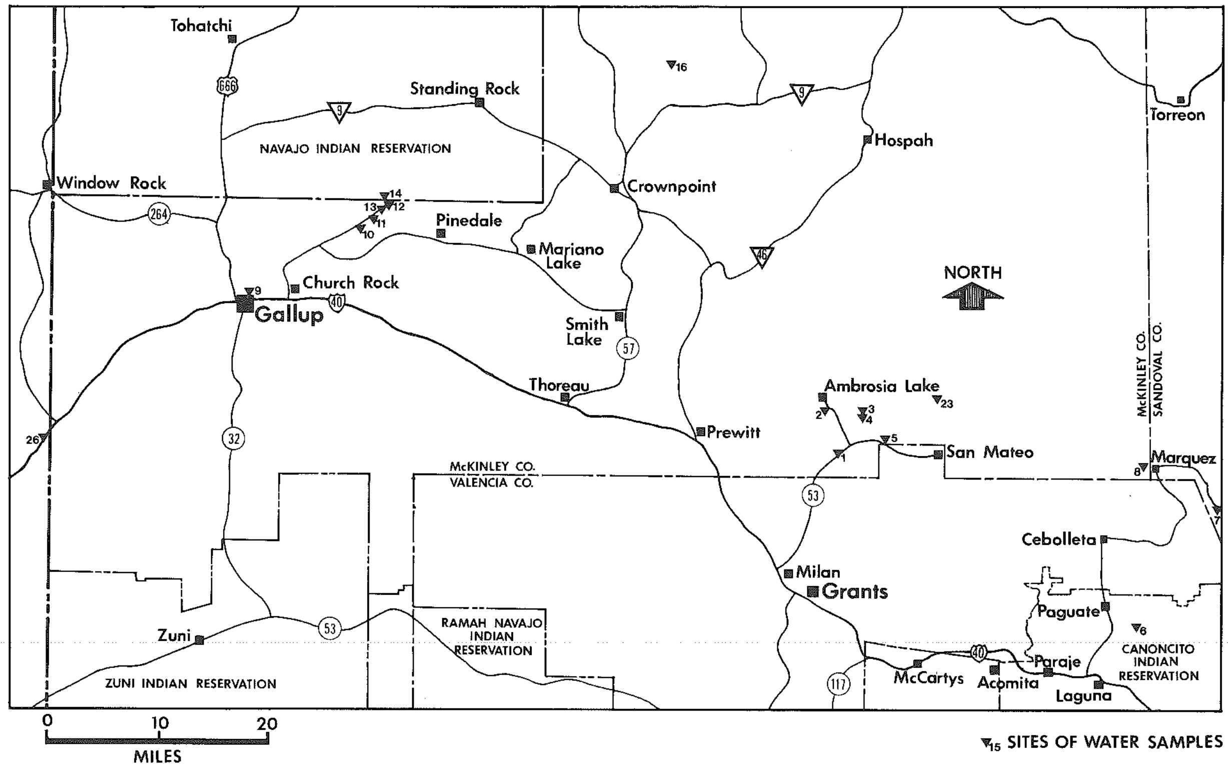
Other data on the quality of mine effluent show that radium-226 is readily adsorbed on stream sediments, and this reaction apparently controls the activity of dissolved radium-226. (Kunkler, Revised 1979, No. 22) Elsewhere, some natural hot springs, brines, and community water supplies contain much greater activities of radium-226 than was analyzed in samples of treated mine discharge water. The public health implications are not clear. Further research is required.

Ground Water. Ground water ranges from saline to drinking water quality. While most ground water does not meet U.S. Public Health Service drinking water standards, as the only water available it is widely used for domestic supply.

The quality tends to deteriorate with distance from the outcrop as the water moves through aquifers and dissolves minerals from the rocks (Maps V-5 & V-6). Many of the Cretaceous sandstone aquifers pinch out toward the center of the basin. In or near these areas of pinch out, the dissolved solids content may be as high as 30,000 mg/L (Busby, 1978, No. 32).

Generally, water from the alluvium is of better quality than that from adjacent bedrock aquifers because the water comes more directly from precipitation and has not been in contact with soluble minerals. However, toward the lower end of the major drainages, such as Canon Largo and Chaco River, the alluvium intercepts mineralized water seeping out of the bedrock. The chemical and selected other properties of water from the various aquifers are summarized in Table V-8.

Because the Morrison Formation is the aquifer most affected by mining, that unit is discussed more thoroughly than other aquifers. Table V-9 lists the water quality from two wells which tap the Morrison. This water is believed to be fairly representative of the Morrison aquifer from the Crownpoint area northwestward. However, in other parts of the basin the water is a poorer quality (Map V-5).



MAP SHOWING LOCATIONS OF SELECTED SITES OF WATER SAMPLES

Map V-4

Concentrations of radioactive minerals in rock affect the quality of ground water. Water from two Morrison wells at Crownpoint was analyzed for radon-222 and showed concentrations of 280 pCi/L and 370 pCi/L. By comparison, a municipal well for the city of Santa Fe measured 380 pCi/L, and tap water in Albuquerque measured at about 125 pCi/L. Some ground water in the states of Maine and New Hampshire contains radon-222 emitting several hundred thousand pCi/L of radioactivity (Kunkler, 1979, No. 22). There is no standard for radon-222 in water as there is for radium-226.

All rock formations contain some radioactivity, sometimes sufficient to render the water unfit for human consumption. Recent radiochemical analyses by the EPA and Indian Health Service (IHS) showed five community wells on the Navajo reservation with gross alpha activity so great that the communities were notified that their drinking water may exceed federal standards. Three are in the San Juan Basin region: one near Thoreau, one at Smith Lake, and the third at Red Rock, southwest of Shiprock. The other two are outside of the region in Arizona. Five other wells have radioactivity levels approaching maximum federal standards. It appears that the radioactivity levels occur naturally in these areas. Confirmation analyses are being conducted which could result in shutting down of the water supplies.

Table V-7.--Chemical and radiochemical analyses of water from selected sites in southern San Juan basin, New Mexico

Explanation: Site number refers to location on Map V-4; time is expressed with a 24 hour clock; CFS = cubic feet per second; MG/L = milligrams per liter; UG/L = micrograms per liter; PCI/L = picocuries per liter.

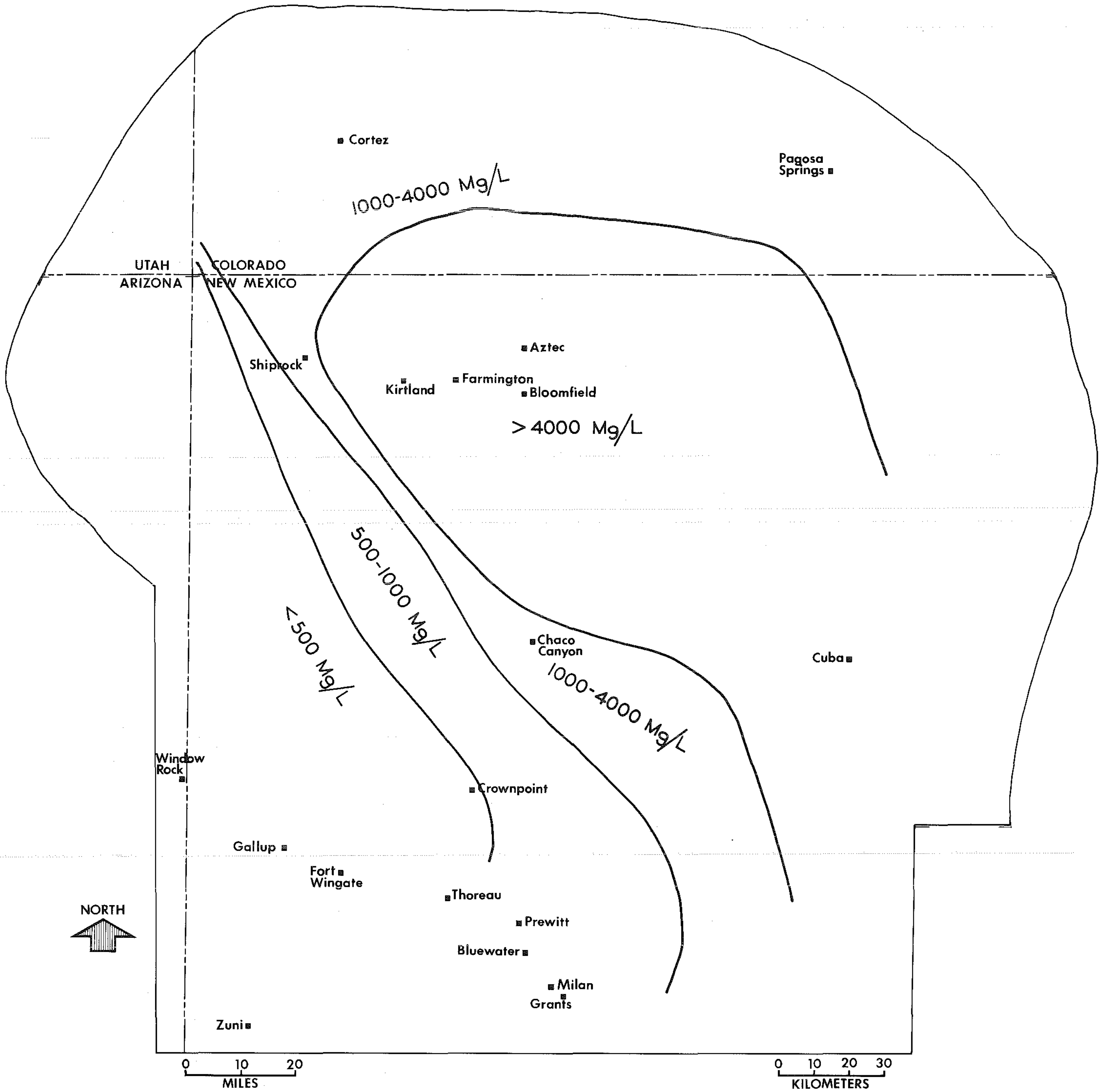
All analyses performed by the U.S. Geological Survey except as indicated.

SAMPLING SITE LOCATION, LATITUDE - LONGITUDE	SITE NO.	DATE	TIME	DIS-CHARGE (CFS)	SILICA (MG/L AS SIO_2)	IRON (UG/L AS FE)	CALCIUM (MG/L AS CA)	MAGNE-SIUM (MG/L AS MG)	SODIUM (MG/L AS NA)	POTAS-SIUM (MG/L AS K)	BICAR-BONATE (MG/L AS HCO_3)
San Lucas Dam near San Mateo, NM 35°24'00"N. - 107°38'20"W.	23	08-02-78	1230	11	--	--	--	--	--	--	336
		01-04-79	1110	--	27	--	4.6	0.8	230	2.8	--
Canon de Marquez at Marquez, NM 35°19'03"N. - 107°19'14"W.	8	04-08-78	1100	0.5	40	--	4.1	1.1	230	3.2	298
		12-28-78	1235	--	34	--	52	23	290	6.5	372
Effluent from Rio Puerco mine near Marquez, NM 35°16'06"N. - 107°12'18"W.	7	04-09-78	1115	0.9	18	--	16	5.8	400	4.6	312
		06-08-78*	1224	0.8	--	0.015	24	3.6	382	6.3	363
		12-28-78	1145	--	26	--	.4	5.0	380	5.6	280
Effluent Johnny M mine near San Mateo, NM 35°21'35"N. - 107°43'24"W.	5	04-11-78	1100	2.9	17	--	490	94	170	2.4	360
Effluent from Sec. 35 & 36 mines at flume near San Mateo, NM 35°23'30"N. - 107°45'14"W.	3	06-07-78*	0945	4.5	--	0.015	100	26	262	8.6	247
		08-03-78	1050	5.7	--	--	--	--	--	--	240
		01-04-79	1150	--	17	--	94	26	17	7.9	--
Effluent from Sec. 35 & 36 mines 1 mi south of flume near San Mateo, NM 35°23'00"N. - 107°45'14"W.	4	06-07-78*	1100	4.4	--	0.01	98	26	267	9.0	245
		08-03-78	1230	6.1	--	--	--	--	--	--	238
Puertocito Creek near Kerr McGee mill near San Mateo, NM 35°23'30"N. - 107°48'55"W.	2	06-06-78*	1200	1.3	2.8	0.02	200	110	270	12	294
		07-13-78*	1150	--	--	0	164	74	271	12	258
		08-01-78	1130	1.8	--	--	--	--	--	--	254
Puertocito Creek at bridge NM Hwy 53 near San Mateo, NM 35°20'22"N. - 107°47'38"W.	1	03-05-78	1100	1.2	4.3	--	190	100	210	14	274
		06-06-78*	1005	0.4	--	0.02	186	106	282	15	268
		07-13-78*	1020	0.7	--	0.03	184	80	317	12	305
		08-01-78	1005	--	--	--	--	--	--	--	262
Rio Paguate below Jackpile mine near Laguna, NM 35°07'09"N. - 107°19'58"W.	6	05-23-78*	1230	0.9	--	0	110	79	147	11	316
		08-16-78	0930	--	--	--	--	--	--	--	364
		12-19-79	1020	--	17	--	110	240	160	7.9	--
Kim-me-ni-oli wash near Crownpoint, NM 35°50'06"N. - 108°03'18"W.	16	06-14-78*	1010	2.0	--	0.04	4.0	0	761	8.6	228
Effluent from United Nuclear mine near Churchrock, NM 35°39'50"N. - 108°30'10"W.	14	05-16-78*	1300	2.5	--	0.02	14	3.6	149	2.0	259
Effluent from United Nuclear & Kerr McGee mines near Churchrock, NM 35°39'30"N. - 100°29'48"W.	12	03-04-78	1500	5.0	15	--	12	3.8	150	6.2	242
		05-25-78*	1200	6.4	--	0.015	12	0	122	4.7	259
		01-09-79	1240	--	17	--	17	9.8	120	3.6	--
Pipeline Canyon at trestle near Churchrock, NM 35°38'50"N. - 108°30'15"W.	13	07-11-78*	1130	8.5	--	0.54	18	6.1	133	20	221
		07-19-78	1140	6.6	--	--	--	--	--	--	222
		07-20-78	1220	7.1	--	--	--	--	--	--	229
		01-09-79	1230	--	17	--	17	9.7	120	3.6	--
Pipeline Canyon near mouth near Churchrock, NM 35°37'40"N. - 108°31'28"W.	11	05-25-78*	1030	5.3	--	0.02	14	3.6	122	5.5	267
		07-12-78*	1150	8.4	--	0.07	40	6.1	131	19	222
		07-19-78	1000	6.2	--	--	--	--	--	--	229
		07-28-78	1050	6.5	--	--	--	--	--	--	228
Puerco River near Springstead, NM 35°36'46"N. - 108°33'09"W.	10	05-18-78*	1345	6.4	--	0.015	16	3.6	131	6.3	284
		07-12-78*	0950	--	--	0.04	38	9.7	129	17	226
		01-09-79	1130	--	18	--	46	16	140	4.8	--
Puerco River at Gallup, NM 35°31'48"N. - 108°44'21"W.	9	02-25-78	1530	--	12	--	36	6.8	170	3.4	244
Puerco River at Lupton, Az 35°24'47"N. - 109°00'00"W.	26	02-25-78	1300	--	13	--	52	11	260	5.3	380

* Part of analyses performed by the Bureau of Indian Affairs Laboratory in Gallup, New Mexico

Table V-7.--Chemical and radiochemical analyses of water from selected sites in southern San Juan basin, New Mexico - Concluded

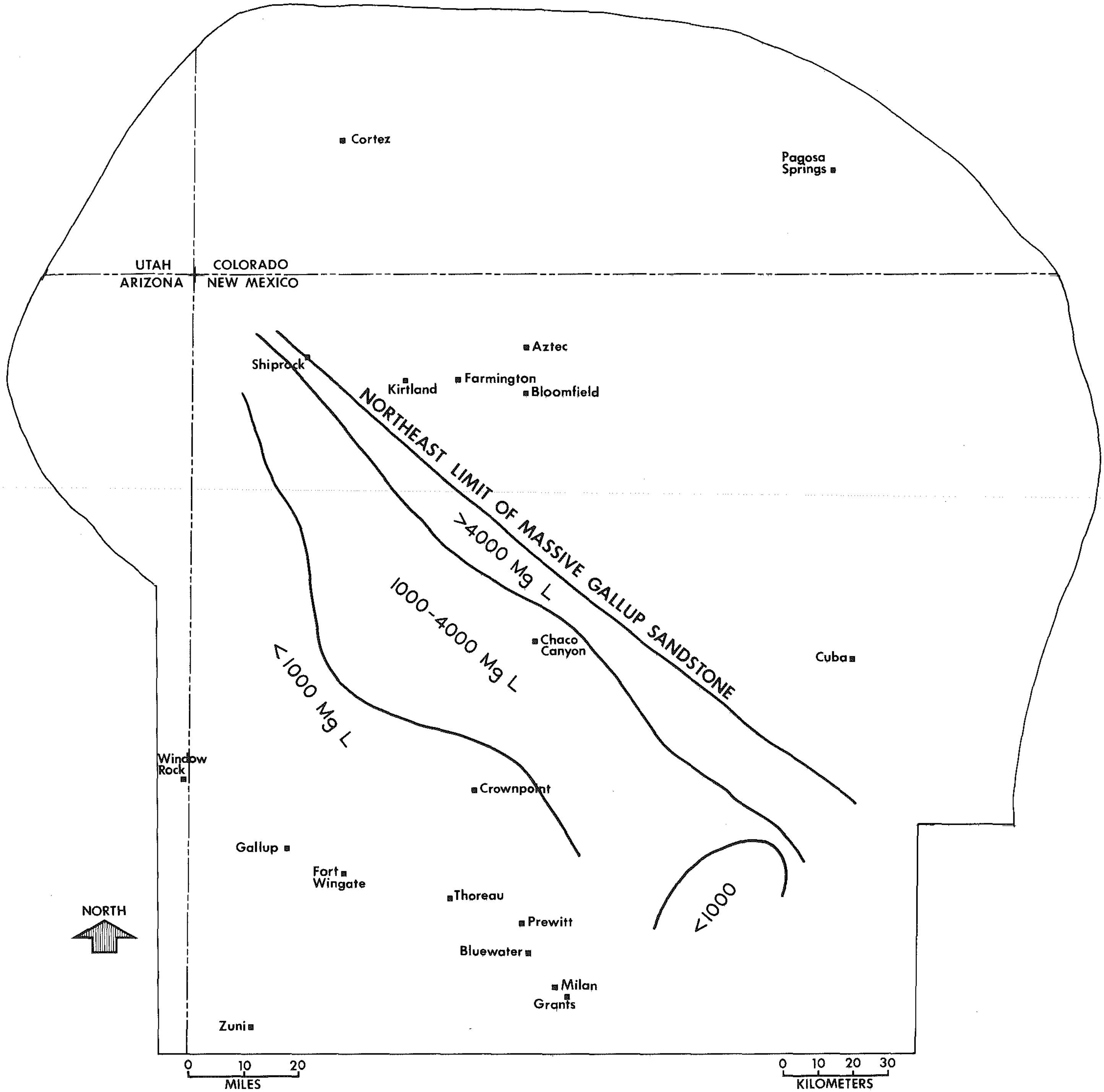
CAR-BONATE (MG/L AS CO_3)	SULFATE AS (MG/L AS SO_4)	CHLO-RIDE (MG/L AS CL)	FLUO-RIDE (MG/L AS F)	PHOS-PHORUS (MG/L AS P)	PH (STD UNITS)	URANIUM (µG/L AS U)	VANADIUM (µG/L AS V)	MOLYB-DENUM (µG/L AS MO)	SELE-NIUM (µG/L AS SE)	SELE-NIUM* (µG/L AS SE)	RADIUM 226 (PCI/L)	ARSENIC (µG/L AS AS)
7	--	--	--	--	8.6	11	1.3	2	--	--	3.1	--
--	--	8.7	--	--	8.7	1.4	--	54	12	5	0.91	--
86	100	22	1.2	--	9.5	4	5.0	3	0	--	0.1	1
8	--	--	--	--	8.4	1.5	--	5	0	--	.12	1
27	560	31	1.0	--	8.9	20	1.0	23	0	--	5.9	2
16	545	32	0.9	0	8.8	34	0.9	18	0	--	23	-
46	--	31	--	--	9.2	12.7	--	27	1	1	4.1	1
--	1,500	31	0.5	--	8.2	22	0	3	6	--	0.5	0
--	673	23	0.7	0	8.3	1,600	23	750	36	42	1.0	--
--	--	--	--	--	8.2	1,700	2.2	980	--	--	1.1	--
--	--	19	--	--	8.4	1,300	--	1,100	6	90	.75	6
3	676	23	0.6	0	8.4	1,000	32	100	37	41	1.0	--
2	--	--	--	--	8.4	510	22	950	--	--	1.6	--
--	990	180	0.5	--	8.3	905	64	630	520	--	4.5	7
--	898	132	0.5	0.01	8.0	2,400	64	520	--	141	2.5	--
--	--	--	--	--	7.9	1,400	100	570	--	--	4.4	--
10	910	210	0.6	--	8.4	1,700	16	500	68	--	5.3	3
4	1,000	189	0.5	0	8.4	1,700	21	450	440	244	9.9	--
--	1,080	126	0.6	0.03	8.3	1,200	9.2	560	--	12	8.7	--
--	--	--	--	--	8.2	1,100	5.5	340	--	--	6.1	--
6	646	21	0.7	0	8.5	898	31	780	110	0	0.7	--
--	--	--	--	--	8.2	--	--	--	--	--	--	
--	--	18	--	--	8.2	138	--	3	3	--	2.3	--
280	1,120	93	2.5	0.02	10.8	2.2	9.0	--	0	0	1.8	--
20	144	27	0.5	0	9.0	3,600	21	200	40	56	0.7	--
27	73	23	0.4	--	9.0	1,000	16	20	8	--	4.6	4
27	63	14	0.4	0	9.2	807	19	12	4	10	2.6	--
--	--	13	--	--	8.8	705	--	280	25	--	8.5	8
17	128	37	0.4	0.09	8.9	940	11	230	--	9	8.6	--
16	--	--	--	--	8.8	591	8.7	430	--	--	3.5	--
16	--	--	--	--	8.8	627	10	260	--	--	4.7	--
--	--	14	--	--	8.8	1,000	--	270	25	--	9.0	8
24	78	20	0.3	0.05	9.1	2,300	28	820	110	11	1.5	--
10	178	39	0.6	0.06	8.7	763	6.0	260	--	11	1.3	--
9	--	--	--	--	8.6	547	6.2	300	--	--	2.9	--
12	--	--	--	--	8.8	666	9.0	300	--	--	2.5	--
12	111	18	0.4	0.01	8.8	1,100	16	12	0	24	0.8	--
6	184	37	0.6	0.03	8.6	768	9.0	240	--	13	2.2	--
--	--	16	--	--	8.4	725	--	290	6	26	.85	--
12	190	53	--	--	8.5	960	3.0	17	20	--	0.3	--
12	330	73	1.0	--	8.9	400	2.0	8	10	--	0.1	--



DISSOLVED-SOLIDS CONCENTRATION IN THE MORRISON FORMATION

Source: Lyford, 1978, No. 37.

Map V-5



DISSOLVED-SOLIDS CONCENTRATION IN THE GALLUP SANDSTONE

Source: Lyford, 1978, No. 37.

Map V-6

Table V-8

Ranges in chemical and physical properties of ground water in the San Juan Basin
(in milligrams per liter, except as noted)

Aquifer	Silica (SiO_2)	Iron (Fe) (ug/L)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness (units)	pH	Temperature (°C)
Alluvium	04.1-63	0-6.6	4-2,870	0.8-2,040	5.5-12,000	34-1,000	2.5-8,890	2-27,500	0-11	0-439	143-47,100	18-15,500	7.3-8.3	4-21
San Jose Formation	7.6-28	0.02-14	1.6-365	0-67	29-745	120-814	71-1,430	3.2-87	0.2-4.0	0-25	323-2,520	4-1,960	6.5-9.2	9-14
Nacimiento Formation	14-22	0.02-0.58	0-385	0-50	3-2,415	0-478	6.2-5,455	1-145	0-4	0.2-5.7	56-14,150	30-966	6.9	12
Ojo Alamo Sandstone	9.6-39	0-2.1	1.6-548	0-126	23-788	0-888	0.4-2,440	0.8-923	0.3-1.8	0-70	275-4,010	4-1,860	6.5-8.9	2-14
Pictured Cliffs Sandstone	11-20	0-0.24	1.9-425	1-217	50-16,600	209-2,400	7.3-4,400	19-26,600	1.2-5.5	0-8.6	383-44,200	11-1,950	7.4-9.1	3-19
Cliff House Sandstone	2.7-19	0-0.01	2.2-280	0.7-170	26-6,140	0-1,250	350-8,230	7-4,210	0-8.1	0.1-2.5	849-3,120	8-1,600	4.3-8.9	13-18
Menefee Formation	5.1-21	0-1.1	1-168	0-34	8-2,620	92-1,890	1.8-3,930	1.5-956	0-12	0-19	129-7,780	4-534	7.4-9.1	12-21
Point Lookout Sandstone	0.05-39	0-0.31	0-684	0.4-267	13-833	116-826	3.8-3,410	2.2-113	0.2-3.7	0.1-14	149-5,080	5-2,800	7.4-10.0	13-21
Crevasse Canyon Formation	5.5-24	0-3.6	1.3-630	0-245	0.9-1,002	122-1,030	9.2-2,980	1.4-94	0-2.0	0-427	243-4,470	4-3,100	6.8-9.1	12-20
Gallup Sandstone	10-38	0.02-15	1-456	0-268	16-1,690	85-763	17-2,854	4-1,940	0-6.8	0-40	285-4,400	4-2,240	7.2-8.8	9-42
Dakota Sandstone	6.5-42	0-7.8	1.5-330	0.9-103	5.8-1,430	130-1,600	7.8-3,540	6-500	0.1-10	0.1-10	165-5,560	9-1,080	7.2-8.4	13-23
Westwater Canyon Member Morrison Formation	6.2-29	0-4	1.2-373	0.2-188	9.2-1,430	60-1,200	11-3,540	0.8-374	0.1-4	0-200	168-5,560	4-1,700	7.2-9.2	14-52
Bluff Sandstone	7.4-18	0-0.39	7.5-221	2.2-106	24-949	168-898	17-2,380	12-118	0.2-5.1	0.1-18	264-3,760	20-988	7.5-8.3	11-24
Entrada Sandstone	9.1-27	0.09	1.2-262	0.2-64	15-543	83-539	5.8-1,930	5-2,230	0.2-1.6	0-33	196-2,870	4-916	9.2	17
Chinle Formation	3.9-45	0-1.2	0.4-304	0.5-587	1.2-5,740	34-1,150	16-4,110	5-9,590	0.1-5.9	0-129	171-6,410	3-3,170	6.8-9.1	12-20
San Andres Limestone	6.7-23	0-1.2	60-266	14-128	1.2-426	161-702	11-1,030	4-254	0-0.8	0-105	272-2,370	72-1,040	6.7-8.2	11-46
Glorieta Sandstone	8.2-13	3.4-4.1	100-183	15-87	9.2-1,330	184-265	230-637	5-1,980	0.1-0.8	0-1.7	567-4,330	412-779	7.2	13-26

Source: Busby, 1978, No. 32.

Table V-9

Morrison Aquifer Water Quality
(In mg/L)

SiO_2	Ca	Mg	Na+K	HCO_3	CO_3	SO_4	Cl	F	NO_3	TDS	Hardness Ca+Mg	Hardness Non-Carb
Sanostee (south of Shiprock)												
21	68	18	9.2	227	0	52	15	.6	1.2	297	244	58
Crownpoint												
--	13	5.9	119	264	0	90	3	.2	.5	362	57	0

Source: Kunkler, 1979, No. 22.

Table V-10 lists the background radiation found in other wells tapping various formations in the basin (Busby, 1979, No. 32). All fall within the EPA limit of 3 pCi/L for radium-226. However, the gross beta activity in waters from the Entrada and Morrison Formations and the gross alpha values in waters from all but the Gallup Formation indicate high levels of natural radioactivity, suggesting the need for additional testing. The natural background radiation in waters from many formations appears to be higher than was previously suspected.

Water Budget and Water Use

A water budget (Geohydrology, 1978, No. 19) prepared for the basin compares inflow, storage, usage, and outflow. It is very difficult to measure adequately such hydrologic factors as ground water recharge, so all water budget figures presented represent magnitudes--not precise quantities.

Water enters the basin as precipitation and surface water inflow. Nearly all precipitation is lost through evapotranspiration (the loss of water vapor into the atmosphere by evaporation from soil and water and transpiration by plants). The remaining precipitation runs off over the surface or recharges ground water aquifers.

Table V-11 presents a hypothetical rough balance for a year of average precipitation. The table shows an enormous evapotranspiration rate and a low ground water recharge rate. Almost all the ground water recharge, even though small, enters the formations at their outcrops near the perimeter of the basin.

The surface water outflow can be further broken into water use segments, shown in projections for 1985 in Figure V-6. The largest withdrawals in the San Juan Basin then, as at present, are for irrigation.

TABLE V-10

Radiochemical properties of ground-water in northwest New Mexico

	Total depth of well (ft)	Dis-solved gross Alpha as U-Nat. (µg/L)	Sus-pended gross Alpha as U-Nat. (µg/L)	Dis-solved gross Beta as CS-137 (pCi/L)	Sus-pended gross Beta as CS-137 (pCi/L)	Dis-solved gross Beta as SR90 /Y90 (pCi/L)	Sus-pended gross Beta as SR90 /Y90 (pCi/L)	Dis-solved RA-226 (Radon Method) (pCi/L)	Dis-solved natural uranium (U) (pCi/L)
McKinley County									
Gallup Sandstone	800	<14	15	3.4	4.9	3.0	3.9	.21	.10
Gallup Sandstone	1,014	<11	<.4	3.3	<.4	2.7	<.4	.22	.07
Gallup Sandstone	--	7.1	.4	7.5	<.4	6.0	<.4	.42	.20
Gallup Sandstone	1,292	<9.4	.6	3.5	<.4	2.8	<.4	.82	.06
Menefee Formation	790	54	<.4	25	.8	20	.7	.14	.30
Pictured Cliffs Sandstone	--	64	<.4	24	<.4	20	<.4	.15	.20
---	--	<43	3.6	18	1.5	14	1.2	.25	.20
Menefee Formation	--	<17	<.4	<7.2	<.4	<5.7	<.4	.05	.05
Alluvium	--	41	<.4	16	1.1	13	1.1	.07	--
Fruitland Formation	--	<37	<.4	16	<.4	13	<.4	.21	.09
Alluvium	90	<18	1.3	<4.4	1.3	2	1.2	.52	2.1
Gallup Sandstone	1,154	--	--	--	--	--	--	--	<.4
Sandoval County									
Entrada Sandstone	--	260	<.4	94	<.4	76	<.4	1.4	<.01
San Juan County									
Westwater Canyon Member Morrison Formation	--	<84	<.4	88	<.4	80	<.4	1.6	<.01
Fruitland Formation	290	--	--	--	--	--	--	--	.9
Fruitland Formation	58	--	--	--	--	--	--	--	<.4
Fruitland Formation	59	--	--	--	--	--	--	--	<.4
Fruitland Formation	190	--	--	--	--	--	--	--	1.1
Fruitland Formation	205	--	--	--	--	--	--	--	2.4
Pictured Cliffs Sandstone	285	--	--	--	--	--	--	--	3.2
Fruitland Formation	150	<73	57	21	20	19	17	.24	.4
Fruitland Formation	150	<58	83	<16	28	<14	23	.12	--
Fruitland Formation	67	310	11	<30	5.1	<26	4.4	.34	2.5
Valencia County									
Alluvium	170	<32	2.4	10	2.6	8.2	2.1	.19	7.2
Alluvium	120	<30	12	8.1	12	6.5	10	.09	7.9
Alluvium	135	<46	<.4	<14	.4	<12	<.4	.15	5.5
Alluvium	--	<10	<.4	7.3	<.4	5.8	<.4	.06	--

Source: Busby, 1978, No. 32.

Table V-11

Water Budget[1/]
(Acre feet per year)

Water Inflow		Water Outflow or Recharge	
Precipitation	14,700,000	Evapotranspiration	14,015,000
Surface Water Inflow	1,897,000	Surface Water Outflow	1,930,000
		Ground Water Recharge	652,000
Total	16,597,000		16,597,000

[1/] Ground water inflow and outflow to and from the basin are unknown.

Source: Geohydrology, 1978, No. 19.

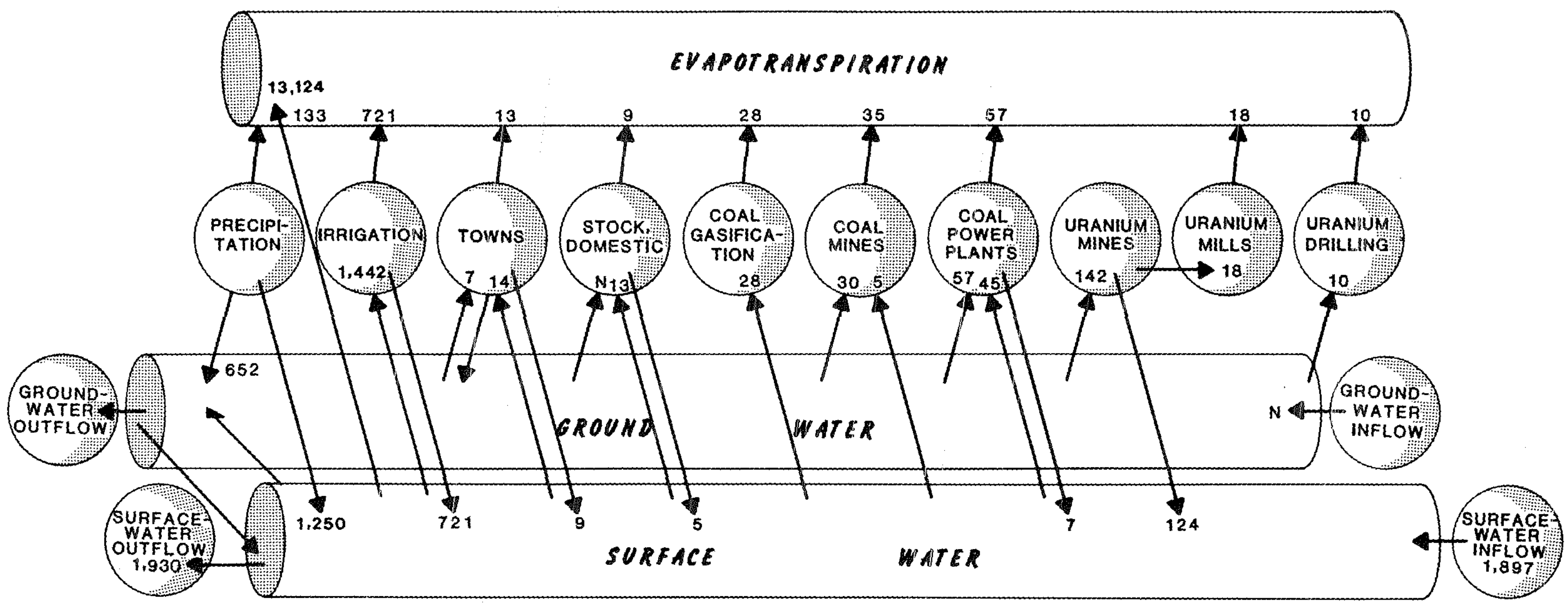
In 1977, this use averaged approximately 335,000 Af/yr, of which all but a very small portion was surface water. This water was used to irrigate approximately 200,000 acres, mostly along the Animas, La Plata, and San Juan Rivers.

The largest single irrigation project in the basin will be the Navajo Indian Irrigation Project (NIIP) south of Farmington. The first 10,000 acres were put under irrigation in 1976. Using water from Navajo Reservoir on the San Juan River, NIIP should grow to 110,000 acres by 1985 or soon afterward.

Figure V-6 indicates that in 1985 the total diversion of surface water for irrigation purposes in the basin will be approximately 1,442,000 acre feet per year. Of this, about half will return to the rivers and half will be lost to evapotranspiration.

The next largest use of water in the San Juan Basin is projected to be by coal-fired power generating plants. The two existing plants used 41,200 AF/yr in 1978, all from the San Juan River. Two proposed plants could use up to 57,000 AF/yr of ground water. Other self-supplied industries in the basin, including coal mining, used an average of about 9,000 AF/yr, all from ground water resources.

Dwarfing all other present users of ground water are the uranium mines. Pumps must operate continuously to prevent the mines from flooding. Depending upon the local hydrology and depth of the mine, dewatering rates in the basin could range from a few gallons per minute up to 5,000 or 6,000 gal/min. Geohydrology and Associates (1978) lists discharge rates totalling 16,000 AF/yr from 10 mines. (Also see dewatering rates in Tables I-2 and I-3.) The present discharge as result of mine dewatering from the Morrison Formation is about 24,000 AF/yr.



1985 PROJECTIONS
WATER BUDGET OF THE SAN JUAN BASIN STUDY AREA
VALUES IN THOUSANDS OF ACRE-FEET PER YEAR
Source: Geohydrology, 1978, No. 19

Figure V-6

In 1978 about 9,000 AF/yr of the mine discharge was used as process water in the uranium mills. The rest was pumped into nearby washes and maintained perennial flow for miles in some streams within the Puerco River and Rio San Jose basins before percolating into the streambed or evaporating. As a result of dewatering, water levels have declined in the few nearby wells tapping the Westwater Canyon Member of the Morrison Formation.

There are 12 large municipal water-supply systems and 66 small community-type water systems in the region. Many rural residents haul water from one of the public supply systems. Eleven public systems use surface water, the others ground water. These public water supply systems used an estimated average of 21 Mgal/d (23,500 AF/yr) in 1975, of which about three quarters came from surface water sources.

Much of the rural population obtains its water from shallow wells or springs. Slightly more than 3 Mgal/d (3,000 AF/yr) was used in 1975 for rural domestic purposes. Nearly all this water came from ground water sources. Another 4 Mgal/d (4,500 AF/yr) was used for livestock. Of this, 1 Mgal/d (1,000 AF/yr) was from ground water, the rest from small surface water stock ponds.

There are legal constraints to the use of both surface water and ground water in the region. The surface waters are fully appropriated and committed to existing uses and authorized projects or are committed tentatively to projects under investigation. Future surface water developments will be largely contingent upon acquisition and transfer of existing water rights or modification of tentative commitments. Disputes over water rights can be anticipated, particularly since the value of these rights may range as high as $3,000 or more per acre foot, depending on supply and demand (Link, 1979).

Except in the Puerco River basin, the office of the state engineer exercises jurisdiction over all ground water development in the San Juan Basin in New Mexico. There is a legal question concerning his jurisdiction over water on and under Indian lands. This is discussed in Chapter XII.

WATER SUPPLIES WITHOUT FURTHER URANIUM DEVELOPMENT

Surface Water

Even without further uranium development, use of the basin's meager surface water supplies would expand, with irrigation the major user. The NIIP has been authorized to divert up to 508,000 acre feet of San Juan River water from Navajo Reservoir annually. Consumptive use could be less, depending upon the mode of irrigation used.

Industrial and municipal use will probably increase dramatically. The only source for this water in the fully appropriated San Juan Basin is via acquisition of water rights from current users, primarily irrigation districts or individual farmers.

A transfer of irrigation water to urban-industrial purposes would particularly affect San Juan River water in the future. This transfer could

itself constitute both an impact and a source of impacts. In a water-scarce area, the uses to which the limited but indispensable water is put largely determine the basic economy and help shape the changing environment.

Any new power generating stations and the proposed Burnham gasification plant would require large quantities of water for cooling and process water. The first unit of the gasification plant (the only unit assumed to be in operation by 2000) would use approximately 14,000 to 16,000 AF/yr. The Public Service Company of New Mexico Bisti power generating station would require from 30,000 to 40,000 AF/yr. The Plains Electric plant would use somewhat less. The Burnham gasification plant would require a contract with the Navajo Tribe or others for surface water rights. No commitments have been made.

The assumption in this section is that uranium mining will decrease as shown in the lower curve (no further development) of Figure II-3. One scheme for obtaining water for the power plants is to pipe water from the uranium mines. This may be a reasonable solution unless uranium mining slows as this scenario postulates. However, since 10 mines pumping 2,000 gal/min apiece could supply the needs for one of these plants, this could be a viable solution for one power plant until close to the year 2000.

After 2000, particularly if more gasification plants should come on line, industrial competition for water will become acute. In fact, unless improved cooling technology reduces the requirements for cooling water, a water shortage will develop by the 1990's.

With declining uranium development, less water would be discharged into streams. Several streams which now carry a continuous flow of mine water discharge would become ephemeral. Sediments in these streams, however, could retain contaminants previously adsorbed. For decades storm runoff could carry the sediments farther downstream. Studies should be undertaken to determine the potential for pollution from this type of occurrence.

Ground Water

The need for potable ground water would increase with the growth of population, particularly in light of national trends of increasing per capita water use. However, the growth of towns in the Grants mineral belt, such as Grants, Milan, and Crownpoint, would be slowed by declining uranium activity, reducing the pressure for increasing water supplies.

Coal mines can be expected to increase their water use by as much as 8,000 AF/yr. They use water for coal washing, dust suppression, human consumption, sanitation, and irrigation of reclaimed land. Much of this water probably would come from the Morrison Formation and the underlying Entrada Sandstone.

As the level of uranium mining decreased, a corresponding decrease in dewatering of the Morrison Formation could be expected. The domestic competition for this water, to serve such communities as Crownpoint, would

ease considerably as mining dwindled. Lower pumping rates from mines would reduce the impact on water levels in wells. On the other hand, because of reduced pumping there would be less mine discharge water available for beneficial use.

With no additional mines planned in the future, those in operation or under construction would discharge water at a maximum rate of about 35.7 cubic feet per second (cfs) around 1985. Drawdowns of 2,000 feet or more could be expected near the deepest mines. Maps V-7 and V-8 show the modeled drawdowns for the present and the year 2000 with no additional uranium development other than that already initiated. Comparison suggests the increased depth of drawdown and the enlarged areas affected.

As may be seen, the impact of overall development on ground water would continue in the San Juan Basin even though uranium development were to wind down. However, this impact would be much less than that accompanying greater uranium development, as discussed below.

WATER SUPPLIES WITH MODERATE URANIUM DEVELOPMENT

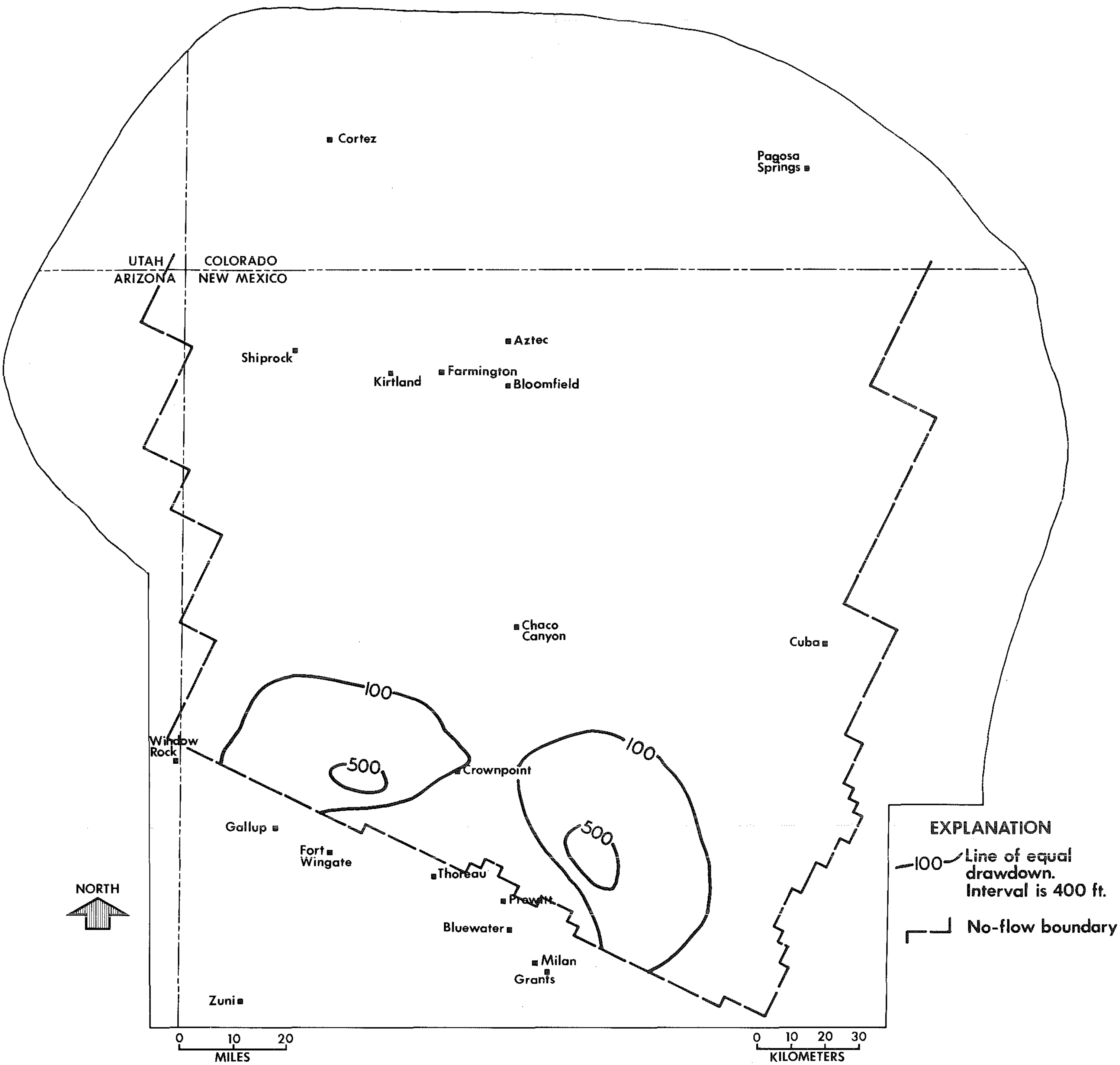
Surface Water

By 2000, a projected Moderate scenario of 72 mines would discharge a cumulative total of about 1,301,000 acre feet of water over their periods of use, and the maximum dewatering rate would be about 90 cubic feet per second (Table V-12, Figure V-7). Many ephemeral streams would become perennial. For a typical channel carrying the discharge from three mines, the dry weather flow could go from zero to 5 cfs or more. Much of this would infiltrate until storage in channel alluvium was filled, although much would also evaporate.

Some of the water discharged from mines in the San Juan River drainage basin and not put to beneficial use might eventually reach the river. It is believed that due to the low permeability of most rocks transversed by streams, only a small fraction of the water pumped from mines would recharge bedrock units. In certain areas such as Ambrosia Lake, however, local faulting and increased permeability might allow a greater recharge.

The impacts of significantly increasing the flow in the streams could be complex. The entire ecosystem downstream could change as water was supplied to plant and animal life. Since livestock would drink the water, its quality assumes some significance. Most trails and secondary roads in the area cross the dry stream beds and washes without benefit of bridges or culverts. Because perennial flow in these washes could render many such crossings impassable, rural residents might find themselves isolated.

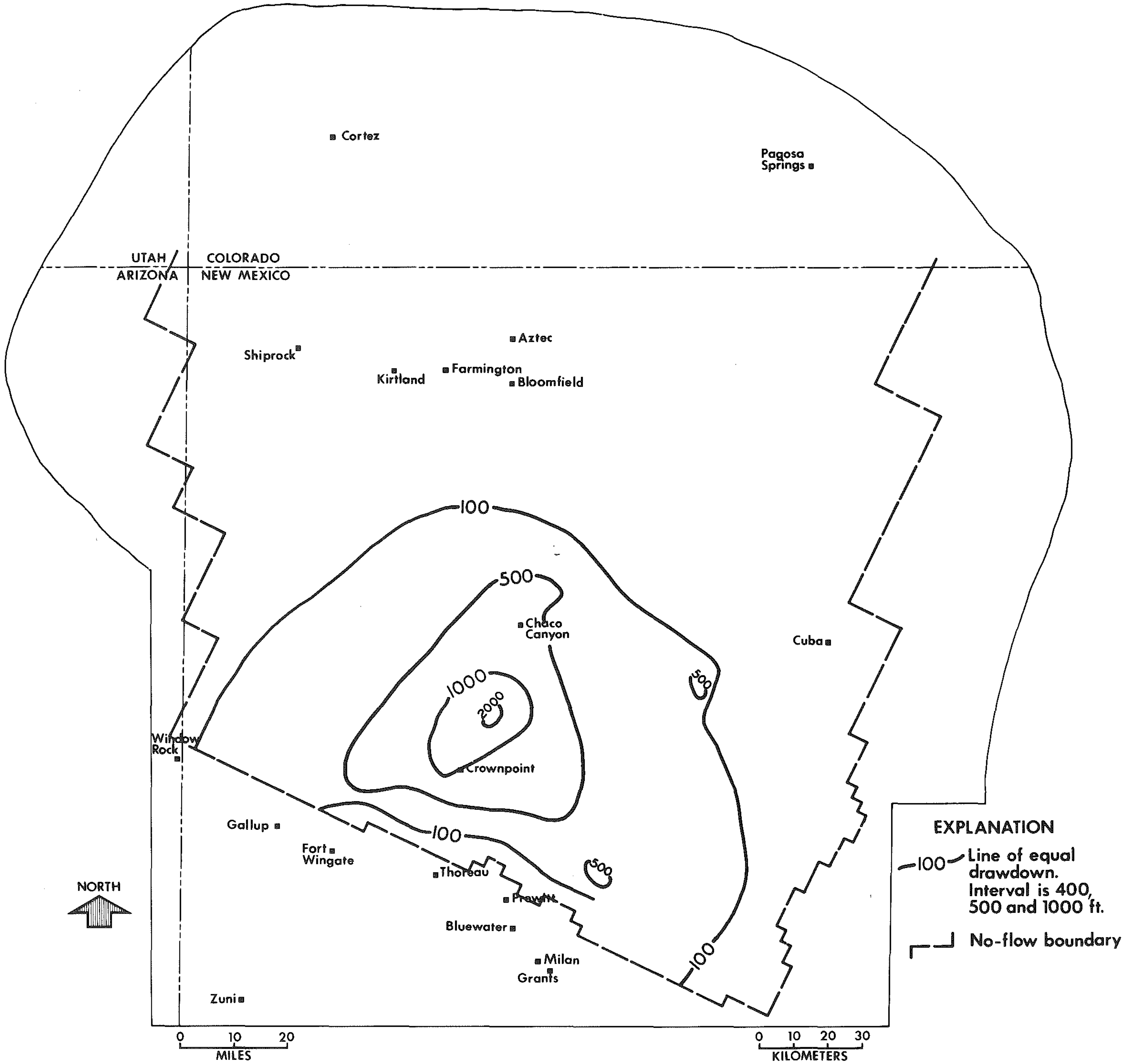
Rivers in the basin that now receive some recharge from ground water flow could experience a minor long term impact. By 2000 mine dewatering and other Morrison Formation withdrawals would reduce the San Juan River flow by less than 0.03 cubic feet per second (21.7 AF/yr) and the Rio Grande flow by 0.5 cubic feet per second (362 AF/yr). The greatest reduction in river flow might not appear until 200 years or more later (Lyford, 1978, No. 37).



MODELED DRAWDOWN IN THE MORRISON FORMATION BY THE YEAR 1980

Source: Lyford, 1978, No. 37.

Map V-7



MODELED DRAWDOWN IN THE MORRISON FORMATION FOR THE YEAR 2000 WITH EXISTING AND ANNOUNCED URANIUM MINING

Source: Lyford, 1978, No. 37.

Map V-8

Table V-12

Modeled Water Production from Uranium Mines and Wells
1985 to 2000

Year	WATER PRODUCED FROM MINES: Total since mining started (acre-ft)	WATER PRODUCED FROM MINES: Total for period (acre-ft)	WATER PRODUCED FROM MINES: Discharge rate at end of period (ft^3/sec)	WATER PRODUCED FROM WELLS: Total since mining started (acre-ft)	WATER PRODUCED FROM WELLS: Total for period (acre-ft)	WATER PRODUCED FROM WELLS: Rate at end of period (ft^3/sec)	Total water produced since mining started, mines and wells (acre-ft)
1985	366,000	192,000	38.8	38,000	15,000	4.1	381,000
1990	629,000	263,000	59.5	62,000	24,000	6.7	691,000
1995	899,000	270,000	62.5	86,000	24,000	6.7	985,000
2000	1,301,000	402,000	90.0	110,000	24,000	6.7	1,411,000

Source: Lyford, 1978, No. 37.

Perhaps the greatest potential impact from uranium development on the surface water resource is presented by mill tailings ponds. These ponds have often been constructed in or along drainage channels by damming swales, arroyos, or dry stream beds. Diversion channels are then cut around the ponds.

Thunderstorms in the headwaters areas can cause the sudden, intense flooding described earlier. Unless the diversion channel is designed with adequate carrying capacity, there is danger of a flash flood eroding or topping the tailings dam, breeching it, and carrying the mill tailings downstream. There, it would affect shallow ground water, the small ecosystem in the channel, and, if carried to a perennial stream or river, possibly the aquatic biota. After being abandoned, the tailings pile could create a potential hazard from flooding or erosion for many centuries.

Ground Water

A three-dimensional digital model was used by the U.S. Geological Survey to project dewatering rates, effects on water levels, and effects on surface flows (Lyford, 1978, No. 37). The anticipated hydrologic effects of the various projected uranium mine dewatering rates were superimposed on the effects of other likely developments using ground water from the Morrison Formation. In this way, the impacts from all projected water development of the Morrison could be approximated for any given year.

Maps V-7 and V-9 show the modeled drawdowns for 1980 using historic and current rates of water withdrawal and for 2000 using anticipated withdrawal rates assuming the Moderate development scenario. These maps facilitate comparison of present and future drawdowns.

The maximum production rate of about 90 cubic feet per second shown in Table V-12 amounts to about 178.5 acre feet of water daily. If this should

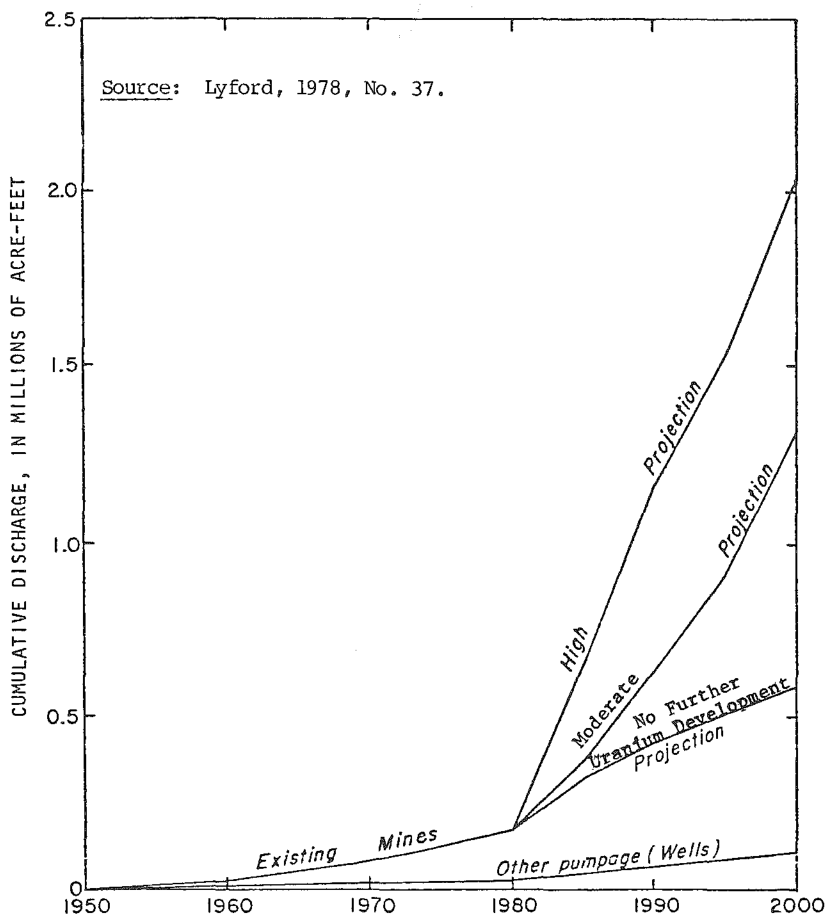


Figure V-7.--Cumulative discharge from existing mines and wells for three projected levels of mining

be continued for one year, the 65,000 acre feet pumped from uranium mines in that period would equal the total ground water consumed in 1970 by all mining, power and manufacturing uses in New Mexico combined. Or, it would constitute 87.5 percent of the state's total municipal water consumption that year (New Mexico Governor's Council of Economic Advisors, 1977). However, the 65,000 acre feet represents only 10 to 20 percent of the total water used within the San Juan Basin when irrigation is included.

Near the mines, drawdown in the Morrison Formation due to mine dewatering might drop the water level to the point that nearby wells completed in the Morrison Formation would become useless, for all practical purposes. Pumps in wells further from the mines would have to be lowered to reach the declining water levels, and motors would have to be increased in horsepower. Eventually the pumping costs for all nearby Morrison wells could exceed the benefits, making them uneconomical to use.

In this event, the use of the Morrison Formation as a water well supply in the vicinity of the mines would, in effect, cease. The town of

Crownpoint and the smaller communities of Mariano Lake and Smith Lake would find it necessary to seek an alternate source.

A major impact could result from a provision in the state law governing beneficial use. If water is put to beneficial use (other than on Indian reservations), a permit for that use must be obtained from the New Mexico state engineer. If water is not put to beneficial use no permit is required.

Because of water rights problems the state engineer has in the past been reluctant to issue permits for large withdrawals without lengthy studies and hearings. Therefore, it has been more expedient to discharge the water down a wash or stream than to utilize it. Great competition for water rights and water supplies among municipal and industrial entities is forecast by 1990 or earlier. Continued waste of water from the Morrison aquifer would compound that problem.

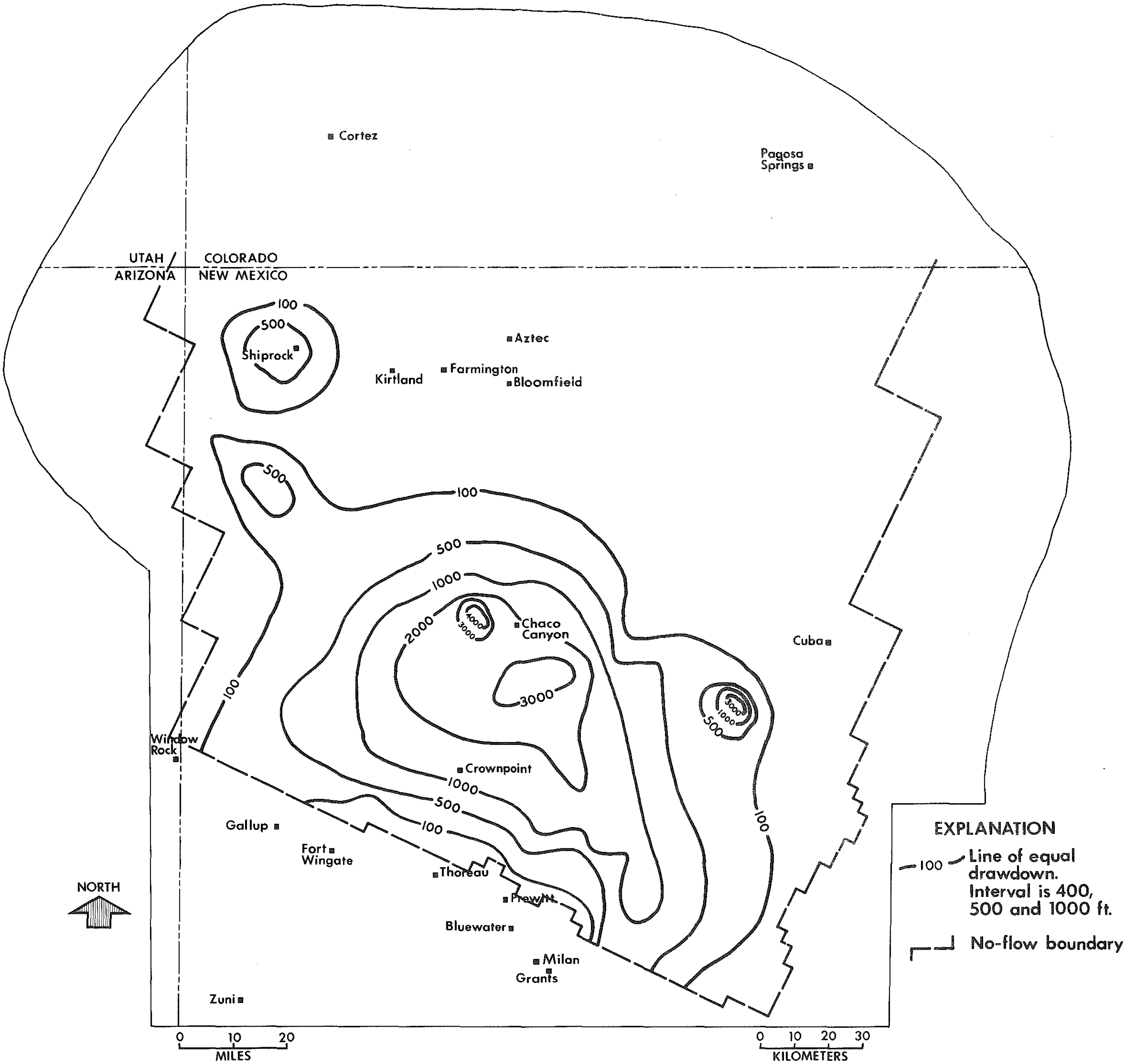
Two New Mexico laws enacted in 1980 could alter this pattern. Together they are designed to prevent overpumping of an aquifer when such a practice would impair the water rights of someone else.

The new laws are entitled the Mine Dewatering Act of 1980 and the Replacement of Water Act of 1980. Through this legislation, the state engineer is given jurisdiction over mine dewatering for the first time. Under these laws the state engineer could limit mine dewatering by a company if studies showed that the drawdown could injure or infringe on the rights of a neighboring owner. The company might then have to replace the water of anyone found to have had his rights impaired. The effect of the laws will be uncertain until they have been tested.

Water Quality. Exploration drilling of the expected magnitude could, through interflow in the drill holes, interconnect the Morrison Formation aquifer with overlying aquifers. However, the lack of data makes the task of determining whether inter-aquifer contamination has occurred formidable. The many drill holes for uranium exploration, as well as for oil and gas development, may have already started this inter-aquifer leakage. It should be noted that the standard hole-plugging methods required by state regulations are intended to prevent inter-aquifer flow and if performed properly should reduce or prevent this impact.

Subsidence from ore and rock removal could rupture aquifers overlying the subsided area, mixing waters of differing quality with consequent degradation of the better quality water. Shaft construction and mining could cause local intermingling of aquifers such as occurred in the San Mateo area, where an increase in turbidity has been observed in some water supplies. Subsidence is unlikely in mines where backfilling practices are used, and in mines where subsidence might occur its effect on the aquifer should be localized. Overall, the impact of subsidence on the aquifer would not be great.

The untreated water pumped from mines generally has a poorer quality than the same water pumped from wells. Blasting, ore removal, and general mining activities add sediment and organic matter to the mine water before



MODELED DRAWDOWN IN THE MORRISON FORMATION FOR THE YEAR 2000 USING THE MID PROJECTED LEVEL OF URANIUM MINING

Source: Lyford, 1978, No. 37

Map V-9

it is pumped to the surface. In addition, the uraniferous minerals and minerals containing such elements as selenium, vanadium and molybdenum, as well as some of the radionuclides, change to more soluble compounds when they come into contact with oxygen at the mine rock face. These soluble compounds are dissolved by seeping water and pumped to the surface (Kunkler, 1979, No. 22). Analyses of some mine effluent samples show uranium content from 10 to 100 times as great as that in the ground water of the study area.

In order to comply with state and EPA standards, mine water is now being stored in reservoirs for settlement, and most companies are treating it to remove radioactive pollutants prior to releasing it to the streams. Moreover, chemical analyses of this mine effluent indicate that the dissolved concentrations of a number of heavy metals or radioisotopes (Ra, Mo, and V) are reduced with downstream transport by adsorption to suspended sediments or deposition on the streambed (Table V-7). The bulk of this effluent is lost by infiltration and evaporation.

Future floods could move some of the deposited heavy metals and radioisotopes farther downstream, but the concentrations would tend to become diluted. More research is necessary to determine details of the transportation process and the ultimate fate of these constituents.

The infiltration of mine and mill pond water could contaminate the ground water, particularly in the alluvial aquifers. Part of the shallow aquifer south of the United Nuclear-Homestake Partners mill has been contaminated with increased levels of selenium, sodium, and sulfate (Kaufmann, et al, 1976). Gray (1975) calculated that 180,000 cubic meters per year (146 AF/yr) of seepage from the Anaconda pond was infiltrating downward.

However, the natural ion exchange capacity of the soil for some constituents should lessen the impact of such infiltration. Laboratory analyses of acid mill waste water from study area tailings ponds indicate that the water is partially neutralized when it comes into contact with alkaline soils and minerals present in the natural environment (Tables V-13 and V-14). These studies indicate that significant amounts of the concentrations of heavy metals and radioisotopes would be precipitated by neutralization or be diluted in the natural environment.

If flooding greater than the design capacity of the mill pond or bypass channels should occur, waste water could be flushed into stream channels. These analyses indicated that problems caused by flood damage and leakage of mill ponds would be partly mitigated by the natural environment, but again additional research is needed.

In July 1979, a break developed in the United Nuclear Corporation's mill pond near Church Rock. Almost 300 acre-feet of mill pond acid and approximately 1,100 tons of tailings spilled into the Puerco River before the break was repaired. The pH of the river was significantly lowered temporarily. Concentrations of dissolved solids, uranium, radium-226, thorium-230, lead-210, polonium-210, arsenic, vanadium, zinc, sulfate, and gross alpha values were significantly raised temporarily. Stream sediments were contaminated with thorium-230, lead-210, uranium, vanadium and

Table V-13

Semi-quantitative chemical analyses showing effect of neutralizing and diluting millpond acid
(analyses by U.S. Geological Survey.)

Concentrations in micrograms per liter

Sample Number	1	2	3	4	5	6	7
Date of Sample Collection	June 16, 1978		June 2, 1978		July 25, 1978		
Location:							
Latitude	30 38'50" N		35 23'59" N		35 23'57" N		
Longitude	108 29'15" W		107 49'32" W		107 48'20" W		
Silver (Ag)	70	30	70	100	100	30	<10
Aluminum (Al)	>1,000,000	<10,000	1,000,000	5,000	>10,000	30,000	500
Boron (B)	5,000	1,000	3,000	700	5,000	700	100
Barium (Ba)	70	50	30	50	10	30	50
Beryllium (Be)	300	10	300	1	700	10	<1
Bismuth (Bi)	1,000	<1,000	1,000	<1,000	3,000	<1,000	<1,000
Calcium (Ca)	700,000	300,000	500,000	500,000	300,000	300,000	100,000
Cadmium (Cd)	700	100	500	70	700	70	<1
Cobalt (Co)	30,000	7,000	10,000	3,000	10,000	3,000	<5
Chromium (Cr)	1,000	100	1,000	70	3,000	100	<50
Copper (Cu)	3,000	1,000	3,000	1,000	5,000	1,000	<10
Iron (Fe)	>1,000,000	700,000	>1,000,000	100,000	>1,000,000	10,000	300
Gallium (Ga)	1,000	500	1,000	100	3,000	300	<30
Germanium (Ge)	3,000	3,000	700	1,000	7,000	3,000	<300
Potassium (K)	70,000	70,000	50,000	70,000	50,000	30,000	10,000
Lithium (Li)	3,000	3,000	3,000	3,000	5,000	1,000	100
Magnesium (Mg)	500,000	700,000	700,000	>1,000,000	3,000,000	700,000	70,000
Manganese (Mn)	50,000	50,000	100,000	100,000	30,000	70,000	30
Molybdenum (Mo)	3,000	300	7,000	–	7,000	100	700
Sodium (Na)	300,000	300,000	1,000,000	1,000,000	500,000	500,000	300,000
Nickel (Ni)	1,000	700	3,000	500	7,000	500	<50
Lead (Pb)	3,000	500	3,000	300	5,000	300	<30
Antimony (Sb)	3,000	300	3,000	300	7,000	300	<30
Silicon (Si)	1,000,000	30,000	1,000,000	30,000	1,000,000	10,000	5,000
Tin (Sn)	10,000	5,000	10,000	3,000	10,000	3,000	500
Strontium (Sr)	7,000	700	10,000	1,000	10,000	3,000	3,000
Titanium (Ti)	700	10	100	7	100	10	<5
Vanadium (V)	30,000	300	50,000	100	10,000	100	70
Zinc (Zn)	5,000	5,000	3,000	1,000	10,000	3,000	10
Zirconium (Zr)	100	50	100	10	300	50	<5

Sample Identification:

Sample Number 1 Millpond acid United Nuclear pond near Churchrock, N.M.
2 Same as 1 except neutralized with $CaCO_3$
3 Millpond acid Kerr McGee pond Ambrosia Lake, N.M.
4 Same as 3 except neutralized with $CaCO_3$
5 Millpond acid Kerr McGee pond Ambrosia Lake, N.M.
6 Same as 5 except neutralized with $CaCO_3$
7 Same as 6 except diluted 1:5 with treated mine effluent.

Explanation of symbols: >greater than <less than

Source: Kunkler, 1978, No. 22.

Table V-14

Chemical and Radiochemical analyses showing effect of neutralizing and diluting millpond acid. Analyses by U.S. Geological Survey

Concentrations of Selenium and Uranium in micrograms per liter, activity of Radium-226 in picocuries per liter

Sample number		1	2	3	4	5	6	7
Date of sample collection		June 16, 1978		June 2, 1978		July 25, 1978		
Location:								
Latitude		35 38'50" N		35 23'59" N		35 23'57" N		
Longitude		108 29'15" W		107 49'32" W		107 48'20" W		
Selenium	(Se)	5	7	2	2	180	180	140
Uranium	(U)	14,000	3,100	19,000	120	32,000	5,000	1,800
Radium-226	(^{226}Ra)	38	1.5	31	<14	58	2.9	5.9

Sample Identification:

Sample number 1 Millpond acid United Nuclear pond near Churchrock, NM.
2 Same as 1 except neutralized with $CaCO_3$
3 Millpond acid Kerr McGee pond Ambrosia Lake, NM.
4 Same as 3 except neutralized with $CaCO_3$
5 Millpond acid Kerr McGee pond Ambrosia Lake, NM.
6 Same as 5 except neutralized with $CaCO_3$
7 Same as 6 except diluted 1:5 with treated mine effluent.

Explanation of symbol: < less than

Source: Kunkler, 1978, No. 22.

sulfate. Significant pollution downstream from Gallup was probably lessened considerably because of the natural absorption capacity of the streambed, possibly supplemented by dilution from the city's sewage disposal system. The EID initiated detailed studies to determine the impact on the health of residents of the area. (For further details, see Kunkler, Revised 1979, No. 22.)

Under existing arid conditions, it is unlikely that percolating precipitation would leach significant radionuclides from the mill pond tailings piles. However, the long half-life of thorium-230 demands that the fate of tailings piles be considered in terms of thousands of years. In the geologic perspective, none of the following possibilities can be ruled out: 1) change to a humid climate with extensive leaching; 2) wind and water erosion; or 3) disruption by earthquakes or lesser earth movements. It should be noted that with the Uranium Mill Tailings Radiation Control Act of 1978 in effect, geologic hazards will be much less of a problem than they otherwise would be.

When the mines are abandoned and pumping ceases, almost all should fill with ground water from infiltration. The water quality would vary with location, but it is known that radium is a naturally occurring component of uranium ore deposits in the Morrison Formation.

During active mining the radium levels of the discharged water significantly increase over those formerly found in wells in the area. This increase is due mainly to physical attrition of the rock matrix, high liquid to solid ratios, and the decrease in surface contact of the water with ion exchange materials. These abnormal conditions change after mining ceases and are not indicative of future radium concentrations in the mined area's ground water. During mining a significant amount of radium is actually removed from the aquifer. Even so, radioactivity levels in the abandoned, flooded mine workings would remain higher than pre-mining levels in the area.

An offsetting circumstance would be that a mined-out area would serve as a ground water sink, eliminating the possibility of radium migration from the abandoned mines until the aquifer head recovered. This recovery could take hundreds of years.

One study which considered dispersion, ion exchange, and radioactive decay showed that after aquifer recovery radium should not migrate farther than 600 to 6,000 feet from the mined area (Conoco, written communication, 1979). Additional studies are needed to confirm these conclusions. Basic research is necessary also to determine the processes and mechanisms of geochemical transformations and contaminant transport.

The water in an abandoned United Nuclear Church Rock mine was analyzed recently, and the levels of total radium activity ranged from about 20 to 35 pCi/L. No water wells exist within several miles of this mine, and it would appear reasonable to recommend that none be drilled within one mile of the mine in the future. Beyond that distance, wells may be possible. Analyses of water from the abandoned La Bajada open pit mine south of Santa Fe showed no evidence of elevated chemical or radiochemical constituents; the quality, in fact, was superior to that from some municipal wells (Kunkler, 1979, No. 22).

Much work remains to be done to determine the impacts of uranium mining and milling on water quality. The EID and EPA are continuing to study these impacts. Complicating the problem is the relatively high natural background level of radiochemical activity. Contamination caused by uranium development is difficult to separate from that naturally present in the ground water and surface water environment.

Finally, because the large water resources of the Morrison Formation are relatively undeveloped and unused, uranium mining impacts on these water resources in the immediate future would be relatively minor. However, the formation holds great potential as a water source. Possibly the greatest impacts from drawdowns in the Morrison, then, would not become evident until future generations sought to put the water to use.

WATER SUPPLIES WITH HIGH URANIUM DEVELOPMENT

Effects on surface and ground water in the uranium-producing areas would be similar under the High development scenario to those discussed for the Moderate level, but more severe.

By 2000, the maximum projected development of 105 mines would discharge a cumulative total of 2,025,000 acre feet of water from the mines. At the peak, the maximum rate of production would be 117 cubic feet per second, or 232 acre feet of water daily. Over a year this would total about 84,700 acre feet, more than all municipal water use in New Mexico in 1970 but still much less than the total water use in the San Juan Basin when irrigation is included.

This rate of pumping could lower water levels in the Morrison Formation 4,000 feet or more near the deepest mines where the base of the Morrison is at these depths (Map V-10). This could make nearby wells unusable or nearly so, raising the possibility of legal disputes.

The risks of inter-aquifer contamination, subsidence, and probable eventual limited drawdowns on surface flow in the San Juan and Rio Grande would be present as outlined earlier assuming Moderate development. Policy issues concerning water rights and beneficial use of the large quantities of water involved would assume still greater significance. In general, all water quantity and quality impacts discussed in the previous section would be almost doubled in intensity.

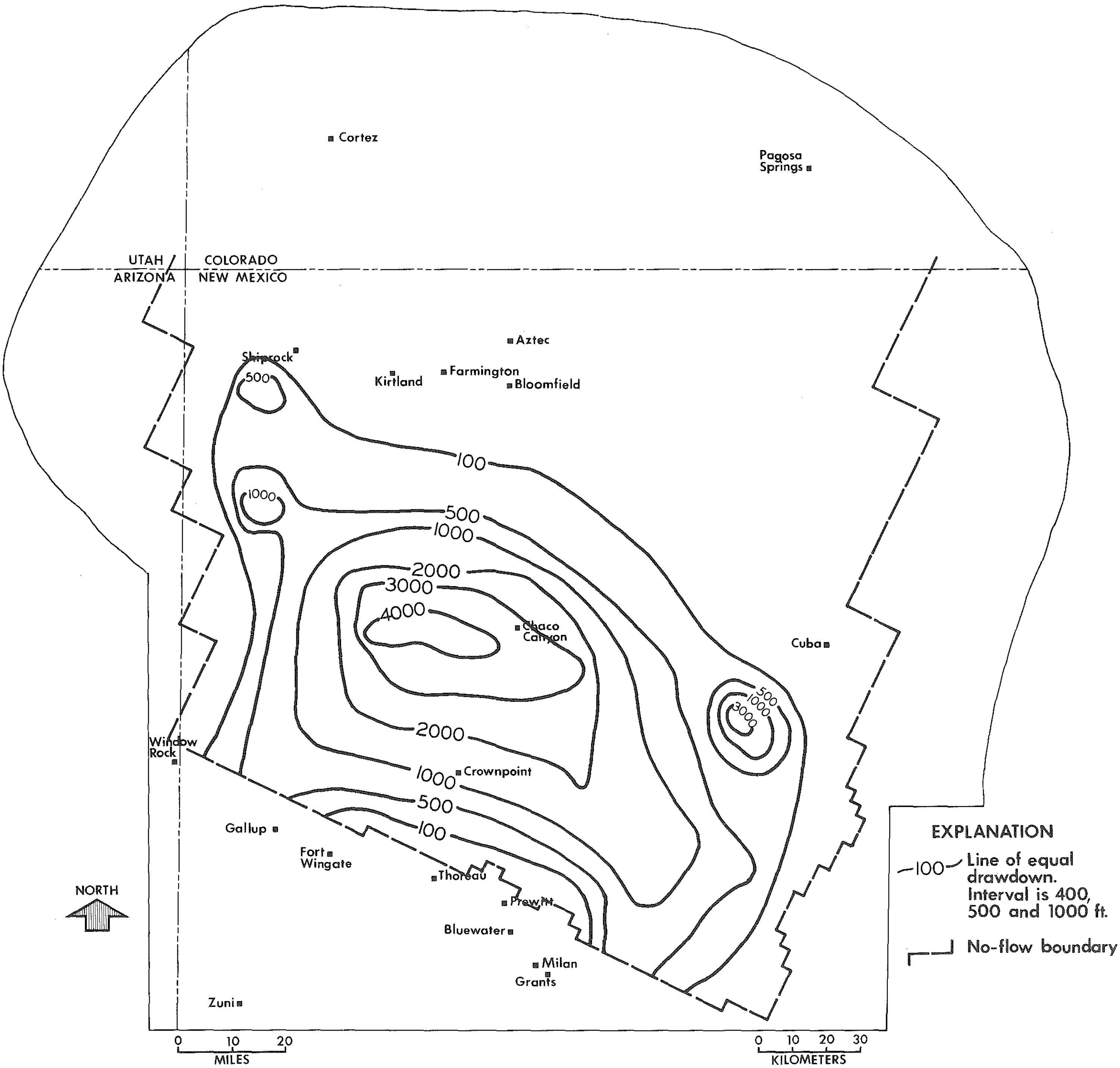
MITIGATION OF WATER RESOURCE PROBLEMS

Beneficial Use

The impacts of uranium development on community water supplies can be mitigated. The Navajo Tribe, BIA, IHS, and USGS are negotiating with the TVA and uranium company lessees for a continuing water supply for Crownpoint, Mariano Lake, and Smith Lake. Leases and mining permits issued by the Department of the Interior require that the companies maintain a suitable water supply to all affected people and communities. While terms of the agreement with the companies have not been fully worked out, they appear to be taking this form:

1. A continuous water supply of quality equal to that of the present supply and of a capacity to meet future demands shall be delivered to the water distribution systems by an industry association.
2. The costs of supply in excess of one dollar per thousand gallons will be borne by the mining industry.
3. When mining ceases in the area, a governmental or tribal authority will take over the supply, but the mining interests will bond or otherwise fund any cost of water above the level it would have been if mining had not occurred.

Several new water supply possibilities are being investigated. They range from the piping of water from a distant source to the treatment of mine water through a coagulation-floculation-filtration water treatment plant followed by an ion exchange process. Among matters that seem to warrant future investigation is the feasibility of using abandoned uranium mines as evaporation-proof underground water storage reservoirs, equipped with high capacity pumps and treatment facilities.



MODELED DRAWDOWN IN THE MORRISON FORMATION FOR THE YEAR 2000 USING THE HIGH PROJECTED LEVEL OF URANIUM MINING

Map V-10

Other towns in the basin could also benefit from the use of uranium mine discharge water. Umshler (1979, No. 66) analyzes the potential use of the Church Rock uranium mines' wastewater as a municipal water supply for Gallup. Water from the Kerr McGee and/or United Nuclear Church Rock mines could be collected after treatment at the mines and delivered to Gallup via a pipeline, or the water could be treated at Gallup as surface flow from the Puerco River. Either alternative is expensive and technologically complex compared to Gallup's current water supply system. Ownership of the land and water and marketability of the mine water further complicate development of this potential water supply. However, if a water shortage develops for Gallup, as predicted, this could be a viable alternative.

Other beneficial uses of the mine water would help mitigate the great waste currently taking place. One proposal is to pump the water, for cooling purposes, to one of the planned power generating stations. The Bisti power plant, for example, would require 30,000 to 40,000 acre feet per year. State and tribal regulations might need revision to make this beneficial use possible.

When put to use the water would assume a value. For example, in the case of the cooling water, a value of $30 to $40 per acre foot of water is conceivable. The exact amount, less cost of delivery, would be negotiated between the water rights owner and power company. If a single property could deliver one-tenth of the water needed, for example, the owner could receive more than $100,000 per year.

The ownership of the ground water, however, is unclear. In the case of tribal or allotted land, the Tribe or Indian allottee apparently retains ownership of ground water under normal lease terms. For other categories of land, particularly when surface ownership and mineral ownership are in different hands, there could be controversy. This is discussed in Chapter XII.

Water Development

A mitigating measure practiced by Exxon south of Shiprock is applicable elsewhere. An agreed upon number of exploration holes have been cased, the upper section grouted, and the lower casing perforated. The new wells are then developed for livestock or domestic water use. Much of the Morrison Formation is ideal for this, and the water short rural area is greatly benefitted where the practice occurs.

Water Pollution

An instrument that appears to hold potential for mitigating water pollution problems exists in the National Pollutant Discharge Elimination System (NPDES) of the Federal Water Pollution Control Act Amendments of 1972 and 1977. However, controversy over the definition of surface water courses has delayed implementation of the permit system.

According to the act, a NPDES permit is required for any waste discharge from a point source into a "water of the United States," but not for discharges into water courses which are not "waters of the United States."

Whether, and under what circumstances, waters in a closed basin completely within one state are waters of that state or of the United States has not been fully determined by the courts.

All uranium companies discharging into watercourses in the Ambrosia Lake area and some discharging in other areas have challenged EPA's implementation of the NPDES permit system. Pending adjudication the permits are stayed and the provisions are not in effect. Some permits issued as early as 1974 have never been in effect, as a result.

Where a permit is in effect, it places limits on contaminants discharged and imposes self monitoring requirements; the permit is updated at least once every five years or whenever there is a change in the discharge.

Fully implemented, the NPDES permit system would cover many types of waste water discharge. Mill tailings would not be discharged, but other waste waters are anticipated. The mines' and mills' sewage would probably be treated in overflowing lagoons. The large numbers of people moving into the region, however, would tax the treatment capabilities of nearly every waste treatment plant in the area. Expansion of most plants in the area should be expected (Chapter VIII).

Water pumped from mines and not put to beneficial use could fall within the NPDES permit system (Chapter XII). Under the act, flow must be monitored, its chemical and radiochemical constituents reported to EPA, and contaminants exceeding federal standards removed by treatment before discharge. Companies are constructing, testing, and operating treatment processes as required by the permit system.

In addition, the NRC has established water quality regulations concerning runoff from mill tailings pursuant to the Uranium Mill Tailings Radiation Control Act of 1978.

Ground Water Protection

The New Mexico Water Quality Control Commission has adopted state regulations to control pollution of ground water due to any discharge onto or below the surface of the ground. Discharges covered include those from tailings ponds and sewage lagoons. Adopted in 1977, the regulations were appealed by uranium interests and were stayed until upheld by the New Mexico supreme court in November, 1979.

Under the Federal Safe Drinking Water Act, regulations have been proposed to control pollution of ground water due to injection wells. The act does not address seepage from tailings ponds and sewage lagoons, which are covered in the Mill Tailings Radiation Control Act. Under this act, the EPA and NRC will establish regulations relating to seepage.

On Indian reservations and Indian allotted lands, USGS permits for exploration drilling require that all holes drilled must be properly plugged to comply with the state engineer's regulations intended to prevent water contamination that could result from interconnecting two or more aquifers penetrated by the holes. Elsewhere, the state engineer's regulations

require that all holes under artesian pressure be cased to prevent mingling of waters from different aquifers. (New Mexico State Engineer, 1977)

Monitoring

Under the NPDES permit system, monitoring of the chemical, biological, and radiation concentrations of various contaminants is required. The companies would normally monitor their own wastes but could expect periodic visits from the EID or EPA to inspect reports and monitoring methods. Moreover, the EPA has authority under the act to take over the monitoring itself.

The EID and contractors for the NRC and DOE are also sampling and testing water discharges in the region. Surveillance of water quality was somewhat sporadic in the past. This often was beyond the control of the federal or state agencies, with funding, manpower, and authority frequently in short supply. This situation is changing rapidly, and monitoring of the quality of stream water can be expected to increase.

Should seepage of mill tailings solutions from the reservoirs into the alluvium be detected by monitoring, construction of seepage collection systems could become necessary. Collected seepage should be pumped back into the impoundment or disposed of by other means.

The USGS also monitors mine operations for those mines under its permitting jurisdiction. It determines whether the water treatment and use conform to the terms of the approved mining plan.

CHAPTER VI

OTHER IMPACTS ON THE NATURAL ENVIRONMENT

Chapter VI

OTHER IMPACTS ON THE NATURAL ENVIRONMENT

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Chapter VI

Summary

Wastes from mines and mills would pose the greatest potential environmental impacts related to land surface, ranges, and wildlife under assumed uranium development levels in the San Juan Basin region. Appropriate actions, which are underway, could ease the effects considerably, however.

Sixty million tons of mill tailings, emitting low level radioactivity, are piled on the surface from a quarter century of milling. This total could grow to between 300 and 600 million tons by the mid-1990's with Moderate development and proportionately more with higher ore outputs. Waste rock from mines could exceed 100 million tons.

New regulations require burial of tailings beneath many feet of earth and provide for anti-erosion measures and stabilization of tailings and mine wastes. Underground disposal is favored where feasible. Federal-state actions to clean up abandoned tailings have been initiated under recent federal legislation.

Vast rangelands in the area are already badly eroded and overgrazed. They would be additionally affected only slightly by uranium activity.

The greatest impacts on wildlife would result from intrusions by increasing numbers of people and disruption of habitats. This will occur as the region's population grows, in any event, but would be exacerbated by added uranium development. Concerns over possible pollution of food chain and water sources warrant study.

Chapter VI

Other Impacts on the Natural Environment

TOPOGRAPHY

Existing Environment

The 27,000 square mile San Juan Basin region makes up more than 17 percent of the Colorado Plateau physiographic province (Map VI-1). The study area takes in about one-fifth of New Mexico and overlaps into the other Four Corners states.

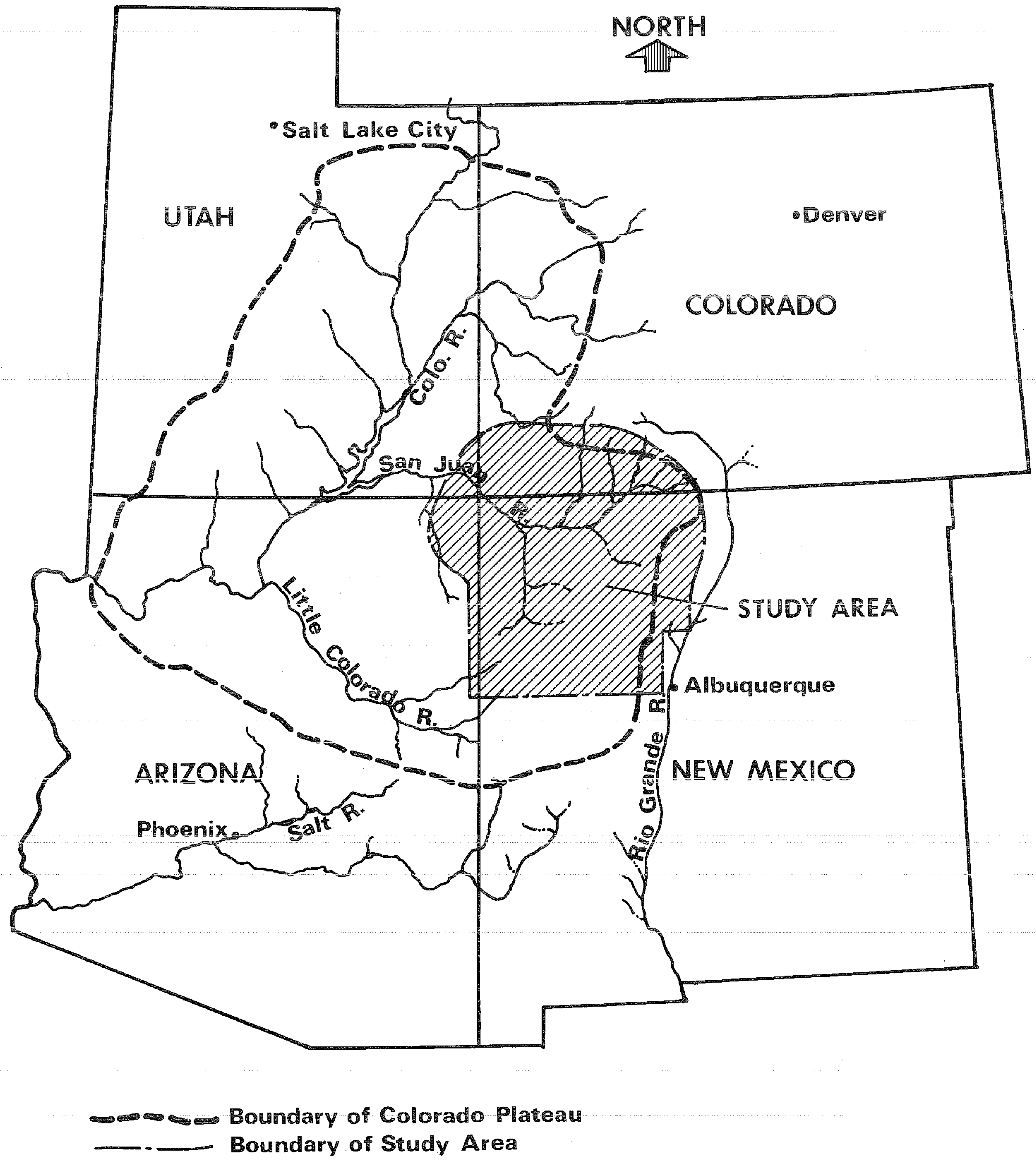
Basin Boundaries. The San Juan structural depression occupies about two-thirds of the uranium study area. It is one of several large basins interspersed among the ranges and chains of the Rocky Mountains. The San Juan Basin can be defined by abrupt boundaries such as uplifts in some areas, while in others it gradually merges with the rest of the Colorado Plateau (Map VI-2).

To the north, the structural basin is bounded by the igneous intrusions of the San Juan and La Plata Mountains of Colorado. To the northeast it is bounded by broad structural arches and to the east by the clearly defined Nacimiento Uplift and the Rio Grande Rift. To the south are the Zuni Uplift and high country generally paralleling Interstate Highway 40, while on the west the Defiance Uplift, Chuska Mountains, and other highlands limit the basin to the approximate vicinity of the New Mexico-Arizona boundary.

While the study area extends beyond the structural basin in several directions, from a geological standpoint, attention in the study necessarily centers primarily upon the parts of the region offering the more immediate uranium development prospects.

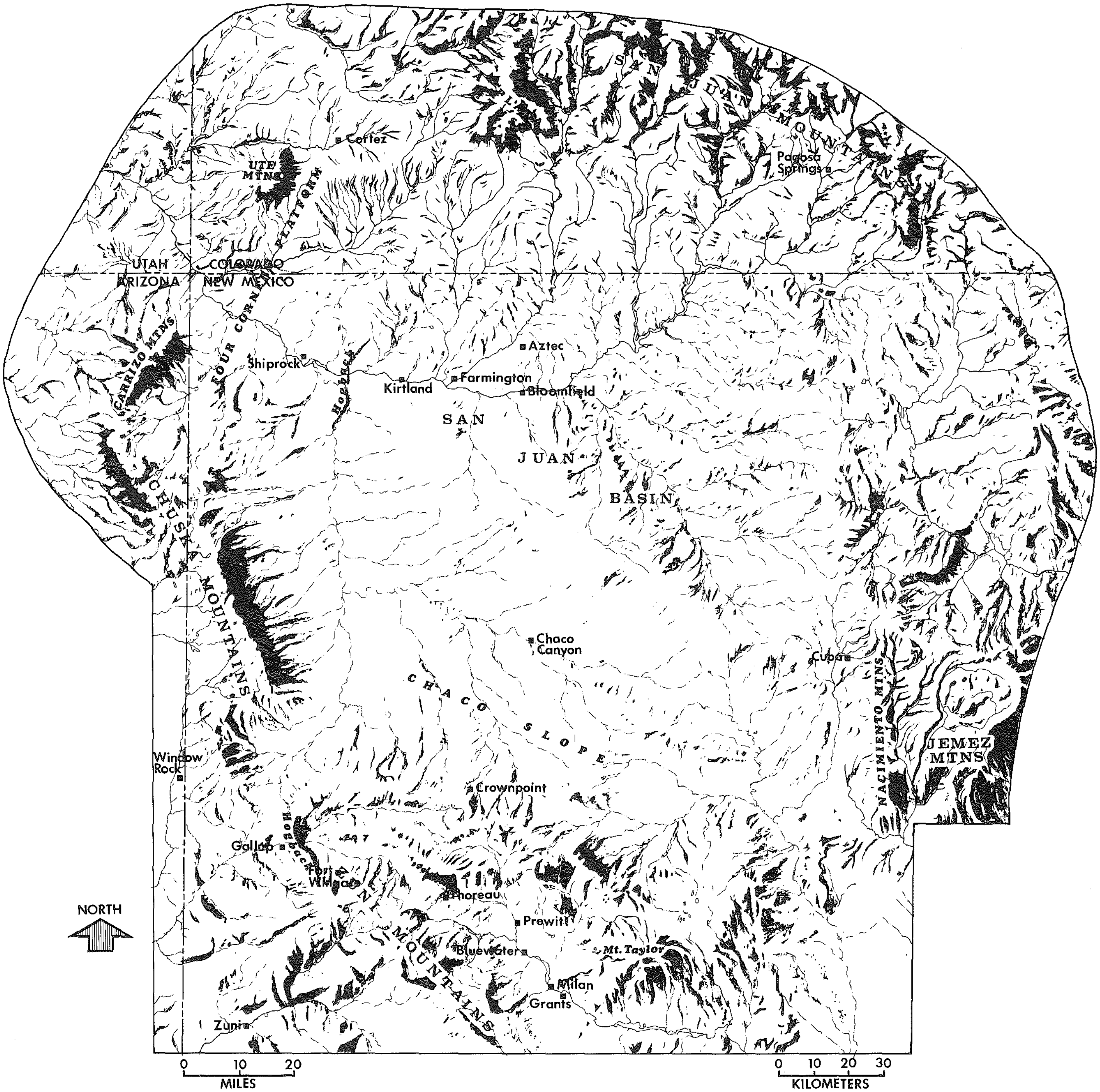
General Description. The visitor to the basin finds himself essentially surrounded by mountains or high plateaus (Map VI-2). The central part is gently dipping to flat, broken by a few buttes and shallow canyons or valleys (Gutierrez, 1978, No. 17; Ridgley, et al, 1978, No. 8).

Overlooking the Grants mineral belt is 11,389-foot-high Mount Taylor, a former volcanic center and sacred to the Navajo and Pueblo peoples. Uranium activity occurs to the north, east, and west of the peak. Another landmark is Shiprock, to the northwest. It rises 1,450 feet above the surrounding flatland and is indeed reminiscent of a ship and its wake. Dikes of black igneous rock radiate from its base (Figure III-2).



Colorado Plateau Province

Map VI-1



REGIONAL TOPOGRAPHY MAP

Map VI-2

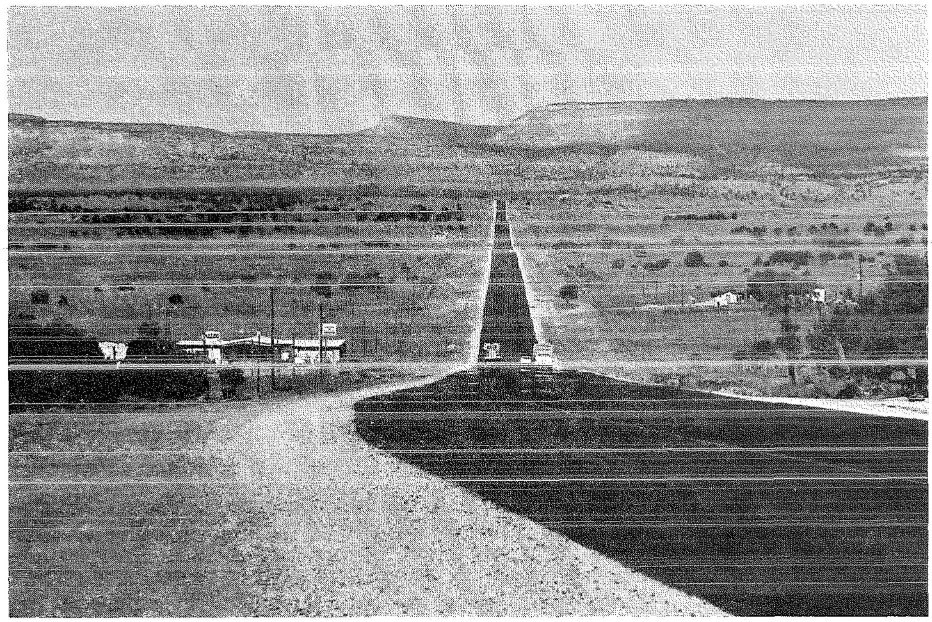


Figure VI-2.--General topography along State Route 57 outside Crownpoint

The Continental Divide runs northeasterly through the San Juan Basin, separating the two major watersheds of the region. Other topographic features include surface expressions of the Hogback, Defiance, and Nutria monoclines. (For geology see Chapter III.)

Erosion. Unstable soils and adverse topography create in many parts of the San Juan Basin region conditions that are sensitive to erosion in the form of headcutting. Headcuts and incised channel degradation are difficult to evaluate but can produce sediment yields several orders of magnitude greater than the rest of a drainage basin.

Flow in an active channel involving a headcut may reach its sediment carrying capacity in a relatively short distance, sometimes within the headcut itself. Then, as the slope of the channel decreases with distance downstream, the carrying capacity of the flow decreases and deposition occurs, further decreasing the slope and capacity. The downstream incised channel will fill with sediment and form a braided channel that widens into a swale with no defined channel as the headcut moves up the drainage basin. This type of sediment moves in steps and eventually reaches the major perennial stream. Because of the natural conditions in many areas, the sediment outflow and headcutting are in equilibrium in the region.

During the last half of the 19th century, ephemeral tributaries of the main streams started to deepen their channels quite rapidly. This arroyo trenching began along the Rio Puerco of the east and elsewhere in the vicinity northeast of Mount Taylor. Widespread erosion at an accelerated pace in the Navajo country started during the 1880's.

Investigators attribute the increased arroyo cutting to effects of man's activities including serious overgrazing by sheep, cattle, and horses, and to effects of rapid runoff from precipitation resulting from unstable weather or climatic conditions, particularly from violent thunderstorms (Cooley, 1978, No. 11). Only a few valleys or short reaches of drainages, mainly in the south-central part of the basin, have not been affected by arroyo trenching.

The most deeply carved channels are found along the southeastern edge of the basin between the Rio Puerco and Mesa Chivato to the east of Mount Taylor. One arroyo (Arroyo del Valley) reaches a depth of 60 feet, and the arroyo of the Rio Puerco is 50 feet deep at one point. Most arroyos in the southern part of the basin range between 15 and 25 feet in depth. Streams in these areas carry heavy sediment loads (Chapter V, "Sediment").

Only minor cutting of arroyos exists in lowlands of the Rio San Jose north and northwest of Grants and near Ambrosia Lake. The Ambrosia Lake area, in which much uranium mining has centered, is generally low in topographic relief and presents little evidence of erosion except along Puertocito Creek, a tributary of San Mateo Wash, which drains the area.

Erosion is discussed from a rangeland perspective under "Soils and Range."

Underground Mines. There are an unknown number of abandoned uranium mines in New Mexico. State witnesses at a congressional hearing estimated there might be 150. Many abandoned mines have unreclaimed ore storage areas and mine waste piles, and State investigators report finding open entries and vent holes at some. (New Mexico Energy and Minerals Department, 1978)

As noted in Chapter I, 37 mines were in operation as of April 1979. Surface manifestations of conventional underground uranium mining in the basin include a disturbed area that can currently exceed 300 acres including roads and contain such features as a headframe at each shaft, service buildings, a temporary ore storage site, a dump for barren rock removed in mine construction, water settling ponds, and employee parking. Power lines are common. (Mine waste is discussed further under the Moderate projection. For future mine assumptions, see Chapter II, "Mine Assumptions." For mining techniques in the region, see Chapter III.)

Subsidence. Underground uranium mining has produced subsidence, or collapse, in local areas near some mines in the San Juan Basin. Subsidence in this area occurs through settling or subsiding of ground into a void created underground by removal of rock and earth. The process is modified by the interaction of such factors as the width and depth of excavation, the characteristics and properties of the mineral deposit and overburden, the mining method, and the passage of time.

There are many unknowns concerning subsidence in the San Juan Basin. As noted later, however, the use of sand backfill to provide structural support in mined-out areas is credited with reducing or preventing subsidence at times. (See "Subsidence" under Moderate development.)

In at least two instances involving shallow mines, subsidence has reached and ruptured the surface. In neither case has this caused serious problems to date, because the land surface was undeveloped. In deep mines, subsidence has progressed upward into the overburden until halted by strong bridging strata. In some cases the upward progression of subsidence has reached and broken aquifers. The extent of damage to ground water quantity and quality caused by this rupturing of aquifers is unknown.

Seismicity. Seismic events known to have occurred in New Mexico have been primarily confined to the Rio Grande Rift zone, an area of rock fracture involving a displacement between adjoining walls. The Rio Grande Rift lies generally along the river's course to the east of the study area.

Files of the National Geophysical and Solar-Terrestrial Data Center show 40 significant earthquakes occurred within a radius of about 124 miles of Crownpoint from 1893 through 1974. All but one were associated with the Rio Grande Rift or with a fracture zone near the Colorado-New Mexico line in the vicinity of Dulce, New Mexico. The exception was an earthquake in 1973 with a magnitude of 4.4 on the Richter scale centered approximately 18 miles southeast of Crownpoint.* On January 4, 1976, an earthquake registering 4.4 was recorded with a center approximately 17 miles north by east of Crownpoint (latitude 35.9° N and longitude 108.2° W.).

Northwest New Mexico is considered an area of low seismic risk, but there is a need for further information. According to Algermissen and Perkins (1976), there is a 90 percent probability that ground motion from earthquakes will not exceed 8 percent g (acceleration of the earth's gravity) once in 50 years in the vicinity (U.S. Department of the Interior, Bureau of Land Management, 1979; Tennessee Valley Authority, 1979).

Surface Mining. Surface mining for uranium is in a category by itself in the study area. As recently as 1977, it is estimated, surface mining supplied approximately 44 percent of the basin's production of U_3O_8 in ore (Chapter II). Although precise figures are not released, for proprietary reasons, this was in line with estimates for other recent years. Nevertheless, this form of mining in the basin is on its way out. Just three of the 34 uranium mines active in New Mexico in 1978 extracted ore by surface mining methods (New Mexico Energy and Minerals Department, 1979).

The Jackpile-Paguate mine on Laguna Pueblo land (Figures III-10 and XI-1) has long ranked as one of the world's largest uranium open pit operations, now covering more than 2,700 acres of disturbed land. Two separate ore bodies exist. The Jackpile operation is about 1.5 miles long and more than 5 miles wide. The Paguate is 2 miles long and several hundred feet wide.

In its quarter-century of operation, this mine has excavated almost 200 million tons of overburden and mine waste. This is stored in 28 dump

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* On the Richter scale measuring the magnitude of a seismic disturbance by the energy dissipated, 4.5 indicates an earthquake that could cause slight damage in developed areas.

sites spread over more than 1,100 acres (U.S. Department of Energy, 1979a). The pit itself encompasses about 1,000 acres and in places approaches the 400-foot depth generally considered the maximum feasible depth for such operations.

The mine constitutes a lasting and locally visible scar on the largely barren landscape, with the grayish overburden clashing in color with the natural terrain. Topographic reclamation was not required in the past. A 1977 mining plan submitted by Anaconda to Laguna Pueblo was eventually deemed insufficient and another plan, dealing with reclamation and special studies, was worked on in 1980. The Jackpile's increasing underground operations generally enter from the pit level, so waste brought from underground is commonly stored nearby inside the surface mining pit. Portions of the pit probably will exist indefinitely in any event.

Mining in the San Juan Basin region is expected to switch entirely to underground methods, possibly supplemented by in situ mining where possible. The ore deposits within 400 feet of the surface that are deemed most economically feasible are largely depleted, and the Jackpile-Paguate is the only major surface operation remaining active. Even this mine is expected to phase out the open pit operation in the early 1980's (Chapter II, "Mine Operations Employment").

Uranium Mills. Four uranium mills operated in New Mexico in 1977. They increased to five by 1979, with three additional license applications pending (Tables VI-2 and VI-3). A mill may occupy 30 or 40 acres of industrialized area, ranging in some cases to 100 acres or more. Prominent evidence of the activity includes railroad facilities, power lines, machinery, conveyers, ore storage areas, chemical facilities, roads, and a tailings pond and heaped waste covering 200 to 500 acres. (For discussion of milling process, see Chapter III.)

Mill Tailings. Uranium development in the San Juan Basin region from the 1950's on produced approximately 60 million tons of mill tailings through 1977. They covered more than 1,000 acres. (Mill tailings comprise the waste after extraction of most of the uranium from the ore. For their makeup see "Major Man-induced Release Sources" in Chapter IV.)

As of December 1977, New Mexico contained five inactive mill tailings piles and five active ones. The inactive piles, left from mill operations that have been discontinued, cover 286 acres and contain an estimated 6,367,000 tons of tailings (Table VI-1). The active piles, at which milling continues; covered 720 acres and were estimated to contain more than 53 million tons of tailings at the end of 1977 (Table VI-2). From 1978 on, five mills with a total capacity of about 21,500 tons of ore daily added to the tailings steadily. They produced approximately 6.3 million tons of additional tailings in 1978 and were capable of yielding approximately 7 million tons (dry) of tailings annually. (New Mexico Energy and Minerals Department, 1980) The three tailings sites for which license applications are pending total 1,285 acres (Table VI-3).

Tailings can be expected to increase with uranium ore output barring important technological change. As lower grade uranium ores are processed,

Table VI-1

Inactive Tailings Piles in New Mexico

COMPANY	LOCATION	AREA ACRES	HEIGHT (FEET)	MILLION TONS TAILINGS	STATUS
Foote Mineral	Shiprock	26 46	14-40 15 average	1.7	Operated 1954-1968; partly stabilized
Homestake	Milan	48	NA	1.22	Operated 1958-1962; not stabilized
Phillips	Ambrosia Lake	91	3 to 33	2.68	Operated 1958-1963; not stabilized
Anaconda	Bluewater	24	NA	.58	Operated 1958-1963; partly stabilized
Anaconda	Bluewater	51	NA	.18	Partly stabilized
Total Inactive Piles		286		6.37	

Source: New Mexico Energy and Minerals Department, January 1979

Table VI-2

Active Tailings Piles in New Mexico (Dec. 1977)

COMPANY	LOCATION	POND (Acres)	DRY (Acres)	TOTAL AREA (Acres)	MAX. HEIGHT (Feet)	MILLION TONS TAILINGS	ESTIMATED RADIUM (Curies)
Kerr-McGee	Ambrosia Lake	70	195	265	100	23	12,850
United Nuclear-Homestake Partners	Milan	25	80	105	75	16.2	5,660
Anaconda	Bluewater	107	159	266	21	13.6	7,600
Sohio-Reserve	Seboyeta	38	22	60	35	.54	247
United Nuclear	Church Rock	18	6	24	8	.01	2.6
Total Active Piles		258	462	720		53.35	

Total Active & Inactive Piles: Area of Tailings 1,006 acres
Tailings 59.7 million tons

Source: New Mexico Energy and Minerals Department, January 1979

Table VI-3

Proposed Tailings Sites
(For which license applications have been received)*

COMPANY	LOCATION	AREA (Acres)	COMMENTS
Bokum	Marquez	315	Covers two major drainage areas, below grade, not completely lined.
Gulf	San Mateo	500	In somewhat of a natural basin, below grade, not completely lined, some fractures in area.
Phillips**	Nose Rock	470	Sands and slimes will be separated in two different above grade unlined disposal areas.
Total acres		1,285	

* Subject to possible revision during license approval.
** As of May 1980, not yet accepted for detailed review by New Mexico Environmental Improvement Division.

Source: New Mexico Energy and Minerals Department, January 1979.

the rate at which tailings are generated will rise accordingly. For example, if mill recovery remains the same, to obtain a given amount of U_3O_8 the waste or tailings is twice as much for ore containing 0.09% U_3O_8 as for 0.18% U_3O_8 ore.

Other Industrial Development. Mining and electric power generation constitute by far the most important role in the basin's current economic trends, though their land requirements are insignificant compared with those of the livestock industry.

Based on the total value of all mineral production, New Mexico as a whole is the eighth largest mineral producing state in the nation. The value of mineral production in the state rose in 1977 to a record $2.9 billion, an increase of 20.8 percent from 1976 and representing a solid growth after allowance for inflation. The San Juan Basin region played a major role in the state's performance.

The Navajo coal mine and its affiliated Four Corners generating station a few miles from Farmington comprise the world's largest contiguous coal mine and power generating complex, according to the mine owner and operator, Utah International, an affiliate of General Electric. The mine in 1977 controlled some 31,400 acres of land leased from the Navajos with estimated reserves of 1.1 billion tons of coal. The power plant burned about 7 million tons of coal per year to generate 2,085 megawatts of

electricity for a power grid taking in Los Angeles, Phoenix, Tucson, El Paso and Albuquerque (New Mexico Geological Society, 1977, p. 251).

The San Juan Generating Station, with a net capacity of 1,110 megawatts in 1980, is within 8 miles of the Four Corners plant. With a combined 1980 generating capacity of 3,195 megawatts, they represent the largest single concentration of coal-fired power generating facilities west of the Mississippi River. The complex was described in 1977 as exceeding the combined capacities of facilities at Hoover and Glen Canyon dams and as exceeding the hydrogenerating capacity of the Columbia River Grand Coulee system (Grant, 1977, p. 47).

Known resources in addition to uranium include the following, summarized mainly from a report by C.M. Molenaar (New Mexico Geological Society, 1977, p. 159 et seq.):

-Coal: The Fruitland Formation has been estimated to contain approximately 200 billion tons of coal in beds more than 2 feet thick at depths of as much as 4,500 feet. This formation contains by far the largest mineable coal reserves in the area.

Estimates of the quantities of strippable sub-bituminous coal contained in the Fruitland Formation range upward to approximately 4.5 billion tons (New Mexico Geological Society, 1977, p. 80). This figure was based on 150 feet as the maximum recovery depth and estimation of the coal outcrop area subject to mining by surface techniques. Fruitland coal is low in sulphur content. The Mesaverde group has been estimated to contain an additional 275 million tons of strippable coal.

Companies with a recent interest in the San Juan Basin's coal include Southern California Edison (Los Angeles); Arizona Public Service Company (Phoenix); Tucson Gas & Electric (Tucson); El Paso Gas & Electric (El Paso); Utah International (General Electric); Pittsburgh-Midway (Gulf); Hospah (Santa Fe Industries); Consolidation Coal; WESCO (Pacific Lighting Co., Los Angeles); El Paso Natural Gas; Texas Utilities; Salt River; Thermal Energy; Amcoal; and Carbon Coal.

-Natural Gas: The Blanco gas field is the nation's third largest gas field. It covers about 1,340,000 acres of the central San Juan Basin and is estimated capable of yielding an eventual 23 trillion cubic feet of gas, plus significant amounts of condensate. Among companies involved are Amoco, Cities Services Oil Co., Continental, Phillips, and Texaco.

-Oil: It has been estimated that about 150 million barrels of oil may ultimately be recovered in the San Juan Basin, based on exploration finds. However, at least one geologist has said the basin can be considered "wholly unexplored for deeper production." (Grant, 1977, p. 27). Most oil fields in the basin are small. The two largest are the Hogback and Rattlesnake, in the 5 to 7 million barrel per day production range and much larger than most of the others. Oil is produced from the Dakota Formation on the flanks of the basin. Oil, gas, and coal are the significant economic resources of the Upper Cretaceous rocks of the San Juan Basin area.

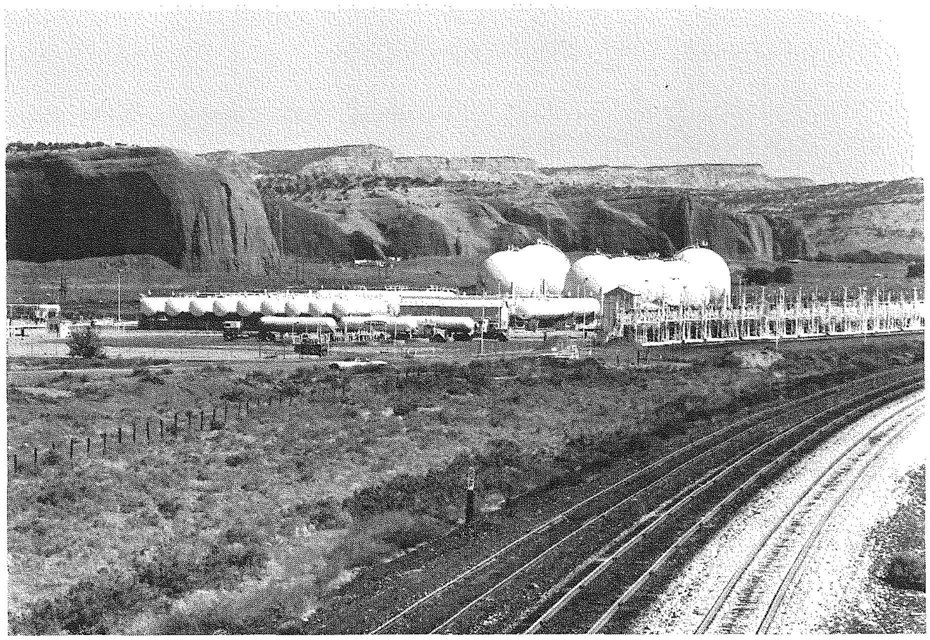

Figure VI-3.--Small natural gas storage depot in front of red rocks east of Gallup

-Humate: Humate, used mainly as a soil conditioner, has been found in huge amounts in the non-marine, marshy deposits of the Crevasse Canyon, Menefee and Fruitland formations in Cretaceous rocks. Now being strip mined in the La Ventana-San Ysidro areas on the southeast side of the basin, it is relatively new to the list of known economic resources in the study area. Production probably will depend on market development.

Topography without Further Uranium Development

Erosion. If uranium activity were gradually phased out on the basis of existing development and that under construction, erosion from water and wind would continue. Gullies would be extended on their upward end, in some cases carved deeper, and often widened as local conditions and events of nature dictated. On the other hand, some stream channels might aggrade, that is, tend to fill with eroded material.

Substantial quantities of sediment would continue to be transported by the Rio Puerco and the Chaco River, which in turn would unload their burden into the Rio Grande above Elephant Butte Reservoir or the San Juan above Lake Powell.

Some reduction in erosion might occur in specific localities with the gradual cessation of uranium mine dewatering and mill runoff. One place erosion would diminish, for example, is the tributary to the North Fork of the Puerco River a short distance below the Church Rock mine, northeast of Gallup. Downstream, the currently perennial Puerco River--both North Fork and main stem--might return to its pre-development ephemeral condition and resume degradation of its channel at least as far as Gallup. Other streams

which drain water pumped from uranium mines similarly would lose their water source as mining and milling tapered off.

Erosion also might lessen as development declines. Some existing exploration sites and development roads, however, would continue to concentrate runoff and cause minor gully erosion. Unless existing roads or mine sites were replanted or otherwise stabilized after falling into disuse, they would be subject to the heavy erosion processes common to the region. Every USGS approved mining plan contains requirements for reclamation, but the terms of the earlier plans and leases were more relaxed than they are in more recent approvals. Moreover, on private lands stringent controls do not exist. Therefore, erosion would vary from place to place (Cooley, 1978, No. 11).

Surface Mining. Because of the switch to underground mines in the region, surface-mining of uranium ore is not likely to figure prominently during most of the study period. The most significant topographic impacts already exist from the past. While the evidence of past activity will remain, it does not appear likely to be expanded appreciably, and some improvement may be expected from future reclamation efforts.

Mill Tailings. Abandoned tailings piles which have been highly visible due to their regularity in form and their heavily leached white-gray color should become much less conspicuous in time. This is because the Uranium Mill Tailings Radiation Control Act of 1978 designated authority for development of programs to reclaim abandoned tailings piles. The act also provided for regulation of the reclamation of currently active tailings ponds.

Unreclaimed tailings from current uranium operations, because they are larger, would tend to be more intrusive than the old piles. Without expanding uranium development, the active tailings would grow ever more slowly than at present.

Other Industrial Development. The surface mining of coal is scheduled to increase significantly in the basin. Although the number of large coal mines has been projected to increase sixfold to 19 by the early 1990's, actual coal development will depend on construction of rail facilities to serve the mines and on the time schedule for federal leasing now expected to expand in the early 1980's. Off the Navajo reservation an estimated 28,000 acres would be disturbed by coal-related development by 1990, assuming the growth to 19 mines in the time frame mentioned. Of this, about 18,000 acres of soils and native vegetation would be disturbed by stripmining operations or related activities.

The probable disturbed area on the reservation is more difficult to predict, but Consolidation Coal Company will mine about 22,260 acres by 2000. Utah International, the McKinley mine, and smaller operations will continue stripping at their present rate for the foreseeable future.

From the standpoint of land opened by tremendous excavations, total acreage mined is less important than the area disrupted at a given time. Reclamation to comply with federal and state regulations is conducted

concurrently with mining (Figure VI-4). More than 5,000 acres are expected to be reclaimed by 1990. The companies are committed to returning the disturbed terrain as closely to its original contours as is feasible.

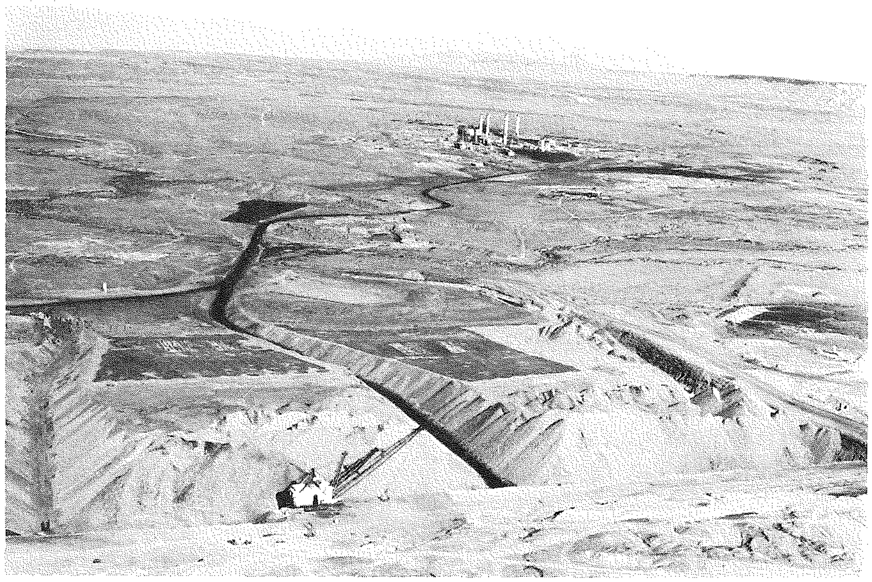

Figure VI-4.--Coal stripmining and reclamation near San Juan Generating Station

In practice this is only marginally successful in a land of buttes and ravines. In places where the rugged southwestern landscape unfolds with a primitive beauty, the land will be tamed, with gentle slopes replacing the vertical walls of picturesque cliffs and grassy swales appearing where once eroded washes wound. Whether this is detrimental or beneficial depends on the point of view.

Construction of the railroads would alter the topography of two narrow bands totalling more than 200 miles in length. Construction of the 230-kv power line would disturb about 310 acres, and construction of the power plants and gasification plant would alter about 6,000 acres.

Reestablishment of vegetation on disturbed areas would be difficult due to lack of moisture and disruption of soils. Successful reclamation is expected, however, where adequate plant growth medium and moisture are provided for. (U.S. Department of the Interior, Bureau of Land Management, 1979)

It should be noted that the assumption of a gradual winding down of uranium activity in a region that supplies half of the nation's U_3O_8 carries with it the premise of reducing future reliance on nuclear electric generating plants. From a national standpoint, the main energy alternative during the study period appears to be coal. Hence, appreciable cutbacks in uranium mining and milling might well mean still higher coal production nationally.

Whether this national increase would necessarily be reflected in a significant rise in coal production within the study area--perhaps meaning the difference between moderate and high coal mining levels with corresponding impacts upon the environment--cannot be predicted with any certainty. Increased need for coal could be met from many other areas of the country, both east and west, and transportation costs, labor supply, and specific market demand and cost factors would influence events.

Current policy indicates moderate levels of both coal and uranium production in the San Juan Basin region. If a change in national policy were considered that might lead to a wind-down in uranium accompanied by escalation to high coal development, the question of environmental trade-offs involved would present legitimate questions deserving careful study. At that point, which is completely hypothetical at this time, the San Juan Basin would certainly fall among the areas rich in both coal and uranium that would require examination.

While uranium-versus-coal aspects were not specifically addressed in this regional study, one recent comparative study analyzed cost-benefit ratios of uranium and coal from an economic standpoint which took into account environmental factors in economic terms (Sandquist, 1980).

"The overall benefit-cost ratio for coal is 14 ± 4 while that for uranium is 66 ± 17," the report concluded. "Thus, from this analysis, for the western states, the net economic advantage of uranium over coal (i.e. the ratio of the benefit-cost ratio of uranium-to-coal) is about a factor of 5."

In other words, this particular study indicated that in the West uranium was almost five times as advantageous to produce as coal, from the vantage point studied.

Alternative scenarios that might require study, for example, could be the net impacts from moderate uranium development relying upon underground mining, on one hand, as compared with net impacts from high coal development relying mostly on strip mining, on the other. Such related factors as the milling of uranium and the potential construction of coal gasification plants, additional mine-mouth power generating plants, and slurry lines would enter the picture. From the broader perspective, the comparative impacts of nuclear and coal-fueled generating plants would introduce still other factors.

Topography with Moderate Uranium Development

Summary. Topographical impacts from Moderate-level uranium production would be minimal compared with the vastness of the San Juan Basin region. They could be locally severe, however.

Impacts would result mainly from mining and milling. They would stem largely from the necessity of handling large amounts of rock and other waste materials in order to obtain comparatively small amounts of uranium. Disposal of the waste would constitute the most conspicuous impact upon the

land surface from the new production. (Table IV-10 shows the numbers of mines and mills assumed at various time intervals for analysis purposes.)

Among the predictable topographical impacts from uranium activity of this scope would be:

1) Buildup of tailings piles near mills and of waste excavation from mines.

2) Excavation of tailings ponds at mills.

3) Subsidence in some mined areas, during mining operations or after abandonment.

4) Increased erosion, at least temporarily, from runoff of water pumped from mines.

5) Intrusions upon the landscape due to construction of mines or mills in scenic areas.

With future mining expected to be predominantly underground, topographical impacts that may be anticipated from Moderate development are suggested in the following compilation (Gutierrez, 1978, No. 17):

Inputs	Activities	Impacts
Roads	Blading, removal of material	Increased erosion (localized).
Drill Sites	Excavation of mudpits.	Mudpits (depressions).
Mines	Local regrading, mine dewatering and barren rock waste removal.	Possible subsidence. Potential erosion, leaching of pollutants, scenic effects.
Mills	Tailings pond excavation, tailings pile construction.	Activities are topographic impacts.
Settlements	Roads, general development.	Increased erosion, removal and fill of material.

Erosion. Some increased erosion from the water pumped from mines and permitted to flow down arroyos would occur in certain areas. The impacts of exploration and development roads upon topography could be locally severe at points where these surfaces concentrate runoff and cause gully erosion.

In general, however, uranium activities have had slight--and mostly localized—effects on erosion and associated sedimentation in the Grants mineral belt. This trend would continue. The possibility of collapse of

tailings pond walls would present a potential problem, especially where steep slopes and stream channels were involved.

Mine Waste. The principal waste products of both open pit and underground mining are overburden (barren rock) and low grade material. Overburden to ore ratios for excavated material from open pit operations range from 8:1 to 35:1. Waste rock from underground mines is reported to range upward from 1/20 of the total ore production (U.S. Department of Energy, 1979a).

With mines assumed to increase both in number and individual capacity, the quantities of overburden and waste rock excavated to permit access to deposits would greatly increase over the present. This waste would thus tend to accumulate near mine sites in greater quantities than under lower production levels.

The amount of waste removed in construction of uranium mines would vary with the size and depth of mine and geological conditions at the site. Kerr-McGee estimated, for example, that approximately 370,000 tons of barren waste rock would be excavated for its Rio Puerco mine. The estimate involved waste from a shaft 14 feet in diameter and 850 feet deep and from horizontal development headings (New Mexico Energy and Minerals Department, 1979). That depth is common among active mines in the basin, with some mines ranging both above and below that level.

However, of seven new mines under development six were scheduled to be deeper, with four of them at least twice as deep. Some could have more than one shaft (Table I-2). Furthermore, more than half of the additional 25 mines considered probable if market conditions warrant (Table I-3) would be sunk to at least twice the 850 foot depth of the Rio Puerco mine.

Among mines under development, as reported by the New Mexico Energy and Minerals Department, the following suggest the variations and range of possible mine waste. Pioneer Nuclear Inc. estimated waste dump requirements for 450,000 tons of waste from its 2,450 foot deep Narrow Canyon mine. Kerr-McGee's Church Rock II mine, planned for a 2,300 foot depth, was expected to yield 761,000 tons of waste. The Dalton Pass project of United Nuclear-TVA, scheduled to become one of the largest uranium recovery operations in the basin, might remove 20 million tons of waste rock from a possible five shafts and their headings. Each shaft was scheduled to be 18 feet in diameter and approximately 2,200 feet deep.

A New Mexico official told a 1978 congressional hearing that mining of the state's $50 uranium ore reserves could yield nearly 110 million tons of mine wastes (New Mexico Energy and Minerals Department, 1978). This would exceed one million cubic feet. Methods used to reduce or eliminate adverse impacts on the topography are cited under "Mitigation of Topographic Problems."

Subsidence. As uranium mining increased, the possibility of subsidence over exhausted mine workings would continue to require attention. The extent of subsidence would be influenced to a considerable extent by mining techniques, including the use of backfill to provide support after

ore removal. (See "Mitigation of Topographic Problems.") The most likely problem involving new mines ranging to depths of one-half mile or more would appear to be rupturing of overlying aquifers where progressive upward subsidence occurred.

The science of rock mechanics is not sufficiently advanced to permit calculating the amount and extent of future subsidence over underground excavations in the study area. Nor do mining methods and conditions allow engineers to predict subsidence by using techniques developed by the National Coal Board (NCB) of Great Britain based upon study of more than 150 underground coal mines.

The NCB method evolved from mines with long room-and-pillar and long-wall panels--mostly the latter--that have reasonably uniform widths and heights. This is uncommon in mining of the irregularly shaped uranium ore deposits of the San Juan Basin. Further restricting the application of the British method is the likely difference in structural properties of rock strata in the San Juan Basin.

A number of variable factors contribute to the difficulty of predicting subsidence. Worldwide, sites judged sound by engineers and geologists have subsided, sometimes catastrophically, after a few years or decades. Subsidence has developed as much as a century after mining was completed.

In deep uranium mines in the study area, subsidence is considered unlikely to progress to the surface in most instances. It could, as stated above, penetrate far enough into the overburden to crack aquifers between the surface and the mine depths. In most areas the only aquifer involved would be the Dakota. The Gallup is separated from the uranium-bearing Morrison Formation by more than 1,000 feet of Mancos Shale. Wherever fracturing of aquifers and the rock layers between them occurred, it would greatly increase vertical permeability, possibly permitting mingling of waters from two or more aquifers with possible contamination of good water. Subsidence from uranium mining could affect any nearby producing oil and gas wells and could damage small areas of overlying hydrocarbon zones through fracturing or contamination of the reservoirs.

However, the need to prevent mine flooding in itself makes preventive backfill measures a necessity in some cases.

Mill Tailings. The most visible topographical impact with Moderate uranium development would probably be the buildup of future tailings piles. Over the 20 to 30 year life of a mill, each tailings area could cover from 200 acres to as much as 500 acres in the case of large operations.

Because of the extremely small quantity of uranium contained in the ore, essentially all of the ore milled becomes tailings (Figures IV-1 and IV-5). Ore grade is declining, requiring removal of more ore to produce a given quantity of U_3O_8. Thus, assuming the Moderate level of production, the quantities of tailings would rise on two counts: due to the reduction in ore grade, which requires that more ore be mined, and to meet the assumed increases in U_3O_8 demand.

It should be noted that new methods of tailings disposal not used in the area in the past should significantly affect the net surface disturbance over the long run. (See "Mitigation of Topographic Problems.")

The possible scope of tailings volume may be approximated from several standpoints, all of which indicate accumulation of several times as much tailings volume as has been discarded by the basin's mills to date. For example, the Moderate assumption calls for cumulative production of approximately 400,000 tons of U_3O_8 (Table II-3). Future mines in the basin are assumed to yield ore averaging 0.14 percent uranium (Chapter II, "Mine Assumptions"). This grade would result in approximately 285 million tons of tailings.

Or, on an annual basis, the assumed possible fourfold rise in U_3O_8 output could increase tailings output from the recent 6-plus million ton per year rate to approximately 26 million tons per year by 2000. This figure could be expected to be increased further in proportion to any additional drop in ore grade that develops.

From another perspective, 10 mills are assumed to be operating in the mid-1980's, each with an average daily capacity of 5,000 tons of ore (Chapter II, "Mill Assumptions"). At capacity, perhaps processing ore mined outside as well as inside the basin, they could yield more than 16 million tons of tailings annually. From the mid-1980's to 2000, these tailings could approach 240 million tons, four times the volume of tailings built up in the basin from the beginning of uranium production through 1977. Assuming that the number of mills grew to 15 by 2000, the annual tailings buildup would exceed 24 million tons.

This combination could produce tailings in the vicinity of 300 million tons, taking into account approximately 30 million tons of new tailings the first half of the 1980's and the possible 240 million tons resulting from 10 mills' operations for about 15 years. These tailings would be dispersed at almost four times as many locations as in 1977.

Mine capacity offers another vantage point. For example, the proposed new Mobil Oil-TVA underground mine near Crownpoint, one of the deeper mines considered likely to become more common with time, is expected to produce 312,000 tons of ore annually by the early 1980's. To all practical purposes, the tailings would grow at about the same rate. If the 38 mines projected for 1985 under Moderate development were to perform at a comparable level, mill tailings could accumulate at close to 12 million tons annually--more than twice the 1977 rate. The possible tailings from ore produced by those mines alone would exceed 177 million tons over a 15-year period, say from 1985 to 2000.

Other mines would gradually come on stream and would total 72 by 2000. These could be expected to swell to beyond 20 million tons annually the ore output destined for eventual discard as mill tailings. From the standpoint of mine ore production, then, new tailings of 300 million tons or more by 2000 would not be surprising, assuming the Moderate development level.

These figures, rough because of the many uncertainties involved, all point toward approximately 300 million tons or more of additional tailings under the Moderate development assumption. Though this would mean production of five times as much mill waste in the next 20 years as resulted from the past 30 years of uranium milling, the estimates do not appear out of line when compared with those from the U.S. Department of Energy and the State of New Mexico.

For example, the DOE expects the approximately 140 million tons of uranium mill tailings now existing in the United States to increase to as much as 750 million tons by the year 2000 (U.S. Department of Energy, 1979a, p. 53). If the San Juan Basin were to account for 40 to 45 percent of the total, its share would range from 300 million to 340 million tons. Or, if the basin's average uranium ore grade should drop as low as the 0.09 percent figure projected in recent DOE studies, the study area could turn out well over 400 million tons of additional tailings by 2000, unless demand falls.

A report by the New Mexico Energy and Minerals Department states that if all $50 forward cost ore reserves are exploited, they will result in an additional 547 million tons of tailings (New Mexico Energy and Minerals Department, 1979). As noted in Chapter II, New Mexico's $50 reserves may be depleted shortly after the end of the century. Production would not end with those reserves, however.

To recapitulate, Moderate uranium development might yield from 300 million to more than 500 million tons of mill tailings at up to 15 mill sites in the San Juan Basin region by 2000. Ore grade would figure significantly. The total would be five to nine times as much tonnage as the tailings produced by uranium milling in the area to date. Three hundred million tons of waste could cover a 275-acre site 30 feet deep at each of 15 mills. The 4,100 plus acres covered would comprise 0.024 percent of the study area or one-tenth of one percent of the overall impact area (Map II-5).

If tailings heaps were permitted to accumulate unreclaimed in the future as they did in the past, their volume and color would constitute significant local intrusions upon the natural landscape. However, new requirements for burial, intended largely to protect against longterm low-level radiation, should make an appreciable difference from a topographic--and therefore an aesthetic--standpoint, as well. (See "Mitigation of Topographic Problems.")

It should be noted that one effect of in situ leaching, at any site where it proves feasible, is virtual elimination of tailings output and related problems.

Other Industrial Development. Topographic aspects of non-uranium developments would probably be little influenced directly by Moderate uranium development, although some conflicts would be possible. (See "Possible Conflicts with Other Resources" section.) Indirectly, the rate of uranium development might affect non-uranium development topographically to the extent that greater quantities of coal were stripmined to fuel

coal-fired power plants called upon to meet the increased electrical consumption demands of the uranium industry.

Topography with High Uranium Development

Uranium development at the assumed High level would result in topographical impacts generally along the lines outlined for the Moderate case but more pronounced in some instances. It should be reiterated that the High scenario appears quite unlikely, though not impossible, at this time. (For assumed numbers of mines and mills in various periods, see Table IV-21.)

Erosion. Erosion potential would increase to some extent with greatly increased pumping of water from the more numerous and deeper mines (Chapter V). Much more exploration also could be anticipated, with an increase in the chances for locally severe erosion from exploration and development roads or offroad trails. Also increased in proportion to the stepped-up activity would be the possibility of collapse of tailings pond walls and subsequent erosion or deposition.

Mine Waste. Quantities of waste from uranium mines would probably be at least half again as plentiful under the assumed High production schedule as under the Moderate one, due to increased numbers of new and larger mines. Not only would the rock heaps be larger in many cases than at present, but they would appear at more than three times as many locations. The State's estimate of almost 110 million tons of waste rock from shafts and headings excavations with depletion of $50 ore reserves might be reached several years earlier than under the Moderate projection, perhaps by 1991. Impacts cited under the Moderate assumption could range as much as 90 percent higher with High production.

Subsidence. The High level of uranium production would increase the opportunities for subsidence that might fracture aquifers as increased numbers of mines penetrated the greater depths which will be required to reach many future ore deposits in the basin. However, the qualifying factors cited for the Moderate level would continue to apply here. Contamination of aquifers through resulting inter-aquifer connections could adversely affect ground water quality in the vicinity over an extended period.

Because many new mines are expected to be much deeper than existing mines, the likelihood of subsidence affecting the surface should be little greater with High production than at present. Nevertheless, the potential for eventual subsidence, possibly after many years, would remain. (See "Mitigation of Topographic Problems.")

Mill Tailings. The High level of uranium mining and milling assumed for the study area would greatly accelerate the accumulation of tailings from milling. This scale of development would mean increasing the output of U_3O_8 in ore by approximately 97 percent over that of the Moderate level. A comparable rise in ore production could yield tailings of more than 550 million tons if ore grade remained fairly constant. This would be 10 times the current accumulation, or more. The High assumption would mean probable

depletion of the $50 ore reserves--with State-estimated tailings possibly totaling 547 million tons--by the early 1990's. Depletion by 1991, for example, at this rate would require an average yield of approximately 50 million tons of tailings per year, nine times the present annual tailings growth. If average ore grade fell to 0.09 percent with this volume of U_3O_8 output, tailings could exceed 800 million tons. It should be reiterated that the High assumption appears quite improbable within the study period, although a few years ago this was not necessarily the case.

Other Industrial Development. High uranium development would require increased electric generating capacity. This in turn would increase the quantities of coal stripmined to stoke the power plants, with corresponding impacts on the topography.

Uranium development at the High level could encourage some additional industrial development as the population and labor force grew. Demands for other fuels such as diesel and natural gas, for both the uranium industry's use and for use by the increased population and industry, also could be expected to grow. Many variables and unpredictable factors, including national economic and political aspects, preclude projections with any assurance of accuracy, but topographical impacts of additional surface development could be locally severe.

Mitigation of Topographic Problems

The prevention or reduction of adverse impacts, from the topographic standpoint as well as others, ideally is built into a mining or milling project from the beginning. Both mitigating provisions and reclamation requirements are provided for in mining plans and mill licensing procedures. They also may be accommodated in connection with surface and mineral leases, as well as under any environmental procedures that may apply on specific sites under federal or state laws. Frequently, such provisions cut more than one way and accomplish two or more environmental preservation purposes simultaneously.

Mine Waste, Subsidence, and Erosion. Mining and reclamation plans sometimes provide that waste rock from the mines will be located, to the extent possible, in a way that will prevent erosion and water runoff leaching of pollutants. It may be specified that, when feasible, waste piles will be placed on leeward slopes and away from natural drainages.

For certain underground uranium mines, it may prove advantageous to return some of the waste rock into the mined-out depths as backfill. Among those for which this possibility has been considered are the Dalton Pass and Narrow Canyon mines.

Many underground uranium mines in the basin have used or considered using sand as a backfill in depleted areas to prevent cave-ins and aquifer disruption. In the deeper mines expected for the future, this back-filling in many cases may be deemed a necessity to prevent mine flooding that would result if subsidence fractured the strata between the mine and overlying water-bearing formations. Some type of permanent support is generally

required where a risk of potential aquifer interference is determined to exist.

Mine wastes left on the surface are often required to be leveled or contoured to blend into the surrounding terrain. They are then covered with several inches of topsoil and planted with selected native plants. On Indian lands, mine waste piles must be reclaimed.

Recent legislation by which the State of New Mexico assumed water rights jurisdiction over mine water put to beneficial use may provide economic incentives for mining companies to find uses for mine water formerly permitted to flow down arroyos. (See Chapter V, "Ground Water" under Moderate scenario.) In time, this could have the side-effect of reducing possibilities for erosion as the runoff flows dwindled.

Mill Tailings. The NRC at present requires: 1) mill tailings dams with water-tight clay cores to be constructed in natural basins using native materials, 2) return of the tailings to the mine, or 3) placement of the tailings below grade in a lined, water-impermeable pit (U.S. Department of Energy, 1979a). Two of the three pending mill site license applications in the basin were changed, after their initial submittal, to provide for below grade tailings disposal (Table VI-3). The large proposed Gulf mill planned to use about 50 percent of the solid tailings, in the form of coarse sands, as mine backfill.

The Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) [PL 95-604, 92 Stat. 3021 (1978)] is intended to provide for 1) clean-up of abandoned uranium milling sites that once operated under federal contract and 2) stricter regulation of uranium and thorium tailings and waste. Steps have begun toward a remedial program, 90 percent financed by the federal government, to clean up the abandoned tailings. The actions must meet standards established by the Environmental Protection Agency and are to be carried out with the concurrence and consultation of the Nuclear Regulatory Commission.

The act requires reclamation and government ownership of tailings and their disposal site once the milling operations are terminated and empowers the NRC to require financial surety of the mill licensee to assure reclamation of sites where milling has ceased and to assure longterm surveillance and, if necessary, maintenance of the tailings and disposal site. The act was later amended to provide, among other things, that states operating under agreement status with the NRC should comply with UMTRCA requirements concerning environmental assessments of uranium mill licensing actions by November 1981. (U.S. Nuclear Regulatory Commission, personal communication, 1980) Emphasis is placed on below grade disposal of tailings in mines or pits, where feasible, in recent requirements. Regulations to take effect in late 1980 also require at least three meters of earth over tailings piles. (For additional discussion of tailings, see "Mitigation of Air Quality Problems" in Chapter IV. The UMTRCA also is discussed in Chapter XII.)

Reclamation. Locally some sites would never return to exactly the same shape or condition that existed before uranium development started.

However, reclamation could return the surface to nearly the original contours, and possibly improve upon them. As stated in a representative EIS, "the objective will be to leave the surface site in a condition similar to that existing prior to mining." (Tennessee Valley Authority, 1978)

The quality of reclamation performed after exploration or mining depends upon the ownership of the land surface. It may also vary to some extent with the degree of enforcement. For tribal, allotted Indian, acquired public lands, and National Forest land, an exploration plan must be approved by the appropriate surface managing agency or agencies, or the agency can put reclamation stipulations into the mineral lease. Either course would serve to return the land to its former use. Exploration holes would be plugged, mud pits filled, and the drill pad area graded, raked, and/or seeded to replace vegetation. Roads to the drill site would be graded and reseeded, except for roads the surface owner wished to retain. When exploration of an area leads to mining, frequently only the drill holes are plugged and reclamation of drill hole pads and roads is deferred until mining is completed.

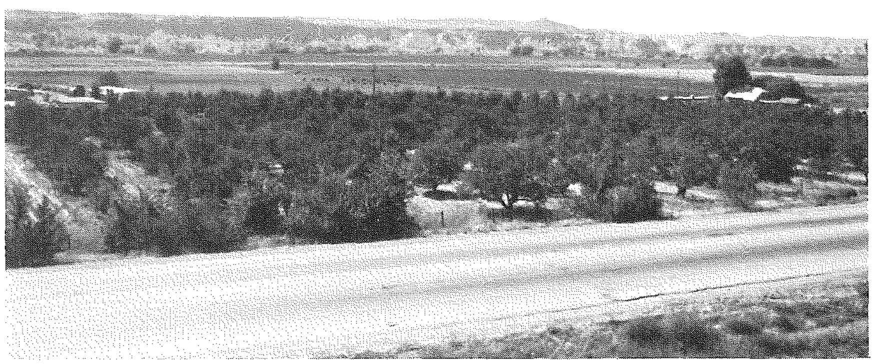

Figure VI-5.--Irrigated farmlands of San Juan River valley

In addition to state engineer requirements for plugging of holes, for public domain or state lands there are a number of mechanisms under Navajo, state, and federal law which govern mining and reclamation practices or which could be used to prevent abandonment of unreclaimed lands. Among these, for example, are water quality control laws, hazardous waste disposal laws, and federal land-use policies. (Chart XI-1 in pocket) On private land, the surface owner negotiates any desired reclamation efforts with the company seeking exploration and/or mining rights on the land.

On tribal, Indian allotted, National Forest, and acquired public lands, a mining and reclamation plan must be approved by the U.S.

Geological Survey and surface owners, as well as by various other government agencies, before mining occurs. The plans normally require that upon abandonment all surface structures not desired by the surface owners be removed, shafts or openings sealed, and disturbed areas contoured, graded, raked and reseeded. Reclaimed areas may be fenced off until vegetation is reestablished. Open pits may be partially backfilled and highwalls eliminated or fenced off.

On private land, reclamation procedures are stipulated with the surface owner when the mining lease is set up. On state land specifications usually require that shafts or other openings be sealed and highwalls fenced off. However, enforcement is difficult because state law provides no penalties for noncompliance. No other laws cover reclamation of uranium mines on state land. There are also no laws requiring reclamation of uranium mines on the public domain.

In Situ Leaching. As noted elsewhere the in situ leaching technique in itself can constitute a major mitigation--or avoidance--of adverse impacts in those localities where conditions make it feasible. From the land surface standpoint, the in situ process eliminates mine waste, drastically reduces mill waste, and greatly minimizes subsidence potential. The potential for contribution to erosion also is significantly reduced in the absence of a need for mine dewatering and large tailings ponds.

SOILS AND RANGE

Existing Environment

Overview. The San Juan Basin is situated in the Colorado Plateau and Rocky Mountain ecological regions. The soils and vegetation are characteristic of those developed in the semiarid continental climate of the area, with limited Great Plains influence on vegetation. Shales and sandstones which dominate the region give rise to large areas of sandy soils and clay soils. Other geological variations produce a corresponding variety of soil types. Differing elevations result in varying climatic influences on soils and vegetation (Maps VI-3 and VI-4).

Vegetation in the study area ranges from grasses and sagebrush--largely replaced by irrigated farmlands in the San Juan River valley--to pinon* and pigmy juniper at intermediate elevations. Pine, fir, and spruce forests are found at higher elevations. (Vegetation also is discussed under Wildlife.)

Overgrazing has severely altered most of the lower elevation vegetation and has influenced nearly all rangelands of the basin. Serious erosion and adverse vegetation changes have resulted.

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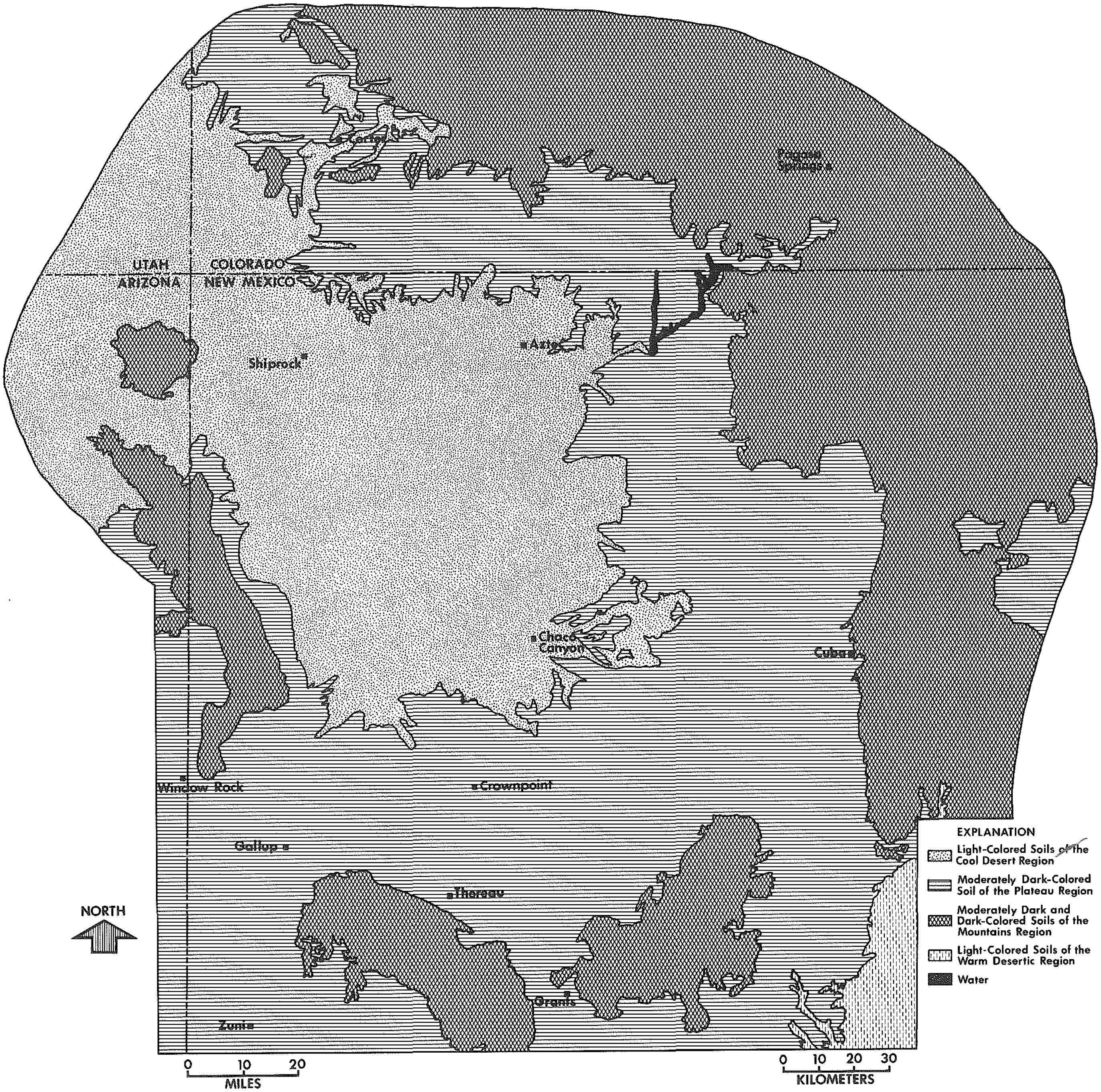
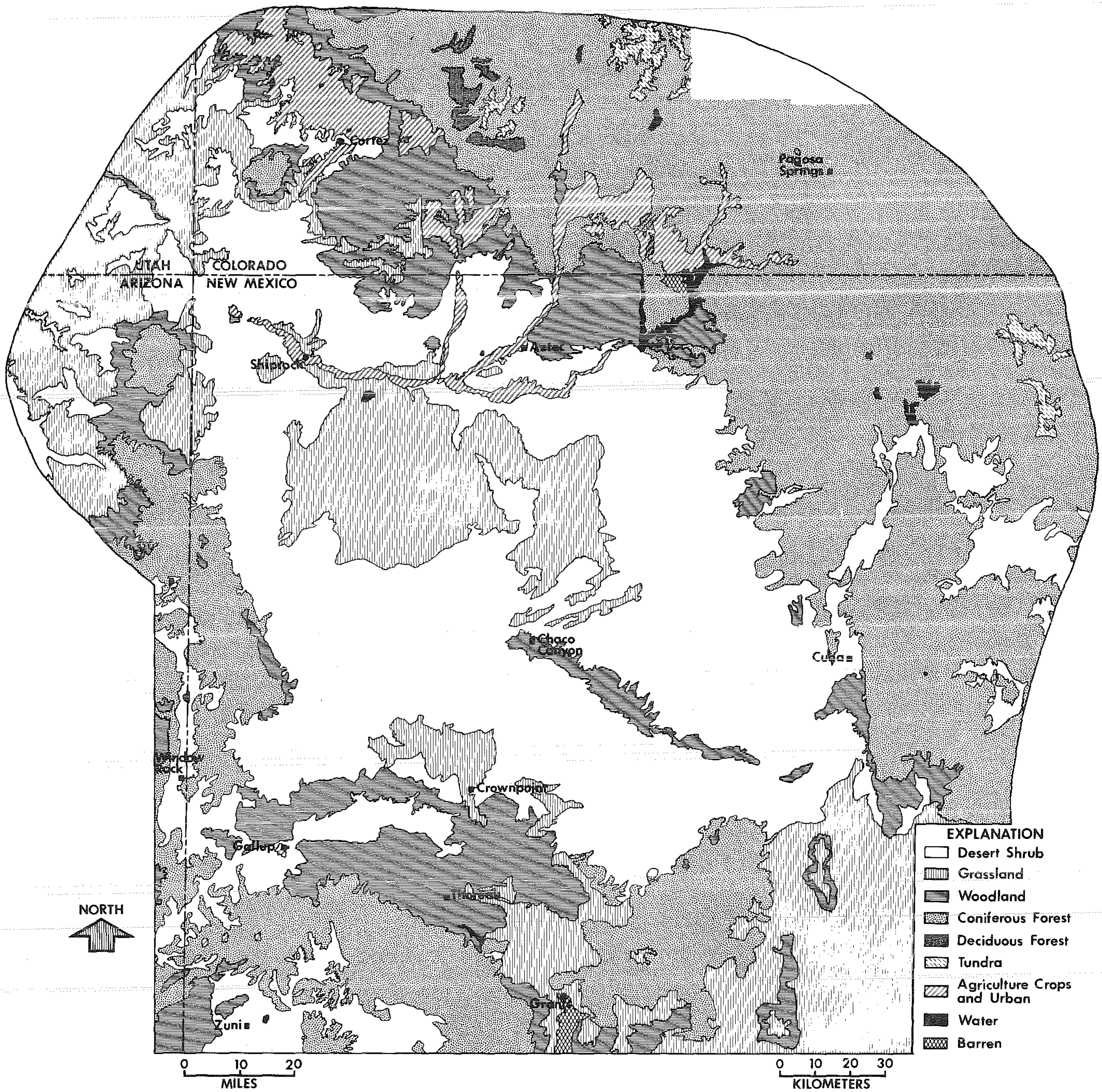
*Pinon, frequently printed with a tilde over the first "n" to denote the Spanish pronunciation similar to that in Senor, also appears in the anglicized form as pinyon. Accent falls on the second syllable in either case.



SOILS MAP

Map VI-3



VEGETATION MAP

Map VI-4

Several woody species have increased as the more desirable herbaceous species were overgrazed. Large areas of sagebrush, oak, and pinon-juniper are largely the result of uncontrolled grazing. Large gullies in many of the valleys and sheet erosion found throughout the area also can result from overgrazing. Erosion occurs when the protecting plants are disturbed, leaving the denuded soils exposed to water and wind.

In a report prepared for this study, a consultant stated:

> The resources of the rangelands of the San Juan Basin, including soils and vegetation, support a large number of subsistence livestock operations. Although the impact of these subsistence operations on the economy of the region is minimal (Gray, 1974), changes in the resource base will affect the individual livestock owners.
>
> There is a great deal of concern that any activity in the fragile ecosystems of the semiarid rangelands, which comprise most of the basin area, will result in irreparable damage to the land-vegetation system. For most of the area, that concern comes too late. The resources throughout the region have been overgrazed for generations, altering the vegetation and eroding the soil. Only a few isolated tracts of land in the San Juan Basin have vegetation which is near climax. Large quantities of soil have been lost due to surface and gully erosion which has taken place over at least the past hundred years (Rangeland Resources International, 1978).

<u>Production by Vegetation Units</u>. Natural vegetation in the San Juan Basin may be divided into six major categories in addition to categories for agriculture, water, and barren lands. The percentage and acreage estimates in Table VI-4 are approximations based on available information.

Carrying capacities in acres per animal unit (AU)* are estimated as shown in Table VI-5. Stocking rates have generally been much higher than carrying capacities, resulting in the deteriorated range conditions existing throughout the area.

<u>Vegetation Dynamics</u>. This description of vegetation dynamics was excerpted from a report by Rangeland Resources International.

Plant species composition evolves over time until a balance between plant requirements and the environment has been reached. This succession begins with pioneer plants which are the first to occupy bare soil. These are generally annual plants which can tolerate the harsh conditions. Many of the less desirable forage species fall into this category.

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*An animal unit or AU here is the equivalent of one mature cow and her calf or five head of sheep and lambs for one year.

Table VI-4
Vegetative Distribution in San Juan Basin

Vegetation	Percent of Area	Millions of Acres
Desert Shrub	30	4.8
Grassland	13	2.0
Woodland	20	3.2
Coniferous Forest	22	3.5
Deciduous Forest	5	0.8
Alpine Tundra	3	0.5
Agricultural Crops & Urban	7	1.1
Water	Trace	---
Barren	Trace	---
	100%	15.9

Source: Rangeland Resources International, 1978.

Table VI-5

Livestock Carrying Capacity by Vegetative Areas

Vegetation	Average Range Capacity in Acres/AU	Total AU's
Desert Shrub	110	44,000
Grassland	80	25,000
Woodland	130	25,000
Coniferous Forest	150	23,000
Deciduous Forest	70	11,000
Alpine Tundra	60	8,000
		136,000

Source: Rangeland Resources International, 1978.

After the initial establishment of plants on a bare soil area, the environment becomes somewhat modified, allowing other plants to succeed the pioneer plant community. This succession process continues until the plant species reach an equilibrium with the environment, forming a climax plant community which will continue to perpetuate itself until there is an outside force which destroys the equilibrium.

Overgrazing is one such disturbing factor. As plants are excessively grazed, an insufficient amount of photosynthetic surface is left to maintain the vigor and carbohydrate reserves. Plant individuals decrease in size or die without being replaced by other individuals of the same species. Unoccupied soil is then open for invasion by species which are

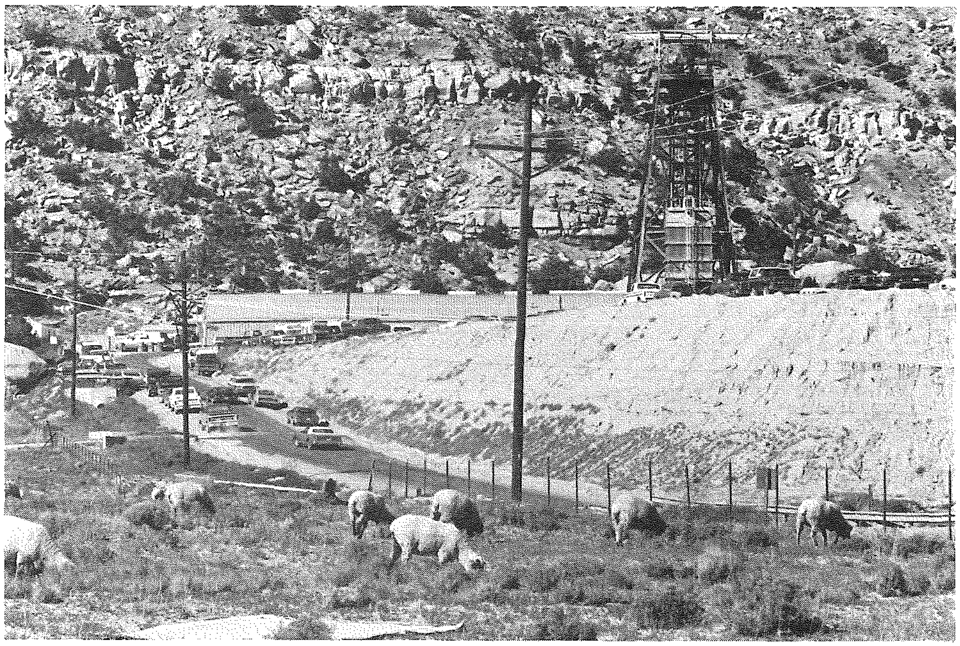


Figure VI-6.--Grazing in shadow of uranium mine surface facilities near Church Rock

not palatable, thus not affected by the disturbing factor, the grazing livestock.

Less desirable plants then tend to increase so the plant community becomes somewhat lower on the successional scale than climax. When the disturbance totally removes or covers existing vegetation, vegetation must completely reinvade the site.

In the San Juan Basin, the majority of the area is far below climax with plant communities mainly composed of plant species which are unpalatable, poisonous, or armed, or which can otherwise withstand the pressures of grazing. These plant communities are far lower in production of livestock and wildlife forage than are those at or near climax. Many of the plant communities are very responsive to management and can rather quickly be restored to a much higher level of production.

Endangered and Threatened Species. Three species of plants which have been proposed for federal listing as endangered species are found in the study area. They are Sclerocactus mesa-verdae, identified in northwest San Juan County, N.M., and southwest Montezuma County, Colo.; Pediocactus knowltonii, recorded only along the Los Pinos River south of the Colorado line in San Juan County, New Mexico; and Erigeron rhizomatus, a perennial forb known only near Fort Wingate in McKinley County, N.M. (Table VI-6).

The following plants have been listed as extremely rare in the area and of questionable status though not officially ruled endangered: Aquilegia micrantha var. mancosana, Astragalus accumbens, Astragalus deterior, Astragalus humillimus, Astragalus naturitensis, Astragalus schmollae,

Atriplex pleiantha, Lesquerella pruinosa, Pediocactus papyracanthus, Petalostemum scariosum, and Stellaria irriqua (Rangeland Resources International, 1978, No. 9 and Whitford and Spellenberg, 1978).

Acreage of Uranium Development. Uranium mining and milling directly involve a small acreage in relation to the total area of the region. Active mines and mills, including the roads they required, in 1977 occupied possibly 13,000 acres, less than five-hundredths of one percent of the San Juan Basin region. The Jackpile-Paguate with its widespread workings accounted for more than 20 percent of the total.

With rangeland in the uranium area considered capable of supporting about 8 animal units per square mile, uranium mining and milling could directly eliminate forage for about 165 AU's. This is equal to about one-tenth of one percent of the study area's estimated current carrying capacity of 136,000 AU's.

Uranium mining and milling may also affect grazing in another way. If land becomes contaminated with radionuclides, or if stream beds become contaminated, a decision may be made to prevent grazing in specific areas. In such an event, perhaps after a tailings dam break, domestic animals may not be permitted to drink from selected sources. (Chapters IV and V discuss some of these impacts.)

Soils and Range without Further Uranium Development

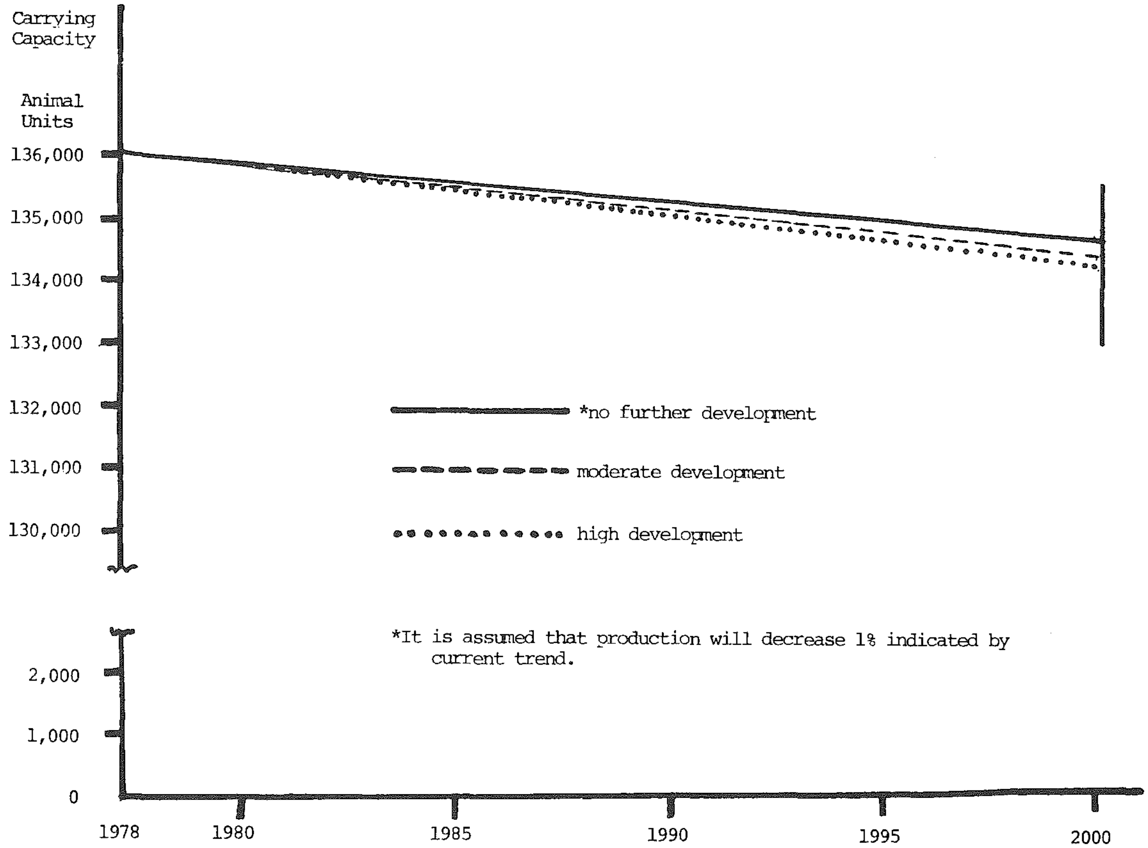
As noted earlier, heavy overgrazing for generations has drastically curtailed the carrying capacity of much of the range. Productive vegetation has been replaced by plants shunned by livestock, and erosion and gullying are widespread and on the increase. Corrective steps now in the making could work a slow improvement where applied.

However, the current reduced carrying capacity is expected to decline further regardless of uranium activities. As shown in Figure VI-7, without any further uranium development the drop in carrying capacity is expected to amount to one percent, reducing the total to about 134,640 AU's by 2000.

The Navajo Indian Irrigation Project will turn 110,000 acres of previously low capacity rangeland to productive use by 2000. Approximately four-fifths of the acreage involved is grassland, the rest being covered by sagebrush. Irrigated crops will be raised on all but a small part of the completed project, with the rest devoted to management and support facilities.

At the same time, current trends indicate that a large percentage of non-Indian irrigated farm land in the San Juan River valley will be retired from agriculture. Both the lands and their water rights will be converted to various urban and industrial uses. This transition is in progress at present and is expected to continue.

Surface mining of coal is expected to affect the soils and vegetation on about 60,000 acres by 2000. Efforts to reclaim the mined land are to be made. The BLM said that research and experience indicated successful



Source: Rangeland Resources International, 1978. (Revised from 1978, No. 9)

Figure VI-7.--Change in animal carrying capacity due to uranium development in San Juan Basin

reclamation of surface-mined coal areas could be achieved "where mining and reclamation plans provide for placing adequate quantities of plant growth medium (topsoil if available) over the graded spoils and assuring sufficient quantities of moisture for emergence and establishment of seeded species." (U.S. Department of the Interior, 1979, Bureau of Land Management)

Tests are in progress concerning the ability of range in this dry climate to sustain new growth. If the tests prove successful, range conditions are expected to undergo gradual improvement on national resource lands as a result of grazing management practices currently being put into use throughout much of the West by the BLM.

These measures would not affect Indian lands, which also have experienced serious damage from overgrazing. However, the BIA and the Navajo tribe have proposed similar management measures on Indian lands. (Note the discussion of erosion in the Topography section.)

Figure VI-8.--Part of the Navajo Indian Irrigation Project

Soils and Range with Moderate Uranium Development

Uranium activities of the scale projected here would have minor effects on the overtaxed soils and range of the San Juan Basin region as a whole, upon which this report focuses, but localized impacts could be severe (Figure VI-7).

The greatest potential impact in this regard would be increased soil erosion where drilling or construction occurred in erosion-prone locations. Prudent site selection and common preventive techniques could minimize this problem.

Acreage of Uranium Development. The area future uranium mines and mills would occupy would vary from site to site with the terrain and the size and type of operation. The acreage involved in Moderate uranium development thus would be determined on a site-specific basis. Exploration activities would be localized, of brief duration, and insignificant in the overall picture assuming proper management.

Rough calculations based on uranium output projections and mine-mill assumptions indicate that mines and mills could occupy approximately 21,000 to 24,000 acres in 1990 and 30,000 to 34,000 acres in 2000. The upper figure, which assumes the larger mill area (Chapter II, "Mill Assumptions") was applied in measuring potential animal unit effects that follow.

Moderate development could eliminate grazing from land capable of supporting up to 300 AU's in 1990 and 425 AU's in 2000. Since the approximate 13,000 acres occupied in 1977 withdraw approximately 165 AU's from potential grazing use, Moderate uranium activity would mean a possible reduction by 2000 of an additional 260 AU's beyond the present uranium-related graz-

ing impact. By 2000, range capacity could be reduced directly by three-tenths of one percent below the level expected if no further uranium development were to occur, or to approximately 134,215 AU's. The total acreage involved would be about one-tenth of one percent of the study area.

It should be noted that, while the acreage affected would be quite small overall, the impact from a grazing standpoint could be severe on any individuals or families directly affected. There would be offsetting compensation, however. (See "Mitigation of Soils and Range Problems.")

Contaminants. The study team feels additional studies on the effects of radionuclides on biota are needed. Divergent opinions have been expressed concerning the pathways by which radionuclides enter the bodies of animals or humans and the potential effects. More data are needed on radionuclides in bone, liver, and kidney of domestic animals, for the purpose of assessing the complete exposure to the human pathway.

A recent study by Argonne National Laboratory (Holtzman, et al, 1979) yielded preliminary results indicating that some contamination of the food chain in uranium producing areas is possible but that the degree of contamination would probably be small. The study, focusing on mill tailings, involved a literature search and use of existing research data. It is continuing.

Studies at Los Alamos Scientific Laboratories (Hanson and Miera, 1977) indicated that even near the point of impact of an atomic explosion, although the soil contained substantial increases in uranium particles, forage plants had no appreciable uptake of radioactive material. These studies found that small mammals living in the immediate area had no more than normal background radiation in the carcasses. According to the Hanson and Miera findings, livestock grazing occasionally in such an area, as would be the case with range animals, would be exposed to little more than background radiation and only for short time periods.

The selenium indicators are poisonous to livestock even in their natural habitat (Dreesen et al, 1978). Because of the unpalatable nature of these plants, livestock will not graze these toxic species unless the range is seriously overgrazed, limiting more palatable species' availability. Some of the metals which are present include selenium, lead, mercury and arsenic. Specific plants in the area that could accumulate these toxic materials are Prince's plume (Stanleya pinnatta), Loco weeds (Astragalus spp.), Crazy weed (Oxytropis lambertii), Tansy mustard (Descurainia pinnata), and Woody aster (Aster spp.) (Rangeland Resources, 1978). (Also see "Uranium Activities" section under Wildlife concerning tailings and vegetation.)

Some authorities believe local streams could possibly become contaminated, raising the problem of possible direct ingestion by humans and animals.

An experiment for this study in growing vegetables (tomatoes, carrots, radishes, lettuce, eggplant, and squash) with neutralized and diluted mill pond acid indicated that the plants did not absorb significant levels of

heavy metals and radioisotopes. These tests also indicated that the mill pond acid water is too saline to be used directly as irrigation water and may contain too much ammonia. However, when diluted and neutralized it may be suitable for irrigation.

Additional testing under controlled scientific conditions to determine the agricultural utility of mill pond waste water is needed (Kunkler, 1979). (See additional discussion under Wildlife and in Chapter V under "Water Quality" and "Surface Water," Moderate development.)

Soils and Range with High Uranium Development

Under the High rate of uranium development, mines and mills would occupy approximately 33,000 to 37,000 acres in 1990 and 43,000 to 48,000 acres in 2000. This could mean direct loss of potential forage totalling up to 465 AU's in 1990 and 600 AU's in 2000 (Figure VI-7).

By 2000 the maximum development could eliminate grazing for approximately 435 more animal units than were directly affected by uranium activity in 1977. This would equal less than one-half of one percent of present grazing capacity. An unknown additional area might be lost temporarily to grazing due to potential pollution by radioactive windblown particulates.

A further increase in the possibility of soil erosion would occur under the higher uranium development, but careful selection of mine and mill sites and ordinary prevention measures could minimize this problem. Other possible impacts would be basically similar to those expected with Moderate development, though somewhat greater in extent.

Mitigation of Soils and Range Problems

Recent leases on tribal and allotted lands contain strict provisions for reclamation of the land when exploration and mining cease. As stated under Topography, after the exploration rigs move on the drill holes must be plugged, the mud pits filled, and the area graded and reseeded. Abandoned roads also must be graded level and reseeded. For abandoned mine sites, structures are removed, topsoil placed, and the area reseeded. The leases have not stipulated the amount of water to be supplied or the length of time that irrigation must continue; they do specify "successful reclamation."

On public domain, private lands, and state lands, mine reclamation has not been defined.

All mill licenses now contain reclamation requirements upon completion of milling. (See references to UMTRCA under "Mitigation of Topographic Problems.") The fill required over tailings ponds and reseeding methods are described in Geomet, 1978, No. 26. At the mill sites, structures must be removed, contaminated soil buried in the tailings pond, and the area reseeded. Vegetation growing on reclaimed tailings or mine wastes can contain elevated levels of radionuclides and toxic materials unless proper

measures are taken. Buildings constructed on such land may also be subject to elevated levels of radon progeny.

Grazing should be restricted in reseeded areas for up to a decade, providing extra protection against wind and water erosion. Special attention should be given, at specific sites, to assessment of radiological factors and the possible need for longterm restrictive measures on grazing or human use.

The effects of loss of grazing land due to uranium development are often relieved through compensation of the owners for the use of their land by such means as royalty agreements, lease fees, or relocation to another area. Such compensation may not always overcome the pangs from interruption with ancestral home, heritage, and lifestyle, however. In the case of lands owned by the Navajo tribe, there have been contentions that the tribe, rather than affected land occupants, has been the beneficiary of such compensation.

WILDLIFE

Existing Environment

The San Juan Basin region provides habitat for a variety of wildlife, some considered rare or endangered. An overview of the vegetative environment is provided under "Soils and Range."

Habitats. Wildlife species vary with habitats in the uranium study area as elsewhere. Much of the region falls into the grassland/desert shrub classification (Map VI-4 and Tables VI-4 and VI-5). In these areas, soils are typically sandy and large barren areas are common. Much has been severely overgrazed by livestock; such areas have low to negligible wildlife value. Blue grama and galleta are the most important grasses of this habitat type. Indian ricegrass, bottlebrush squirreltail, ring muhly, sand dropseed and alkali sacaton are common. Aster, pingue, globemallow, Rocky Mountain beeweed and Russian thistle are common forbs. Important shrubs include fourwing saltbush, broom snakeweed, and rubber rabbitbrush. Big sagebrush dominates a large portion of the north-central part of the study area.

Pinon pine-juniper woodlands occur throughout northwest New Mexico at elevations of 5,000 to 7,500 feet. Ponderosa pine forests can be found at elevations of 7,000 to 9,500 feet, with stands of spruce and fir occurring at elevations of 8,500 to 12,000 feet. Alpine tundra are found above timberline in the mountains to the north.

Riparian habitat exists in the limited areas where surface water is present.

Mammals. Ninety-nine species of mammals have been identified in the San Juan Basin region. They include 44 species of native rodents, 16 species of bats, and 7 lagomorphs (rabbit-related species).

Coyotes are the most common carnivores in the area, particularly in the grassland/desert shrub habitat. Badgers and bobcats are equally widespread but fewer in number. Black bears and mountain lions are present in the forests and broken country.

The mule deer is the most widely distributed and most common big game animal in the study area (Map VI-5). These deer can be found in all habitats and at all elevations but are most numerous in ponderosa pine and pinon-juniper areas. Heaviest concentrations are in the Chuska Mountains, which support more than 90 percent of the deer on the Navajo reservation, and in the north central part of the study area between Farmington and the eastern boundary of the Jicarilla Apache reservation.

Elk are typically found in high mountain meadows and woodlands of the ponderosa pine and mixed conifer types, and in the alpine tundra. The elk migrate to lower elevations during the winter. Between 1,700 and 2,000 elk inhabit the Colorado portion of the region. The Mount Taylor herd is estimated at 60 to 80 head.

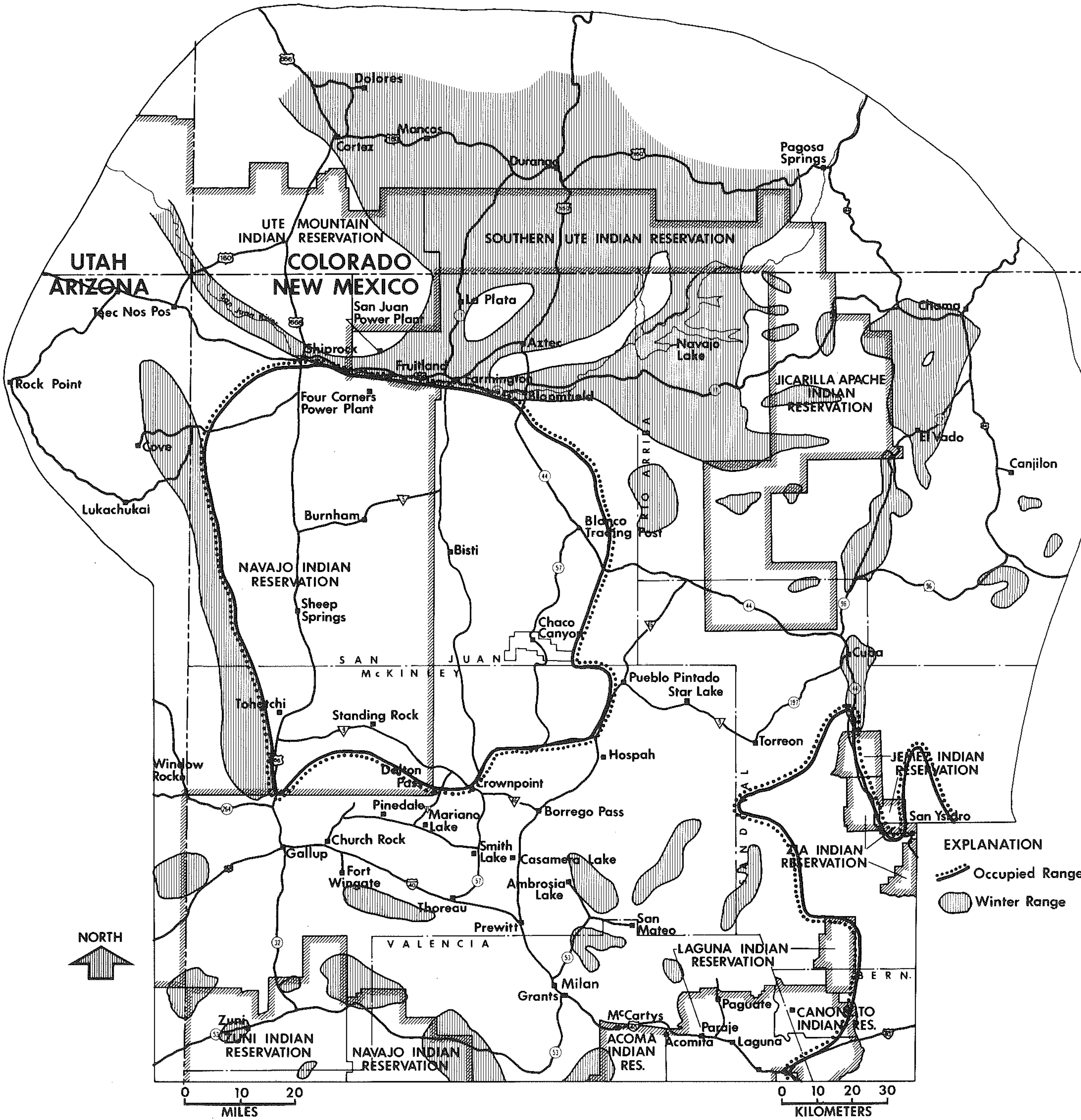
Approximate ranges of elk, as well as pronghorn, are shown on Map VI-6. In addition to the areas indicated, the Animas Valley to the north, south, and west of Durango, Colo., also provides winter elk range (Colorado Division of Wildlife, personal communication, 1980).

Other hoofed animals found in the region include the pronghorn, bighorn sheep, and Barbary sheep. Whitetail deer and tahr, a goatlike animal, have been reported to exist in the area but without verification to date. Feral (wild) horses can be found on the Navajo and Jicarilla Apache reservations and in the Jicarilla district of the Carson National Forest.

Birds. The region is thought to support 311 species of birds representing 17 taxonomic orders. Of these, 198 species or nearly two-thirds depend in some way upon riparian (surface water) habitat. Ninety-three species are directly dependent on it for survival and reproduction. The grassland/desert shrub community supports 96 of the bird species using the study area, with 23 of these restricted to this habitat.

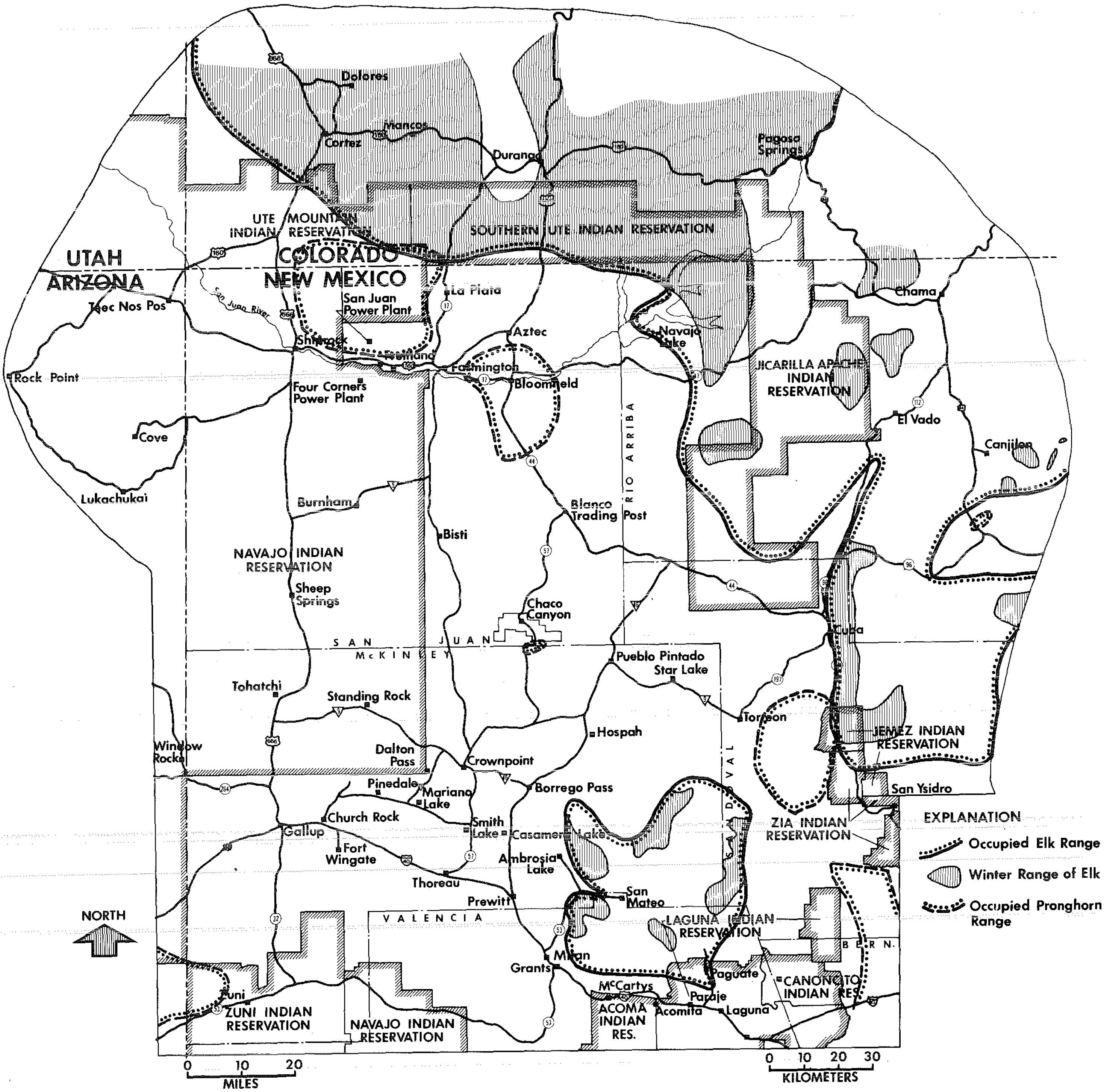
While the pinon-juniper areas support 135 species of birds, only 8 depend completely upon such habitat. The ponderosa pine areas support 105 species, but just 7 are restricted to them for survival and reproduction. Of 71 bird species using the mixed conifer habitat, one relies totally upon it. The alpine tundra supports at least 13 species of birds, of which one is totally dependent upon this vegetation type.

More than one-fifth of the species known to appear in the San Juan Basin region are considered year-around residents, the others visiting the area on a migratory or occasional basis. Permanent residents include the great blue heron, golden eagle, roadrunner, red-winged blackbird, wild turkey, and several species each of hawks, ducks, owls, woodpeckers, and finches. Among those that breed in the region is the blue grouse. The mourning dove, which provides the largest annual harvest of any game bird in the area, is a year-around resident. (A complete inventory of birds and habitats is provided in Schemnitz et al, 1979, No. 43.)



MULE DEER RANGE

Map VI-5



PRONGHORN AND ELK RANGE

Map VI-6

Fish. Fifty species of fish occur within the study area. Of these, 16 are native to the region. The San Juan River, second largest tributary of the upper Colorado River, contains a variety of fish, both native and introduced. Navajo Dam, about 15 miles northeast of Blanco, N.M., regulates the volume of river flow for approximately 180 miles downstream.

The San Juan is a rather large, complex and sensitive river ecosystem. Much of the aquatic fauna is dependent on the natural enrichment of the soil and water of the watershed. Because of good growth rates achieved by trout in recent years, a section of the river below Navajo Dam has been designated "Quality Trophy Fishing Water." In this 2.75 mile section fishermen are restricted to artificial lures and flies, with a 15-inch minimum size limit and a four trout daily bag limit.

Various fish species also are found in the Animas River to the north and in such other waters as Rio Chama, Dolores River, and the Heron, El Vado and Abiquiu reservoirs. Navajo Reservoir is the largest sports fishing lake. Bluewater Lake near Grants is a popular fishing water.

Endangered and Threatened Species. A survey of wildlife in the region identified 24 species of animal life as endangered. They include 4 mammals, 11 birds, and 6 fishes. Five species are on the federal endangered list of "any species which is in danger of extinction throughout all or a significant portion of its range."

These are the black-footed ferret, bald eagle, peregrine falcon, whooping crane, and Colorado squawfish. The humpback sucker and the blueblack silverspot butterfly are proposed for federal listing as threatened, a category warranting a lower level of protection than accorded those species considered endangered.

Endangered or threatened species are shown in Table VI-6. Endangered and threatened species are identified by the federal government or by the states of New Mexico, Colorado, Arizona, or Utah as warranting protection. The black-footed ferret is assumed to be almost totally dependent upon prairie dogs for food and upon their burrows for shelter. There have been no recent confirmed sightings of the black-footed ferret in the study area, but potential habitat exists on the Ute Mountain Ute, Navajo, and Zuni reservations, and in the Mount Taylor area.

The marten is known, in the study area, only from the San Juan Mountains and generally is associated with mesic Engelmann spruce/subalpine fir communities more than 100 years old with a canopy cover greater than 30 percent.

The mink is found in various habitats, seldom far from permanent water. In the region the mink has been recorded in the San Juan and upper Rio Grande drainages and in the Colorado portions of the Animas, Florida, Pine, Navajo, and Piedra Rivers. Little is known about the spotted bat. It has never been very common; specific habitat requirements such as the location of sedimentary cliffs in relation to water and food habits may be limiting factors.

Table VI-6

Endangered and Threatened Wildlife and Plants in San Juan Basin Region

Common Name	Scientific Name	Status[1]
Black-footed Ferret	*Mustela nigripes*	Federal endangered, NM endangered (Group I), Colorado endangered, Arizona endangered (Group II), Utah endangered
Marten	*Martes americana*	NM endangered (Group II)
Mink	*Mustela vison energumenos*	NM endangered (Group II)
Spotted Bat	*Euderma maculata*	Arizona endangered (Group III)
Bald Eagle	*Haliaeetus leucocephalus*	Federal endangered, NM endangered (Group I), Arizona endangered (Group II), Utah endangered
Peregrine Falcon	*Falco peregrinus anatum*	Federal endangered, NM endangered (Group I), Colorado endangered, Arizona endangered (Group II), Utah endangered
Whooping Crane	*Grus americana*	Federal endangered, NM endangered (Group I), Colorado endangered
Mississippi Kite	*Ictinia mississippiensis*	NM endangered (Group II), Arizona endangered (Group IV)
Zone-tailed Hawk	*Buteo albonotatus*	NM endangered (Group II), Arizona endangered (Group III)
Osprey	*Pandion haliaetus carolinensis*	NM endangered (Group II), Arizona endangered (Group III)
Sage Grouse	*Centrocercus urophasianus*	NM endangered (Group I)
Red-headed Woodpecker	*Melanerpes erythrocephalus caurinus*	NM endangered (Group II)
Buff-breasted Flycatcher	*Empidonax fulvifrons pygmaeus*	NM endangered (Group I), Arizona endangered (Group IV)
Baird Sparrow	*Ammodramus bairdii*	NM endangered (Group II)
White Pelican	*Pelecanus erythrorhynchos*	Colorado threatened
Jemez Mountains Salamander	*Plethodon neomexicanus*	NM endangered (Group II)
Boreal Toad	*Bufo boreas boreas*	NM endangered (Group II)
Colorado Squawfish	*Ptychocheilus lucius*	Federal endangered, NM endangered (Group I), Colorado endangered, Arizona endangered (Group II), Utah endangered
Humpback Sucker	*Xyrauchen texanus*	Proposed Federal threatened, Colorado threatened, Arizona endangered (Group III), Utah threatened
Zuni Mountain Sucker	*Catostomus (Pantosteus) discobolus yarrowi*	NM endangered (Group II)
Bonytail Chub	*Gila elegans*	NM endangered (Group I), Colorado endangered, Arizona endangered (Group II), Utah endangered
Roundtail Chub	*Gila robusta robusta*	NM endangered (Group II)
Colorado River Cutthroat Trout	*Salmo clarki pleuriticus*	Colorado threatened
Blue-black Silverspot Butterfly	*Speyeria nokomis nictocris*	Proposed federal threatened
	Sclerocactus mesa-verde	Proposed federal endangered
	Pediocactus knowltonii	Proposed federal endangered
	Erigeron rhizomatus	Proposed federal endangered

1/ The Endangered Species Act of 1973 (P.L. 93-205) establishes two groups of protected wildlife and plant species: federal endangered---"any species which is in danger of extinction throughout all or a significant portion of its range," and federal threatened---"any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." The New Mexico Wildlife Conservation Act of 1974 focuses on wildlife population within the state and classes as Group I those species whose prospects of survival or recruitment within the state are endangered and as Group II those species whose prospects may become in jeopardy in the foreseeable future. The Arizona Game and Fish Commission in 1978 defined four groups for endangered wildlife: Group I, species known or suspected to be extinct in Arizona though existing elsewhere; Groups II and III, corresponding closely to the federal "endangered" and "threatened" categories, respectively; Group IV, species in no less jeopardy than those in Group III but of interest mainly due to limited distribution. Utah and Colorado endangered and threatened categories are similar to the federal groupings.

Source: Schemnitz, et al, 1979, No. 43.

The bald eagle is water-oriented and seems to be widespread and locally common during winter and migration, especially along major streams and reservoirs such as the San Juan River, Navajo Dam, and El Vado Lake. During migration bald eagles also inhabit the Colorado streams cited above for the mink. The peregrine falcon also favors areas near permanent water and has been sighted on the Zuni and Ute Mountain Ute reservations and in the San Juan River and Chaco Canyon areas. In Colorado active nesting occurs at Perins Peak west of Durango and in the Chimney Rock area.

Whooping cranes may pass through the eastern part of the region while migrating along the Rio Grande Valley. Preferred habitat of the Mississippi kite is lowland riparian woodland and planted groves. Vagrants of this species occur in the San Juan Valley.

The zone-tailed hawk can occasionally be found in the Jemez Mountains, inhabiting pinon-juniper, ponderosa pine, and riparian communities. The osprey lives on fish and has been observed as a migrant in the San Juan Valley and at Navajo Dam, the Chuska Lakes, and Morgan Lake. An annual active osprey nest is located at Electra Lake north of Durango, Colo. The sage grouse no longer exists in New Mexico, although it is common in many parts of its range. It prefers areas with sagebrush.

The red-headed woodpecker, in the study area, is known to inhabit only low elevation riparian woodland and planted groves of trees. The San Juan Basin region provides the northern limits of the buff-breasted flycatcher's range, last verified in New Mexico in 1921. The Baird sparrow is a migrant which prefers grasslands. The white pelican, a migrant, has been observed in the San Juan Valley and at Red Lake.

The Jemez Mountains salamander is known only from a few localities in the Jemez Mountains. Not discovered until 1949, it is restricted to the volcanic substratum surrounding Redondo Peak and the Valles Caldera. Habitat type is mixed conifer. The boreal toad is found exclusively in the San Juan Mountains near permanent water.

Specimens of the Colorado squawfish have been collected in the vicinities of Navajo Dam, Rosa, N.M., and Aneth, Utah. The humpback sucker has never been collected in the San Juan drainage of New Mexico. Specimens have been collected at Mexican Hat, Utah, however, and there are no barriers to prevent the species from moving as far upstream as the Navajo Dam. The Zuni Mountain sucker is found only in the Zuni drainage.

Little is known of the bonytail chub, but recent studies indicate it never occurred in New Mexico. The roundtail chub has become reduced and restricted throughout much of its former range due to competition with and predation by introduced species of fishes. The Colorado cutthroat trout may still exist in the headwaters of the San Juan in Colorado, but otherwise this species is no longer present in the study area.

The blue-black silverspot butterfly is restricted to isolated seeps and springs in the Colorado Plateau and Great Basin. It occurs in the Chuska Mountains. (Schemnitz et al, 1979, No. 43)

Wildlife without Further Uranium Development

Increasing human populations over the next two decades will produce greater impacts on the fish and wildlife than would uranium mining and milling of themselves at any foreseeable level.

The influx of large numbers of people, with all this involves, will affect not only the survival of wildlife but also the normal functioning of life processes such as growth, behavior, and reproduction. The projected development of the San Juan Basin, even without additional uranium growth, will increase recreational activities and harassment of wildlife by man and his domestic animals. Habitat alteration, increased pollution, and increasing traffic hazards are among the problems that will arise. (Schemnitz et al, 1979, No. 43)

Habitat Alteration. In much of the San Juan Basin, indigenous game species are extremely limited due to poor range conditions. Any activity which further reduces the value of a habitat would be detrimental to the species using that habitat. As the human population expands, wildlife habitat will be affected by growing urbanization and increasing agriculture and industry. Construction of roads takes a toll of wildlife environment, with traffic an added disruption.

Habitat will be destroyed as Farmington, Gallup, Grants, Milan, and Crownpoint expand. The Navajo Indian Irrigation Project will remove or alter tens of thousands of acres of wildlife habitat for agricultural use. While this could destroy habitat for some species, it might create new habitat for others. Mammals and birds that adapt successfully to cropland habitat could increase. Examples of these are upland game birds, rabbits, starlings, house sparrows, house mice, and rats.

Riparian habitat, with its attractions of water and often better soil conditions, will be particularly vulnerable to the pressures of a growing population. The draining and clearing of riparian habitat will affect both terrestrial and aquatic life. Many birds winter in riparian areas and tend to specialize in specific localities. If the portion of the habitat in which winter migrants concentrate was destroyed, the result could be the total loss of a breeding bird population. Moreover, loss of riparian habitat has been found to decrease the productivity of wildlife in adjacent areas. Several endangered species depend heavily on riparian habitat. Among these are the mink, bald eagle, Mississippi kite, osprey, and red-headed woodpecker.

Further changes in riparian habitat will make additional inroads into the populations of native cutthroat trout, Colorado squawfish, humpback sucker, roundtail chub, and Zuni Mountain sucker, already drastically reduced by past environmental changes.

The lack of available water and habitat due to increasing diversion for agricultural, municipal, and industrial uses will be the most critical limiting factors for fish and wildlife resources in the future. Eventual drying up of wetlands would eliminate food, cover, and nesting areas for

certain species. Pollution of surface waters would be detrimental to wildlife.

Livestock grazing will continue to influence wildlife habitat. Further range deterioration could eliminate some species, such as the pronghorn. New grazing practices being put into effect on national resource lands are expected to stabilize plant communities, however, and eventually could improve conditions for both wildlife and livestock. Similar systems are proposed for Indian lands.

Large-scale clearing of pinon-juniper areas or indiscriminate logging could be harmful to deer, elk, and numerous bird species. Properly designed timber harvesting, however, can increase herbage production and create diversified habitat for deer and elk. The marten and Jemez Mountains salamander both occur in mixed conifer forests, making discretion necessary in logging areas they occupy. Expanding populations probably will restrict the ranges of black bears and mountain lions.

Harassment. Harassment of big game by dogs and people can be most detrimental at critical periods, such as in later winter, late pregnancy, and fawning (calving) time. Domestic dogs, both pets and those turned wild, are a growing problem in Colorado and on the Navajo reservation. Dogs can seriously affect big game by pursuing them for long distances through snow or over bare ground, causing pregnant doe deer and cow elk to abort. In some cases wildlife are killed or can contract emphysema and die as a result of these prolonged pursuits. Predation by dogs and cats on small mammals and birds has also been documented. Human disturbance has been influential in the decline of some endangered raptors.

Recreation Activities. It is expected that with the expanding human population and increased amount of leisure time, more people will take advantage of recreational areas, thus increasing the pressure on wildlife populations. The New Mexico department of game and fish has predicted the demand for hunting and fishing licenses in New Mexico will rise an average of 11.5 percent from 1979 to 1985. In 1977, 23 percent of the elk bagged in New Mexico were taken in the study area. The area supplied 11.7 percent of the deer and 2.9 percent of the pronghorn taken in New Mexico.

The key factor in regard to increased hunting and fishing pressure may be the quantity and quality of habitat available to game. With proper management, and ,if enough habitat is available, both big and small game may continue to prosper.

Uranium Activities. Gradual phasing out of uranium activity would reduce the number of mines to 14 by 1985 and to 3 by 2000, with 6 mills operating throughout the period. Approximately 3,100 acres of potential wildlife habitat, mostly in grassland/desert shrub and pinon-juniper, would be lost to these operations in the mid-1980's, falling to 2,300 acres by 2000. Total proper reclamation of abandoned mine sites could result in improved habitat for local populations of rabbits, rodents, deer, some birds, and predators which prey on these species.

Poaching of wildlife and the impacts of thousands of incoming people are of great concern to wildlife authorities. The Colorado division of wildlife, noting that "people and wildlife do not stop at state lines," has expressed reservations about the possible impacts of further growth and development on Colorado's wildlife resources.

Impacts of uranium activity upon wildlife cited under the Moderate projection would apply here, but to a lesser extent.

Wildlife with Moderate Uranium Development

Summary. Moderate uranium mining and milling would add approximately 65,000 inhabitants to the 350,000-plus population the region can expect by 2000 from non-uranium development. This additional growth of almost 20 percent would be largely centered in McKinley and Valencia counties where uranium activity is prevalent.

The already rising pressures on wildlife that accompany human habitation and activity (discussed under "Without Further Uranium Development") would be accentuated in and near the uranium growth areas. Habitat disruption would induce larger animals such as deer, pronghorn, coyotes, fox, and bobcats to migrate in search of undisturbed areas. Small animals would be relatively unaffected except where their living areas were disrupted.

Increased uranium activity itself could disturb or destroy locally important wildlife habitat, though on a modest scale compared with the expanse of the overall region. Effects on water quality and quantity could prove either adverse or beneficial, depending on local conditions. Reclamation of abandoned sites could improve forage conditions from their former state.

Uranium Activities. With Moderate uranium development, the rising number of mines and mills would increase the potential for loss of key habitats and for possible contamination of surface water. Most mines and mills would be located in grassland/desert shrub or pinon-juniper areas. Some ponderosa pine and mixed conifer habitat might also be lost.

The acreage lost (See Soils and Range) would be small in comparison to the total acreage of these habitats in the basin but could be significant to local populations of wildlife. Such key habitats as deer and elk winter range, prairie dog towns, and nesting and wintering sites of endangered raptors and other birds could be jeopardized. Destruction of forage plants and of escape and nesting cover would occur at construction sites and along new roads.

Uranium mill ponds and tailings piles are major objects of concern at all levels of activity. Little information is available on wildlife-millpond-tailings relationships and there is a strong need for research on this subject.

Mill ponds contain dilute sulfuric acid (H_2SO_4). This acid is strong enough to retain its basic chemical properties and some of its corrosive power (pH about 1 to 2). There have been reports of waterfowl landing on

these ponds and being injured as a result. The extent to which waterfowl and other wildlife use these ponds should be thoroughly investigated before conclusions are made concerning their effects.

Mill tailings, which would increase significantly, present a potential hazard to wildlife. Particular attention should be given to the naturally occurring radionuclides of the ^{238}U natural decay series (Dreesen et al, 1978). Radium-226 poses an ingestion hazard comparatively greater than that from most radionuclides. It behaves chemically in a manner similar to calcium, an essential element, and is assimilated by plants and animals. Radium-226 has caused cancer in humans and is of more concern than other radionuclides in mill tailings because of food-chain transport processes. (See related material under Soils and Range-"Contaminants," and in Chapter IV.)

Toxic elements such as selenium (Se), molybdenum (Mo), arsenic (As), and vanadium (V) are also present in many tailings piles. Selenium has been identified as an essential trace element in the diets of cattle, sheep, swine, horses, chickens, turkeys, quail, and dogs. However, though both Se and Mo are essential elements in the diets of livestock, very small amounts are required (0.1 mg/kg or less, dry matter basis, National Academy of Sciences, 1976).

When these elements migrate into the soil, their uptake by vegetation is of considerable significance to foodchains (Dreesen et al, 1978). In grazing foodchains, problems of toxicity and further bioaccumulation become significant. Molybdenosis has been diagnosed in cattle grazing in uranium mining areas in Texas (Dollahite et al, 1972). Molybdenosis also has been a problem near some Colorado uranium mills (U.S. Department of Energy, 1980b).

Selenium poisoning is suspected to be responsible for sheep mortalities in a uranium ore outcrop area in New Mexico (Rapaport, 1963). Selenium toxicity may occur when livestock consume forage containing 10-30 ppm Se (dry matter basis) (National Academy of Sciences, 1976). It is possible that wildlife such as deer, elk, rabbits, and rodents could be similarly affected. However, more research is needed before conclusions can be made.

Kelly (1979) found vegetation growing on uranium tailings piles in New Mexico to contain higher concentrations of selenium, arsenic, lead, and copper than vegetation growing on adjacent rangeland. For example, bottlebrush squirreltail from tailings piles contained selenium in concentrations averaging as high as 60.9 ppm, while on adjacent rangeland 1.9 ppm was maximum.

In detrital food chains, these elements may concentrate in the humus horizon of the soil (Dreesen et al, 1978). The accumulation of these contaminants in the upper soil horizons could inhibit mineralization of organic matter via toxic effects on soil microorganisms or soil invertebrates. (Schemnitz et al, 1979, No. 43)

Tailings and associated contaminants can be moved into the environment by water or wind erosion, by leaching followed by seepage of contaminated ground water from tailings, or by failures in the tailings pond dike.

The uptake of contaminants by vegetation, its consumption by wildlife, and the possible consumption of wildlife by people may be a significant transport process also. Dreesen, et al, (1978) stated, however, that uptake by vegetation is probably a minor transport process compared to the erosion of bare tailings. If soil cover over a tailings pile is deep enough to prevent roots and/or moisture from penetrating into tailings, little contaminant uptake should occur. The depth of cover required to prevent root penetration may be great, though. Some typical western grasses have root systems from 10 to 12 feet deep.

The possibility of small animals digging into tailings piles, and their possible contamination and spread through the food chain deserves consideration. Little research appears to have been performed on this subject. Potential uptake by vegetation via foliar dispersion of wind blown material should also be considered as a potential contamination mode.

Benefits for wildlife could result from uranium operations. Reclamation of abandoned sites could improve forage conditions. Mine dewatering could increase surface water supplies for wildlife, assuming the water has been treated to achieve acceptable quality, as it should be.

Mine dewatering could be detrimental to wildlife, however, if an aquifer providing water to wildlife was allowed to become contaminated by activities related to uranium mining or milling.

If in situ mining should be proposed on a regular basis in the San Juan Basin, further study of the ecological effects and possible impacts on aquifers would be essential. If drawdowns predicted near deep mines in the Morrison Formation (Chapter V) should cause wells to go dry, local wildlife would be affected adversely. Such drawdowns should not affect springs. Predicted reductions in flow toward the San Juan River and the Rio Grande would have negligible effects upon aquatic life of those river systems.

Wildlife with High Uranium Development

The impacts on wildlife under the assumed High level of uranium development would increase considerably over those foreseen for the Moderate level. This scale of uranium activity would add about 50,000 more inhabitants to the region than anticipated under Moderate development by the end of the century. Many of the new arrivals would live and work in the vicinity of McKinley and Valencia counties. Impacts cited under "Without Further Uranium Development," associated with pressures from growing population and expanded human and industrial activity, would be correspondingly greater.

The High assumption visualizes an increase to 57 uranium mines and 12 mills by 1985 and to 105 mines and 22 mills by 2000. Although the acreage of potential wildlife habitat lost to mining and milling would be small in proportion to the total available, much would depend on the specific

locations of future activity. (For estimates of area involved, see Soils and Range.)

Mitigation of Wildlife Problems

Wildlife in the San Juan Basin region will be subject, during the next two decades, to increasing pressures from rising human population and growing competition for water and living areas.

This increased stress is virtually assured in any event, due to general growth. However, it will be intensified if uranium development approximates the scale assumed in the Moderate projection.

A shortage of detailed information concerning the region's fish and wildlife resources existed until recently. The U.S. Fish and Wildlife Service overcame that deficiency when it arranged for inventories of those resources for this study and for the BLM's coal study (U.S. Department of the Interior, Bureau of Land Management, 1979).

As a result, for the first time federal and state game authorities possess the information required for planning to meet future needs. Study of existing wildlife conditions, the land and water available and the foreseeable problems should indicate any future actions needed. Questions that merit attention in the near future include: 1) whether existing game and fish management areas will meet future growth requirements, and 2) the preservation of adequate key habitats.

With reference to uranium activities, the use of scare devices or pond covers might be considered to discourage migratory water fowl from using tailings impoundment water that might harm them. The U.S. Fish and Wildlife Service would advise owners concerning such a program, upon request. Water pumped from mines can establish vegetation in previously dry washes, creating new wildlife habitat for at least the life of the mines, assuming an alternative use is not developed.

Study should be given to the feasibility of making further use of the mine discharge, perhaps partly for wildlife or other recreational purposes. Such a study would necessarily include, or be preceded by, a determination that radionuclide contamination presented no problems after the removal of contaminants which is necessary before release of the mine water (Chapter V).

Once contamination was proven not to be a factor in a given situation, it might be practical, for example, to impound some of the currently unused mine water for a fishing lake. (The New Mexico EID's water pollution control section, for instance, said in 1980 the agency "feels comfortable with the quality of the water" being pumped from the Phillips Nose Rock mine during construction.) (Albuquerque Journal, July 6, 1980)

Other potential uses of newly available water in a semiarid region come readily to mind. The entire issue of putting mine water to beneficial use might well become the focus of a joint effort in which special efforts were taken to protect the various interests, reminiscent of multiple use

policies in National Forests. Another possible mitigation of adverse effects involves the conversion of selected exploration holes into water wells for wildlife and possible livestock use.

Reclamation of uranium activity sites can restore a damaged habitat to at least its original condition and sometimes improve upon it. Where threatened or endangered species of flora or faura are encountered, mitigation measures should be taken to comply with Section 7 of the Endangered Species Act.

MISCELLANEOUS ENVIRONMENTAL ASPECTS

Possible Conflicts with Other Resources

Exploration for and development of uranium resources should not significantly interfere with development of other mineral resources or with agricultural activity in the San Juan Basin.

Most deposits of oil, natural gas, and coal occur farther north in the basin than predicted uranium operations, including exploratory activities. This is also true of the Navajo Indian Irrigation Project (NIIP).

The study team assumed in modeling impacts that nearly all uranium development activities would occur at depths of less than 5,000 feet. Exploration holes for uranium are likely to be drilled to the top of the Recapture Member of the Morrison Formation. In the vicinity of the NIIP and major oil and gas production (Map I-4), the Recapture is more than 6,000 feet below the surface. Most of the planned coal production is to come from leases within the much shallower Fruitland Formation (Figure III-3) where the Recapture Member is more than 5,000 feet deep.

Conflicts between uranium and coal development would be more likely to occur if coal mines should be constructed in the Menefee or Crevasse Canyon Formations, where a good deal of exploration drilling for uranium is taking place. Conflicts might arise over the location of surface facilities, power lines, and roads, for example, if coal and uranium were to be mined simultaneously in overlapping areas.

However, the coal deposits are always stratigraphically much higher than uranium deposits of the Morrison Formation, so uranium activities should not significantly affect the recoverability of the coal.

Little oil or gas has been produced from areas of the San Juan Basin where uranium activity dominates. Small quantities of oil are produced north of Ambrosia Lake (Sect. 13, T. 15 N., R. 10 W.), and oil and gas are produced from the Hospah area. Conflicts could occur over the siting of oil wells, gas wells, and uranium drill holes, surface facilities, roads, and power lines. Overall, multiple mineral development conflicts should be minimal in the basin. (Also see "Subsidence" under Topography.)

Paleontology

Fossil resources of the San Juan Basin have been studied for more than a century. A major use of these paleontological resources has been biostratigraphic correlation, a dating method which provides rock body dating on the basis of fossil age. Well-exposed, relatively undisturbed sections of rock with diverse fossil remains are necessary for biostratigraphic correlation. One such section is that of the continental deposits of late Cretaceous and early Tertiary age along the southern flank of the basin. These deposits have been studied with increasing interest by paleontologists from around the world.

A recent survey by the University of New Mexico and Louisiana State University (Kues, et al, 1977) documented the widespread occurrence of locally plentiful vertebrate, invertebrate, reptile, mammal, and plant fossils. The survey recorded 1,157 new localities in the basin in addition to those previously known.

The vertebrate material is varied and ranges from nearly complete, articulated dinosaur skeletons to isolated teeth of primitive mammals. Fossil mollusk beds are commonly associated with these remains. Some areas contain large numbers of fossil tree stumps in growth position, fossil logs (some more than 100 feet long), and well-preserved leaf materials. The combination of such variety and preservation is rare.

Most of the fossil materials appear to be concentrated in or near sediments of ancient stream channels. Uppermost sandstone units of the Kirtland Shale or basal units of the Ojo Alamo Sandstone contain the last record of dinosaurs in the San Juan Basin.

The final occurrence of dinosaur materials is the classic sign for the ending of the Mesozoic Era, when mammals first appeared, and the beginning of the Cenozoic Era, during which mammals became abundant. The basin is one of the few places in the world where this transition can be studied. (U.S. Department of the Interior, Bureau of Land Management, 1979)

Uranium mining activity in the basin will impact paleontological resources, and increased scientific fossil collection can be expected to provide a force for conservation. Fossils are subject to loss from weathering, erosion, unauthorized removal, and vandalism. Population increases, greater industrial development, and off-road vehicle use would increase the possibility of irreplaceable fossil loss, as these fossils become less isolated.

In the absence of mitigation measures, mining activity on state and private lands could destroy the integrity of fossil deposits. As the shafts are sunk and tunnels dug, several fossilized formations (such as the Mancos Shale and the Dakota and Gallup Sandstones) would be encountered.

Under the Antiquities Act of 1906 discoveries of fossils or other paleontological remains on federal lands are usually treated in the same manner as discoveries of archeological artifacts, with respect to collection and removal. Under recent internal instructions of the BLM, federal

coal lessees are obligated to provide data on fossil resources found in the lease area and to provide protective measures for finds having significant scientific, educational, or recreational value. The Navajo tribe (Antiquities Preservation Law of 1972) similarly requires such data of lessees and permittees and otherwise protects the resource from unauthorized collection or destruction.

The State of New Mexico also has extensive cultural preservation regulations (NMSA 4-27-4 through 4-27-18) covering all lands in New Mexico, including those lands privately owned. Conditions and requirements for protection or salvage of such resources can become firm only after the extent, nature, value, and probable disturbance of the paleontological resource are determined. The exploration and mining plan is required to include a survey recording the finds. Neither exploration nor mining can begin until plans are approved. Mining is sometimes the only method that would allow recovery of deeply buried fossils.

Noise

The basin is a relatively quiet region. While no noise measurements are available, similar rural areas have background sound levels below 30 decibels. For about 1,000 feet on each side of major highways or streets in larger towns, traffic and particularly trucks produce much higher noise levels than elsewhere. This can reach as high as 80 decibels on a momentary basis next to the road.

Elsewhere, the only sounds that can be expected to break the stillness would be a car passing on a nearby road, a jet aircraft overhead, or events of nature such as the frequent wind or a storm.

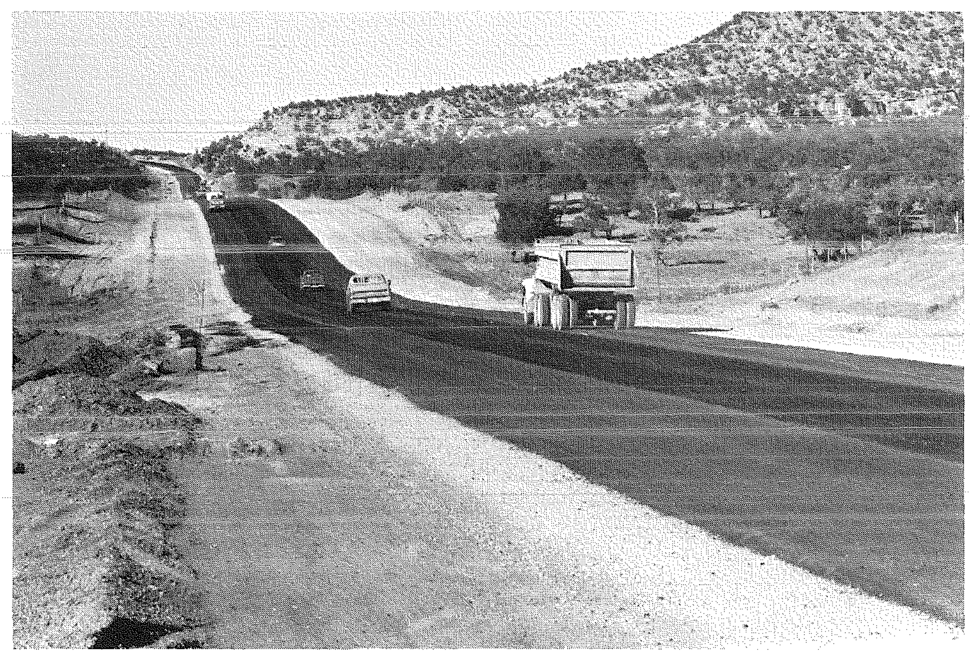


Figure VI-9.--Uranium ore trucks passing on Highway 57 north of Thoreau

Uranium exploration, mining, and milling do little to break this pattern. Inside a mine or in the immediate vicinity of a mill, noise levels of about 65 decibels can be expected. On a regional basis, however, the effect would be small. The areas affected are extremely small in comparison to the size of the basin.

Of greater regional concern is the noise produced by uranium ore trucks hauling from the mines to the mills. A study by Battelle (1975) found that the noise level for an ore truck could reach 80 to 90 decibels next to a highway and 52 decibels 1,500 feet away. Where several mines used the same road for hauling, with perhaps five or six trucks passing each hour, the impact could be quite noticeable near the road.

The New Mexico EID, given authority in noise matters by the state's Environmental Improvement Act, is studying needs and regulatory involvement. The results might affect to a slight degree such uranium operations as truck operations and blasting.

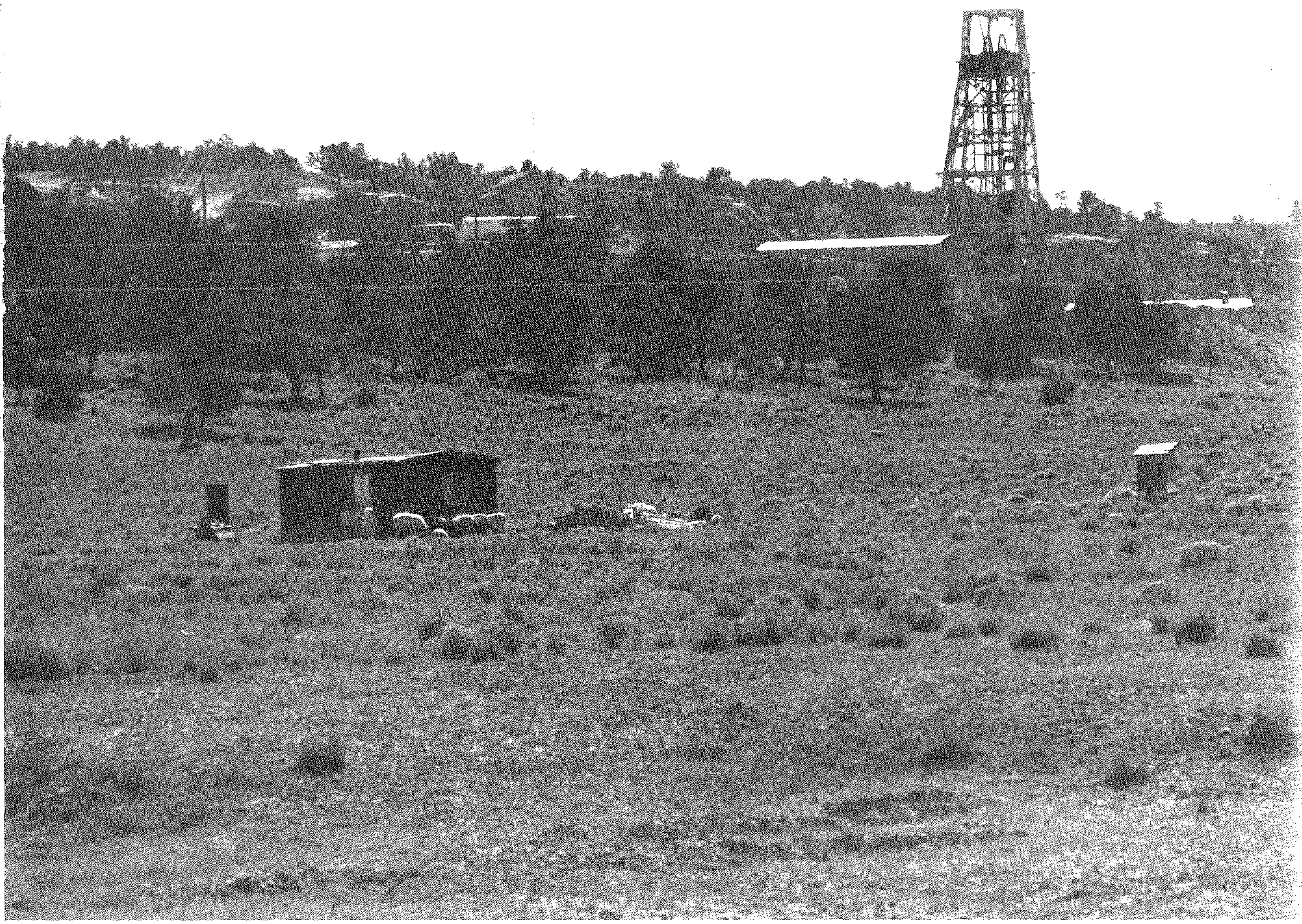
PART 3

ENVIRONMENTAL IMPACTS:

Human Environment

CHAPTER VII

IMPACTS ON THE SOCIOCULTURAL LANDSCAPE



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Chapter VII

Summary

Uranium development in the San Juan Basin at or above the assumed Moderate level would create personal and organizational stress on all parties involved. It would also create two distinct types of impacts on the inhabitants, depending on whether they are Indians or non-Indians.

For non-Indian residents, stresses from rapid growth of some smaller towns would probably occur. Involving housing, public services, and quality of life, these effects would be those traditionally associated with regional population expansion. They could be managed with advance planning and financing.

For Indians, particularly the older Navajos who occupy outlying camps in much of the uranium country, the main impact would be more qualitative in nature and, therefore, more difficult for others to grasp. This impact would be the fears, real or imagined, of people who felt their entire way of life was threatened. Especially affected would be those with little or no formal education.

These fears would require serious efforts to establish mutual understanding and to solve the inevitable problems arising from industrial activity near people's ancestral homes.

Chapter VII

Impacts on the Sociocultural Landscape

THE HUMAN ENVIRONMENT

General Description: Present and Future

Until recently northwest New Mexico could be described from a sociological standpoint as economically poor, little touched by major national trends and forces, and relatively lacking in political power within the state. Its mixture of Anglo, Spanish American, and Indian inhabitants, however, gave this part of the San Juan Basin a rich cultural and historical heritage.

Low in population and sparsely settled, the area in the recent past has possessed marginal or subsistence agriculture and low level resource extraction. It lacked a significant manufacturing sector. Resources and people were exported from the basin, goods imported. Job opportunities were scarce, unemployment and public welfare caseloads high. Per capita income trailed near the bottom in one of the poorest states in the nation. Little money passed into or out of this large territory until boom periods in oil, natural gas, and uranium occurred in the 1950's.

More recently, energy-related development has placed the people and the area "on the map," so to speak. As a result of this development, external forces seem likely to play a larger role in shaping the basin's future than in the past and to draw significant areas into the economic mainstream of American life.

Stepped-up development of uranium and other energy resources, if it occurs within the expected range, will mean more people in the basin, more money in circulation, a greater flow of goods and services, and more complex and larger communities. Rural areas will gain new residents and lose more and more of the remoteness that long typified them.

With this increased tempo, the area may impress many observers as more homogenized and internally integrated than it was before. In reality, however, cultural pluralism will persist and perhaps intensify. While inhabitants' awareness of overall changes in the area will be raised, perhaps inspiring a feeling of activity and excitement, this consciousness of change will not in itself suffice to unify the area's fragmented nature. The old relationships of rural to town areas and ethnic solidarity will be preserved (Gibson, 1979, No. 47).

Efforts to accelerate two movements centered in the West--Indian sovereignty and the "sagebrush rebellion" against land domination by the federal government--can be expected.

The political power of northwest New Mexico will not increase overall, even with High level uranium development. However, within the anticipated range of energy development the political influence and forces of the energy industry will probably figure still more heavily than heretofore at the state level and perhaps others.

In the next two decades, northwest New Mexico can be expected to continue its present pattern of exporting resources while importing goods and people. It also will go on importing and exporting large sums of money with little local capture. For some persons, many of them Anglos, the basin will be considered a place to make money and leave behind when its resources are gone.

Due to the continued lack of a manufacturing sector to provide employment, without careful planning there could be an eventual return to pre-1950's conditions.

Human Interaction Impacts Model

To identify impacts that could accompany this evolution, the team created a regional model of human interrelationships in the San Juan Basin region. As energy development accelerates within the range outlined in Chapter II, human relationships can be expected to become more complex (Knight, 1980, No. 49).

Figure VII-2 suggests some of the elements and linkages involved, as a sociologist might analyze them. These elements, or key actors, in uranium and other energy-related development in the study area are:

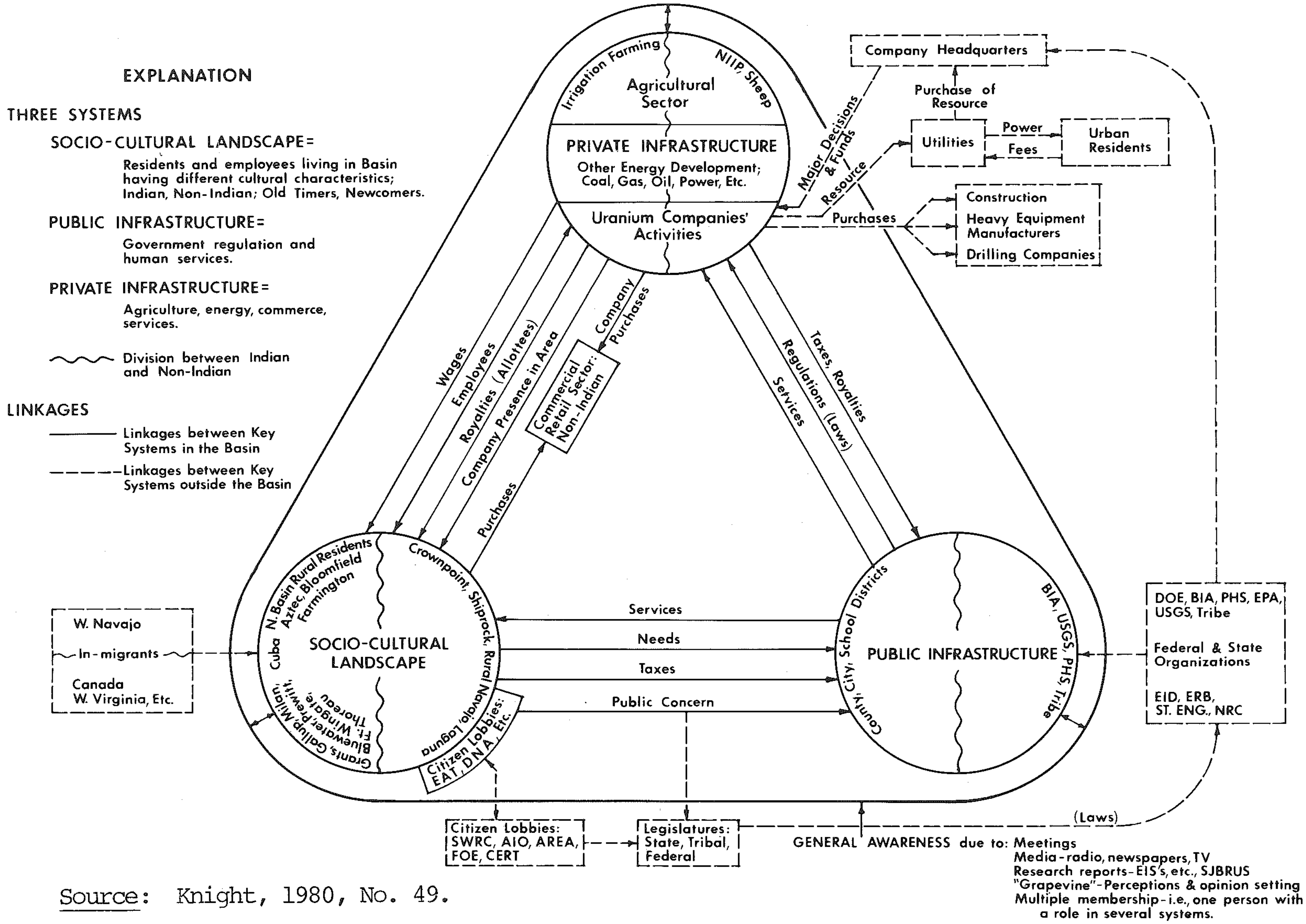
1) In the Private Infrastructure--the company people and others in business and industry who make up the private enterprise sector;

2) In the Sociocultural Landscape--the inhabitants;

3) In the Public Infrastructure--the representatives of government at all levels.

Participants in these three systems interact with each other through such linkages as the hiring of basin residents by employers, the payment or receipt of wages, the consumption or supplying of local goods and services, and the payment or receipt of taxes or mineral royalties. Other examples: residents' various expressions of public concern; their participation in the voting process and their needs for social services; the governmental sector's supplying of certain services, and its regulation of business and industry.

Many relationships or linkages were worked out on an ad hoc basis prior to major energy-related development and are low key. They could not be expected to serve future industrial growth in a basically rural region.



Source: Knight, 1980, No. 49.

HUMAN INTERACTION IN THE SAN JUAN BASIN AREA
SYSTEMS (STRUCTURE) AND LINKAGES (INTERRELATING PROCESSES)

Figure VII-2

The only linkage that tends to unite all elements under present conditions, then, is "general awareness" of events in the area.

Figure VII-3 indicates some of the concerns of persons involved in or affected by uranium development. Shown are the apparent paucity of overlapping goals and concerns, as well as the existence of conflicting issues and suspicious attitudes in some instances.

At a regional level, uranium development impacts occur in the human environment as a result of changes in the linkages, or relationships, between the private infrastructure, sociocultural landscape, and public infrastructure. The sequence involved might look like this.

Companies enter the basin, planning to mine or mill uranium ore, and initiate activities affecting private, federal, or Indian tribal lands. With these enterprises comes the prospect of new employment opportunities and an influx of newcomers. The new arrivals include a variety of non-Indians, as well as Indians, particularly Navajos from other areas.

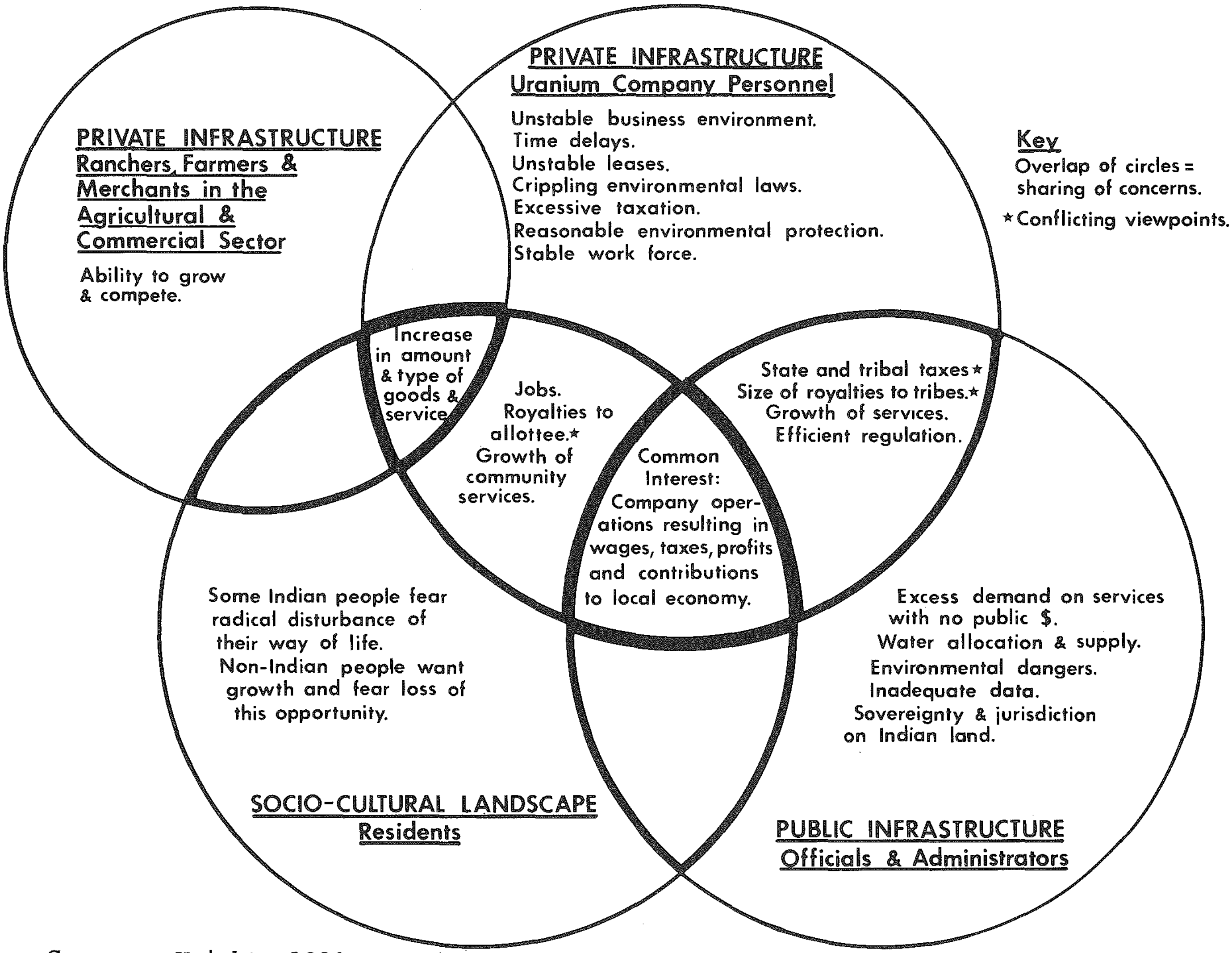
The presence of the companies and in-migrants is seen as an opportunity by Anglos, Spanish-speaking, and some Indians, but as a possible threat by a sizable number of rural Navajo inhabitants. These divergent viewpoints generate pressures on service and regulatory agencies, including pressures from interests polarized on the basis of a pro-nuclear or anti-nuclear electric power stance. Regulatory or social service agencies may assume larger roles than previously as they undertake to deal with impacts. Along with market forces, their actions may affect decisions by individual companies or the overall development pace.

The loosely linked systems of the basin are thus subjected to strains as public entities seek resources to meet new demand, factions pursue goals that sometimes conflict, and large companies accustomed to low profiles find themselves, perhaps, involved in turmoil. A complicating factor often is the lack of solid information, opening the way for rumors and potential manipulation of public opinion.

At the most abstract level, the key impact on all people affected by uranium development in the basin is personal and organizational stress. This stress persists partly because of the non-existence of a central force with the appropriate status and capability to pull all concerned together in a joint resolution of conflicting goals and issues.

The team's social scientists believe it would be difficult to establish a central unifying force at this point, due to the established position of the uranium industry and the complex jurisdictional questions. This might be achieved through high level executive or legislative initiatives at the federal level.

It appears more likely that conflicting purposes will be ironed out on a piecemeal basis, perhaps somewhat painfully at times. As such issues as those cited in Figure VII-3 are faced and resolved, mutual trust and agreements can be expected to develop among the participants. This process has already started in some cases. Hopefully, improved understanding on all



Source: Knight, 1980, No. 49.

ISSUES OF CONCERN OF "KEY ACTORS" INVOLVED IN URANIUM DEVELOPMENT

Figure VII-3

sides will gradually produce a new state of balance and cooperation among all parties.

Impacts can be defined as changes occurring not only among the basin's three major systems but also within each of them. Figure VII-2 in effect provides a schematic overview setting the stage for events dealt with in three chapters: Chapter VII, dealing with changes in the sociocultural landscape; Chapter VIII, discussing changes in the public infrastructure, and Chapter IX, changes in the private infrastructure. The foregoing discussion serves as a blanket preface to these chapters.

IMPACTS ON THE SOCIOCULTURAL LANDSCAPE

Introduction

Like the land they inhabit, the people and cultures of the San Juan Basin region present a picture of variety and change. The sociocultural landscape portrayed in Map VII-1 depicts the latter 20th century interval in a story of man in the basin dating back 120 centuries.

While knowledge of human activity embraces less than 1/250,000th of the time spanned by rock history in the Four Corners area, it suffices to show that the human environment, too, has passed through differing phases. These reflect changes both in cultures and in human use of the natural resources, as discussed in Chapter X concerning archeological resources.

Today's pursuit of such energy resources as uranium and coal promises to affect far more people than all earlier endeavors to exploit the resources of the San Juan Basin region combined.

Definition of Sociocultural Landscape

The term sociocultural landscape, as shown in Map VII-1, refers to the various cultural and ethnic groups within the San Juan Basin. Geographically, lands occupied by members of several Indian tribes are conspicuous, extending well beyond the reservations themselves in some places. (Reservation boundaries are shown in Map I-2. Land status is shown in Map XI-1.)

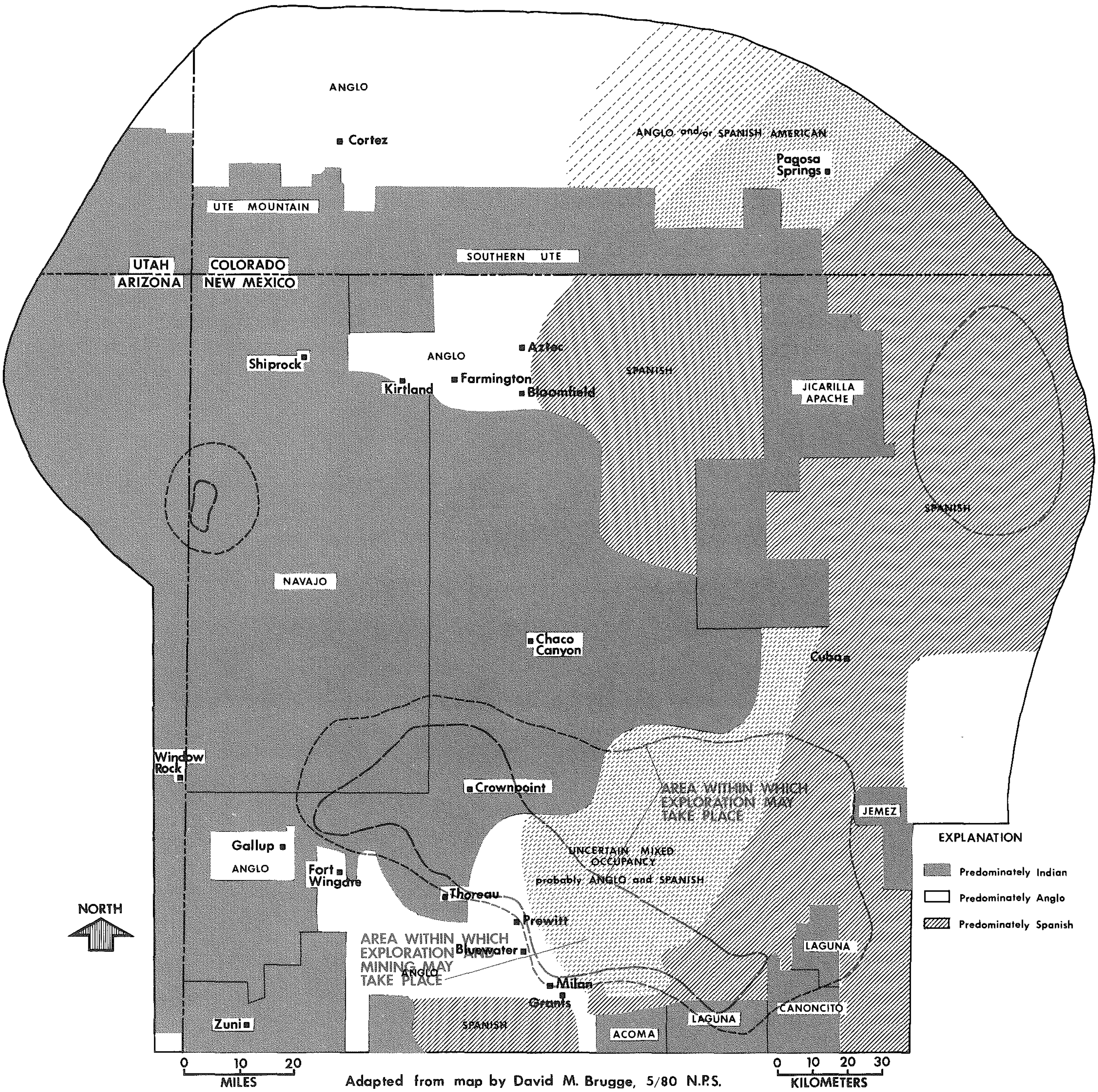
Other basin inhabitants are primarily Anglo and Hispanic ranchers, farmers, and town dwellers. Sociologists would describe the area as essentially culturally pluralistic.

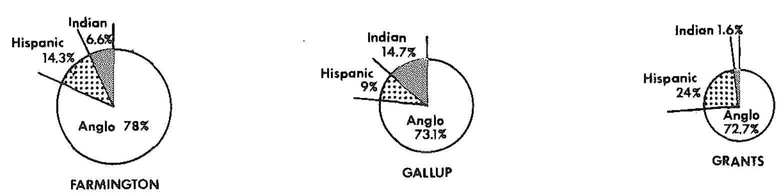
Methodology and Levels of Analysis

Analysis of impacts starts at the regional level, then deals in increasing detail with subregional ethnic interrelationships and specific cultures, particularly the Eastern Navajos. Boomtown potentials in the southern part of the basin also are discussed. Further analyses focusing on selected communities or site areas should be performed as the need arises. This particularly applies to Hispanic communities in the southeast basin area.

Key Findings

The key impacts of increased uranium development would occur at subregional and area-specific levels. Growth stress would be experienced by the smaller basin towns. In Navajo areas, actual and potential economic gains for some persons from uranium development have produced community upset, some factionalism, and general concern over the implications for the Navajo way of life. (Other predictable impacts are summarized in Table VII-14.)





Ethnic Percentages of Basin Towns

Map VII-1.--Sociocultural landscape, 1980

Differing Lifestyles and Ethnic Interrelationships

Diversity of Ethnic Groups

Three basic cultural groups inhabit the region. Persons of Indian and Anglo descent are roughly equal in numbers in the northwest New Mexico part of the study area. Estimated at approximately 85,000 each, the Indians and Anglos comprised almost three-fourths of the 1977 population of the five counties. The other fourth were residents of Spanish-speaking descent, estimated at approximately 59,000. (U.S. Department of the Interior, Bureau of Land Management, 1979) Many sub-cultures which are a variance of the three dominant cultures (Table VII-3) exist, and mixed ancestries are common.

Figure VII-4.--Navajo mother and children at Fruitland Post Office near the San Juan River

The San Juan Basin is not a sociological unit in people's minds. Inhabitants look on the basin in terms of personal contacts, largely among others in their own cultural groups. Sociologists might refer to these as networks of interrelationships. Perhaps the only unifying factor in the area is the relationship of ethnic groups to the mainstream of American life as expressed through public education, the media, the consumer economy, and employment in the energy development sector.

Navajos and other Indians are a sizable minority in Farmington, Gallup, and Grants. The reservations of other tribes, including the Zuni, Acoma, Laguna, and Rio Grande Pueblos, the Jicarilla Apaches, and Utes,

circle the southern, eastern, and northern perimeters (Map VII-1). Anglos are in the majority in the three main towns and several small ones. In rural areas, Anglos are the leading lessees of public lands for grazing and farming, largely in the north central basin, and in the privately owned lands making up part of the checkerboard area in the south.

Americans of Spanish and Mexican descent occupy small settlements in the east, southeast, and north central basin and comprise a minority in the three leading towns. They control several land grants in the rural southeast and lease public lands for grazing in the east and north central basin.

Ethnic distribution of residents of the San Juan Basin in New Mexico is shown in Table VII-1. Map VII-2 delineates the counties. Ethnic compositions of Farmington, Grants, and Gallup are given in Table VII-2. These figures are approximations.

Table VII-1

Ethnic Percentages in Five Counties

(Approximations based on 1970 and 1976 data)

County	Anglo	Spanish	Indian	Black	Other
McKinley	26%	11%	62%	1%	1%
Valencia	43%	42%	15%	-	-
San Juan	56%	7%	35%	-	-
Sandoval	24%	35%	41%	-	-
Rio Arriba	15%	71%	15%	-	-

Source: U. S. Department of the Interior, BLM, 1979.

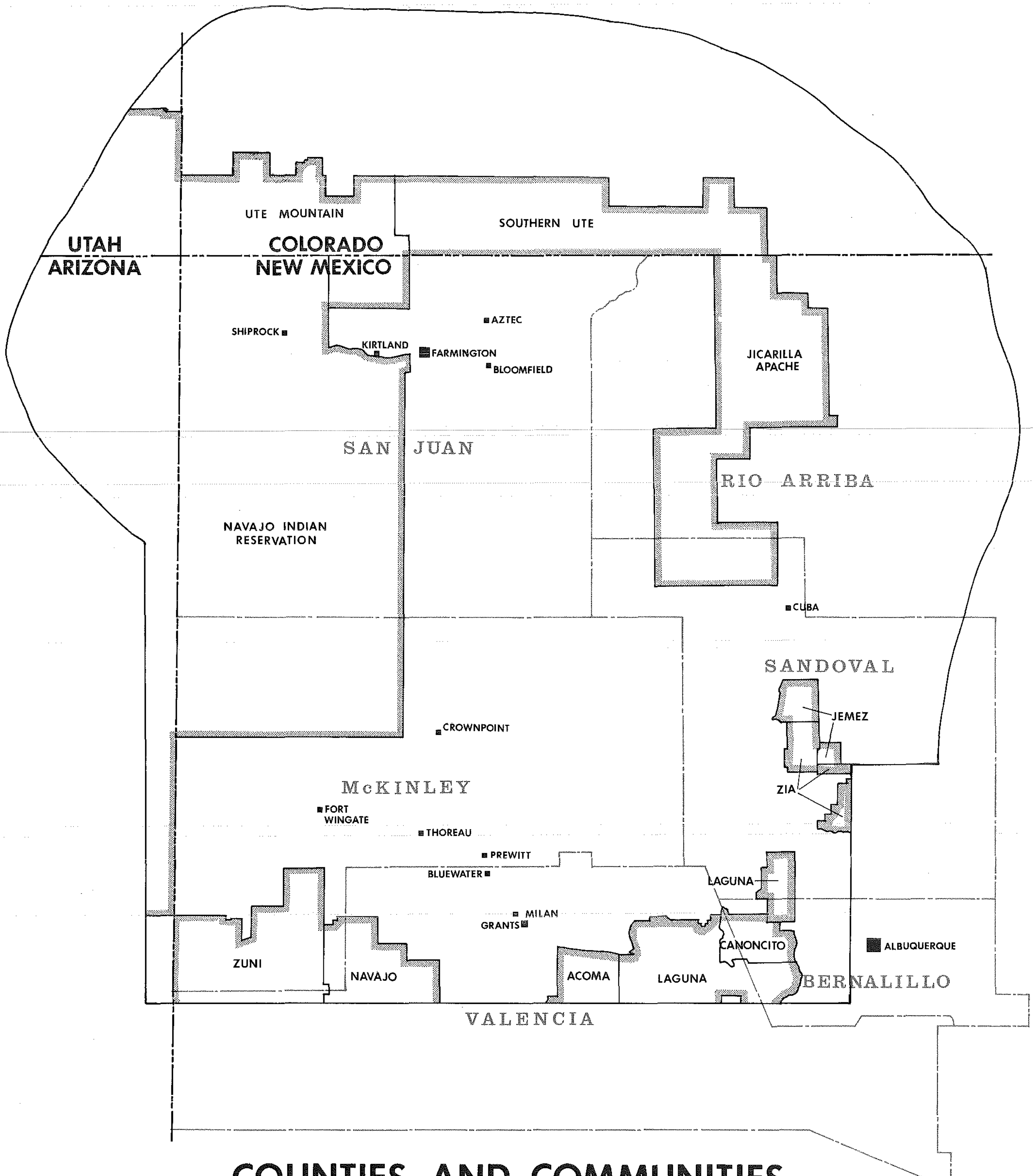
Table VII-2

Ethnic Percentages of Basin Towns*

	Anglo	Hispanic	Indian	Black	Other
Farmington (Chamber of Commerce)	78%	14.3%	6.6%	1.1%	.6%
Grants (UNM Data Bank)	72.7% *	24% *	1.6%	.8%	.9%
Gallup	73.1% *	9% *	14.7%	2.1%	1.1%

*Extrapolated from county "Spanish speaking" figures.

Source: U. S. Department of the Interior, BLM, 1979.



COUNTIES AND COMMUNITIES of the SAN JUAN BASIN

Map VII-2

Traditional sociocultural orientations and values of selected cultural groups in the basin are summarized in Table VII-3. The significance of these generalizations lies in 1) the various types of sociocultural adaptation which differing cultures have made to the natural environment, and 2) the potentials for accommodation and controversy which exist between societies and cultures based upon their attitudes toward environmental manipulation.

For example, a major area of cultural difference is that of traditional attitudes as to what is appropriate in exploiting the environment. In general, the traditional Indian orientation to the environment is one of harmony with nature, implying a minimal alteration of the existing state of man-nature relationships. This is a religious attitude which acknowledges mutual interdependence of life forces. In sharp contrast is the frequent Anglo viewpoint that natural resources--which are part of the environment--should be capitalized upon and used. These greatly generalized points of view both depict goals deemed desirable by their proponents, yet they differ widely in their fundamental assumptions.

Current Experience with Uranium Development

Map VII-1 (Sociocultural Landscape) shows cultural groups and areas currently experiencing uranium exploration, mining or milling activities. The central section of this area, largely Anglo, is accustomed to heavy uranium development, whereas Spanish Americans and Navajos to the east and west have recently experienced exploration drilling and site development for the first time.

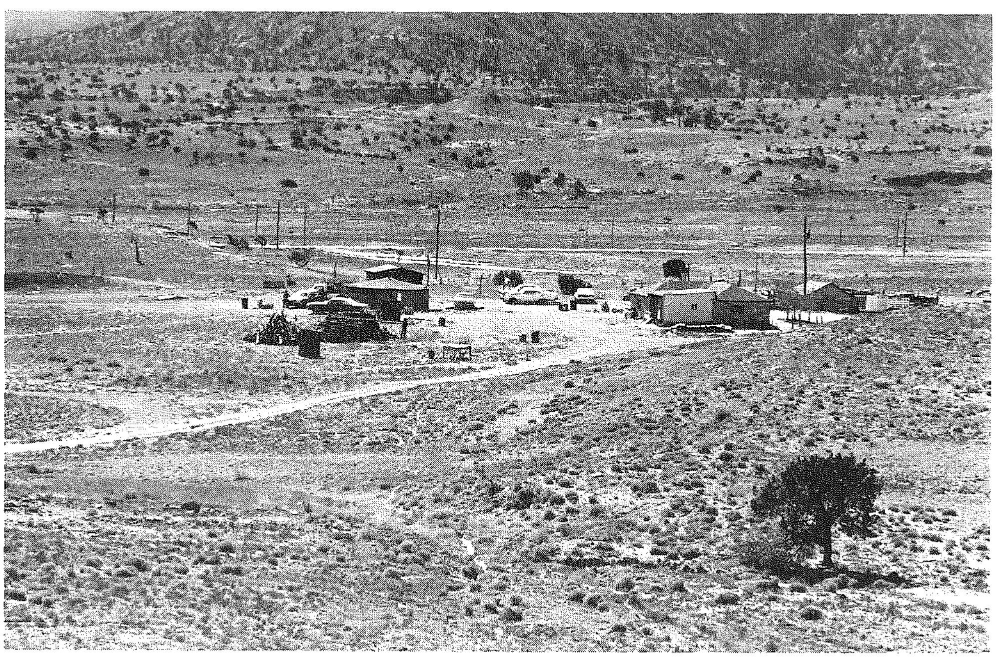


Figure VII-5.--Members of Navajo extended families often live in remote family clusters, sometimes miles from neighbors

Table VII-3

Cultures in Uranium Area: Dominant Themes

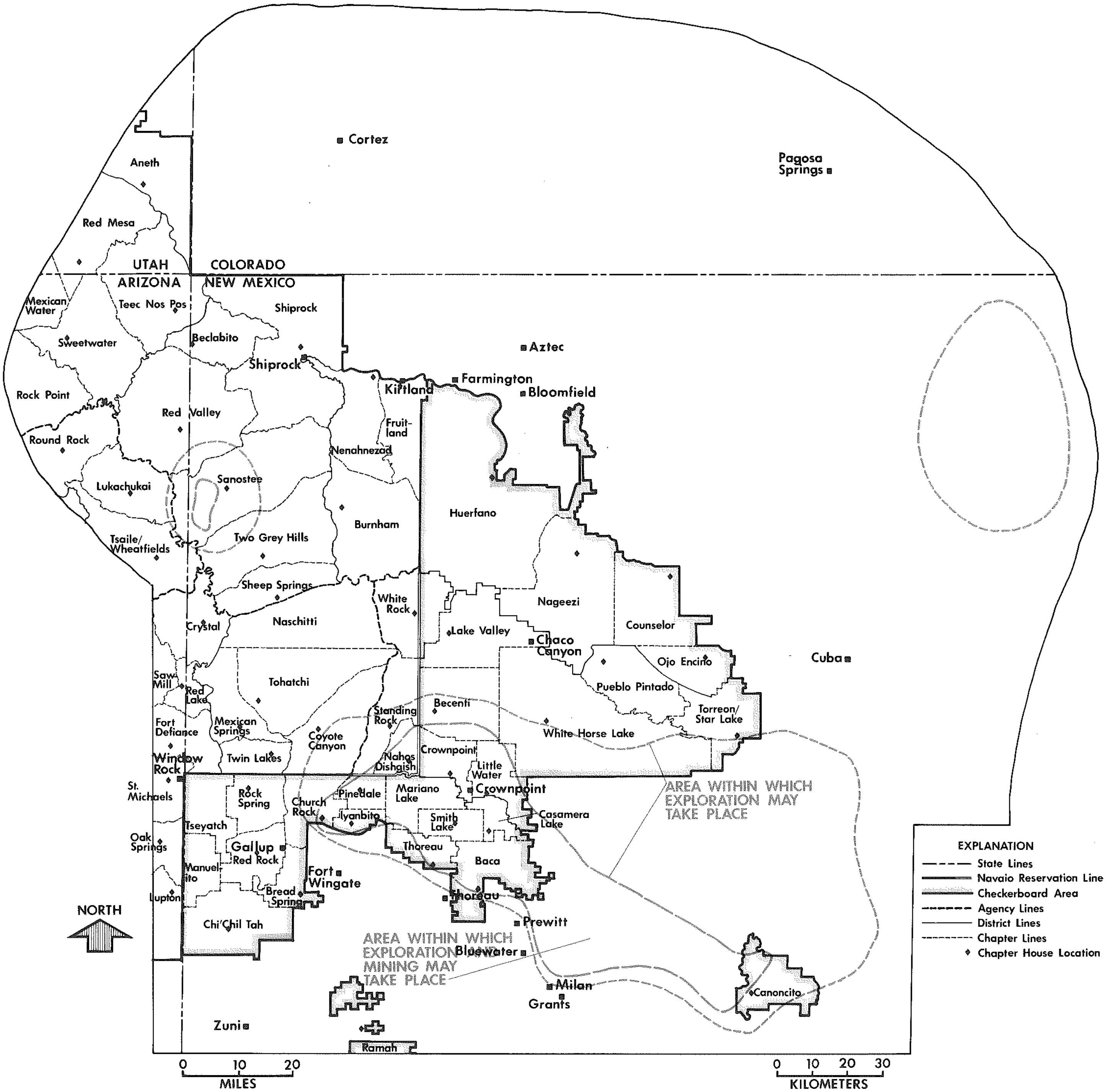
Cultures	Arrival Time in Area	Traditional Economy	Kinship System	Residence Patterns	Family
<u>Indian</u>					
Navajo	1500 +	Pastoral	Matrilineal	Dispersed	Extended
Laguna	1350 +	Horticulture	Matrilineal	Pueblo	Extended
Acoma	1350 +	Horticulture	Matrilineal	Pueblo	Extended
<u>Non-Indian</u>					
Spanish-American	1540 (1592)	Pastoral/Agriculture	Patrilineal	Village	Extended
Mormon	1880 +	Agriculture	Patrilineal	Village	Nuclear
Homesteader	1920 +	Agriculture	Patrilineal	Dispersed	Nuclear
Rancher	1870 +	Pastoral	Patrilineal	Dispersed	Nuclear
Anglo Urban	1848 +	Wagework	Patrilineal	City	Nuclear
Anglo Rural	1848 +	Farming-Ranching	Patrilineal	Dispersed	Nuclear
Miner-Sub-Culture	1950 +	Wagework	Patrilineal	City	Nuclear

Cultures	Value Orientation[1]			Man-Nature Relationships		
	Social	Political	Religion	Harmony with Nature	Controlled Alteration of Nature	Mastery Over Nature
<u>Indian</u>						
Navajo	Bands	Headmen/Council	Native	X		
Laguna	Collectivity	Sacred-Secular	Native	X		
Acoma	Collectivity	Sacred-Secular	Native	X		
<u>Non-Indian</u>						
Spanish-American	Familistic	Council	Catholic		X	
Mormon	Collectivity	Elected	LDS[2]			X
Homesteader	Individualism	Representatives	Protestant			X
Rancher	Individualism	Representatives	Protestant			X
Anglo Urban	Individualism	Representatives	Protestant/Catholic.			X
Anglo Rural	Individualism	Representatives	Protestant/Catholic.			X
Miner Sub-Culture	Individualism	Representatives	Protestant/Catholic.			X

[1] Value orientations indicate historically dominant patterns. Interaction among cultures has resulted in profound alterations of traditional culture patterns. Today with ongoing acculturation, each culture has developed alternative, frequently conflicting, value orientations.

[2] Church of Jesus Christ of Latter Day Saints.

<u>Source:</u> F. Kluckhohn and F. Strodtbeck, <u>Variations in Value Orientations</u>, 1961, modified, Griffith, 1979.



Navajo Chapters Affected by Uranium Development - 1980

Map VII-3

Population

Population and other demographic data are collected on the basis of political and administrative boundaries which do not necessarily directly reflect cultural conditions. Estimated populations for the five New Mexico counties touched by the study area are shown in Table VII-4. Key communities are given, with Albuquerque, New Mexico's largest city, included because its population is affected by the nearby uranium development even though the city lies outside the study area (Map VII-2). As Table VII-5 shows, of approximately 67,000 Navajos living in the eastern Navajo country, about 17,000 or 25 percent live in areas that may be somewhat affected by uranium activity in the early 1980's. Exploration would account for much of this. These figures are included in statistics for the respective counties. Locations of chapters, Navajo administrative units, are shown on Map VII-3.

Urban concentrations, largely comprised of Anglo residents, in the Gallup, Farmington, and Grants-Milan areas are reflected in Table VII-6.

Table VII-4

1977-1978 Populations

San Juan Basin Counties and Towns

STATE OF NEW MEXICO - 1,212,000

McKINLEY COUNTY	-	58,000	VALENCIA COUNTY	-	49,900	SAN JUAN COUNTY	-	68,700
Gallup	-	17,600	Grants	-	11,700	Farmington	-	29,700
Thoreau	-	700	Milan	-	3,500	Bloomfield	-	3,000
Prewitt	-	300	Bluewater	-	300	Aztec	-	6,400
Ft. Wingate	-	800	San Rafael	-		Kirtland	-	4,000
Reservation:			San Mateo	-		Reservation:		
Crownpoint			San Fidel	-		Shiprock		
(Navajo)	-	3,100	Cebolleta	-		(Navajo)	-	5,000
			Reservations:					
SANDOVAL COUNTY	-	24,400	Laguna	-	6,059	BERNALILLO		
Cuba	-	1,200	Acoma	-	3,408	COUNTY		
			Canoncito	-	1,030	Albuquerque	-	326,047
RIO ARRIBA								
COUNTY	-	28,100						

Total area affected from standpoint of population impact:

Population of 5 counties	-	229,100
14 towns and Albuquerque	-	413,347
14 towns only	-	87,300
Northwest New Mexico and Albuquerque	-	555,147

Note: Town populations estimated to include contiguous residential areas.

Table VII-5

Navajos Affected by Uranium Development by 1980
(Based on 1978 Chapter Populations)

Eastern Navajo Agency

Becenti	615	Smith Lake	763
Standing Rock	932	Thoreau	948
Dalton Pass	537	Iyanbito	1,069
Crownpoint	869	Church Rock	1,668
Pinedale	1,477	Baca	926
Mariano Lake	867	Casamera Lake	793
Littlewater	912	Whitehorse Lake	963
		Number Affected:	13,339
		(Total Agency Population):	30,395

Shiprock Agency

Sanostee	2,347		
		Number Affected:	2,347
		(Total Agency Population in area):	29,430

Ft. Defiance Agency

Coyote Canyon	1,414		
		Number Affected:	1,414
		(Total Agency Population in area):	7,590
		Total Affected by 1980 Uranium Development:	17,127
		Total Chapter Populations in area:	67,415

Table VII-6

Rural-Urban Population Distribution - 1977

	McKinley County	Valencia County	San Juan County	Sandoval County	Rio Arriba County
Rural	55%	62.1%	39%	100%	80.1%
Urban	45%	37.9%	61%*	---	19.9%

*Due to population of Farmington.

Source: U. S. Department of the Interior, BLM, 1979.

Rural areas in McKinley County, western Valencia County, and part of San Juan County are inhabited by Navajos and a few non-Indian ranchers.

As shown in Table VII-7, the populations of four of the five counties have grown significantly since 1950. San Juan County, with a growth of more than 270 percent from 1950 through 1977, led the way.

Table VII-7

Past County Population Growth

	McKinley County	Valencia County	San Juan County	Sandoval County	Rio Arriba County
1950	27,451	22,481	18,292*	12,438	24,997
1960	37,209	39,085**	53,306	14,201	24,193
1970	43,208	40,539	52,517	17,492	25,170
1977	58,000	49,700	68,700	24,400	28,100

*Grants: First Uranium Boom and Decline.
**Oil and Gas Boom and Stabilization.

Source: U. S. Department of the Interior, BLM, 1979.

The other counties experienced population increases of 90 to 120 percent in that period. Growth has been sporadic, however, accompanying local economic cycles. In general, growth occurred in the 1950's, followed by stagnation and even decline in the 1960's. The 1970's saw a resurgence. This alternating growth and stagnation reflects the expansion and contraction of the regional economy, mainly due to changing demand and supply involving the area's mineral resources.

Backgrounds of Inhabitants

History. The various sectors of the population listed in Table VII-3 represent historic incursions into the San Juan Basin region, motivated by a quest for land and resources. Details on prehistoric occupations of the area and a brief review of early historic episodes are contained in Chapter X. Indians occupied the area before the first European explorers arrived in the 1500's. In the words of David Brugge, chief curator, National Park Service, Southwest Regional Office:

> While Spain claimed sovereignty over this area even prior to the 1600's, most of it remained under effective Indian tribal control until the late 1800's. There was no significant Spanish settlement within the region until well into the 1700's and that about the edges only. There was no significant Anglo-American settlement until the 1870's.

The latter 19th century saw the cultural milieu transformed as Hispanic settlers moved in from the Rio Grande Valley, and as Anglo ranchers, farmers, and businessmen settled in the San Juan River area and in the area between Gallup and Grants. Many Mormons were among the latter. Important in basin development were the arrival of the railroads and the start of coal mining in the 1880's. These events brought cultural diversity with arrivals of Slavs, Irish, Welsh, Italians, some Blacks, and Chinese. In the 1920's, shortly after New Mexico's admission to the Union, Anglo homesteaders arrived from other states.

For a century, these three broad cultural groups--Spanish, Indian and Anglo--shared in a primarily agrarian lifestyle. Each maintained a large measure of independence; separate languages, value systems, and religious traditions persisted. Recent minerals development has resulted in the in-migration of Anglos from outside northwest New Mexico. At the same time, small-scale and subsistence ranching have become less feasible economically, forcing rural residents of all backgrounds to migrate into urban areas to obtain work.

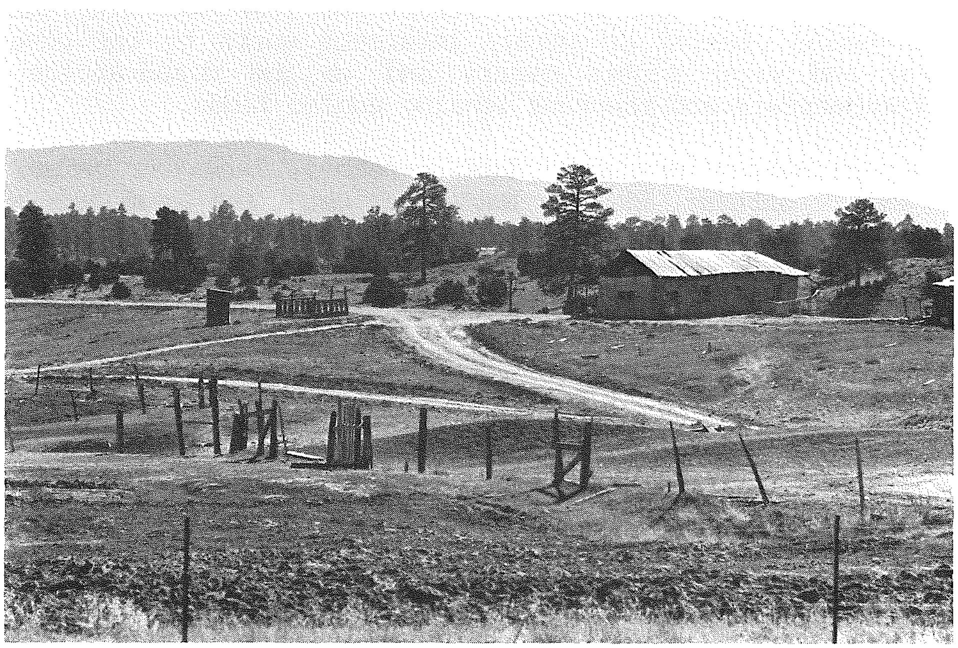


Figure VII-6.--Hispanic ranch site near Cuba, N.M.

Land and Jobs Competition. In the late 19th century, land occupation became more "fixed" as the area was legally divided into public domain, reservations, privately owned lands and land grant lands. The eastern boundary between the Navajo reservation and public lands has shifted radically on three occasions. The Navajo reservation was established by treaty in 1868. Executive orders in the early 1900's extended the boundaries for Navajo occupation eastward almost to the Rio Puerco, but in 1911 these were revoked. Recently the Navajo tribe has purchased much of the old homestead

ranching area to re-extend Navajo lands eastward. These are managed as tribal ranches and are not open to Navajo occupation on a family basis.

The changing reservation boundaries had only limited effect on Navajo settlement, but they did affect the legal status of that settlement and the areas and nature of competition with white settlers, according to Brugge. Whether land status presented a constraint at a given time depended on who benefitted from boundary changes. (Bliss, 1979, No. 42; Maynard, 1978, No. 29)

The Indian, Spanish, and Anglo people periodically engage in disputes over rural lands. The Indians seek to reclaim historically occupied areas through purchase and land exchanges, and the Spanish assert rights to land grant holdings. The BLM and Forest Service are sometimes caught between the claims of these parties and of Anglos who use the public lands. Current questions arise as to tribal jurisdiction on allotted lands and state jurisdiction on Indian lands.

Off reservation, as small scale agriculture and ranching have become less economical, a rural land base in itself has lost much economic attraction. The demand created by energy interests works to the advantage of some mineral and water rights owners and to the disadvantage of some displaced sheepherders and ranchers leasing public lands.

As the reservation population has increased, land has become both an advantage and constraint for the Navajo tribe. The land and population provide a base for determining federal benefits. The land also defines legal tribal sovereignty and is important to tribal identity. On the other hand, the Navajos' rapid population growth has outstripped the subsistence agrarian economy. As the land base declines on a per capita basis, more Navajos will have to enter the growing local wage economy to continue to live in the region. The influx of energy workers, Indians and Spanish into the area's towns is creating a new form of competition for jobs, housing, and credit.

Recent Social Trends. Increased energy development and economic growth bring newcomers and more wealth. This encourages development of an economically prosperous middle class in all cultural groups. The growth is seen in urbanization of increasing complexity and in the filling in of the rural landscape, especially along I-40, U.S. Highway 550, and the area between Crownpoint and Thoreau.

Another trend that must be taken into account is minority activism begun during the War on Poverty of the 1960's. On the Indian reservations, it takes the name of "Tribal Sovereignty" or "Self Determination." This is an ideological, political, and administrative effort, aided by the federal government, to develop the capacity of tribes and their members to take over and manage government, public services, development or any other factors shaping their lives and destiny.

Anyone dealing with a reservation, such as a company, should gain an understanding of how this complex new grassroots-oriented ideology is being used to refocus outside relationships to tribes as relationships to a

sovereign entity. The trend is a powerful one fully backed by the federal government and undoubtedly will continue into the future, with influence on the nature of future relationships between tribes and non-Indian entities.

Minority activism by Spanish American residents in the south and east parts of the basin and around Farmington has not had the same force or emphasis on land based separatism but has pressed for more jobs and social services sensitive to Hispanic needs. Spanish Americans in Rio Arriba County have focused intense activity around claims associated with Spanish land grants.

Structure of Community Interrelationships. Although there is little inter-ethnic mixing in the San Juan Basin, there are rural to village to urban linkages--tending to be economic in nature--that hold the territory together and tie into the mainstream of American life. (For key towns and their characteristics see Table VII-8.)

Farmington is the most urbanized town, followed by Gallup and Grants. In the north, Shiprock, Kirtland, Bloomfield, and Aztec relate to Farmington as a "higher order central place" or provider of more complex goods and services. Gallup is the central focus for the southwestern part of the basin, drawing trade from the Crownpoint, Thoreau, Fort Wingate, Window Rock, and Gamerco areas. Grants is a focus for Prewitt, Bluewater, small Spanish towns and rural dwellers of the southeastern basin, competing with nearby Albuquerque, Farmington, Gallup, Grants and Cuba. All relate to Albuquerque as the central source of goods and services for the basin.

Shiprock and Crownpoint can be considered "underdeveloped" compared to off-reservation towns their size, due largely to the lower income of surrounding residents and the difficulties of setting up a business there (Gibson, 1978, No. 47, 1980, No. 62; Griffith, 1978, No. 52).

Inter-Ethnic Relations. Indian people associate with each other across tribal lines through the schools, employment, varied activities in Indian professional or citizen groups, and at dances, rodeos, pow-wows, and ceremonials. Their relationships to the Anglo culture often come in connection with sales, commerce, and services in the off-reservation towns, or through attendance at public schools off the reservation. Employment also is a frequent link between the Indian, Anglo, and Hispanic elements. Aside from economically or through the schools, Anglo interaction with Indians might be considered as minimal in terms of numbers.

Small Hispanic communities in the basin are largely insular and family based. Hispanic people are part of a hierarchical cultural system in the state involving old and influential families organized along economic and political lines. These relationships are a source of protection and advancement. (Gibson and Leonard, 1980, No. 62)

Relations between individuals in the three groups are sometimes strained. While Spanish-speaking Americans are aware of possible discrimination and have long had occasional friction with Indians, the more visible and publicized tensions appear to exist between Indians and Anglos. Incidents, ranging from insults to violence, occur in border town schools and

Table VII-8

Key Characteristics of Basin Towns

Region	Towns	Region	Towns
South Basin (Along) Highway I-40, old route 66).	Grants (City), Milan (Village): Grants began as a town serving the railroads at the turn of the century and later as a stopping point along Route 66. Both grew substantially in the 1950's with development of extensive uranium deposits around the slopes of Mount Taylor and in Ambrosia Lake. In addition, unincorporated areas such as San Mateo and San Rafael were the sights of subdivision and settlement. Bluewater (Village): Bluewater began as a small Mormon farming village, and also now houses employees at the local uranium mill. Prewitt is a small town composed of Anglo homesteaders. Thoreau (Unincorporated): This town is composed of Anglo homesteaders, workers on the El Paso gas pipeline, Navajo residents, students and teachers at the BIA boarding school, and uranium miners in the Gulf subdivision.		Fort Wingate (Village): Fort Wingate is a small town associated with the Fort Wingate Military reserve and BIA Boarding School. There are military workers, Anglo teachers and off-reservation Navajos. Gallup (City): Gallup has historically been the largest of the Basin towns, growing up around a station on the transcontinental Atlantic & Pacific Railroad. The city prospered as a mining center, a rail shipping point, and a market (or so-called "border") town for Navajo and Zuni Indians from nearby reservations. By 1900, it had surpassed in size the Zuni Pueblo located 43 miles south whose 1977 estimated population of 4,200 was approximately the same as was reported by Coronado in 1540. Additional retail trade was developed for tourists and traders along Route 66. Since 1960, Gallup has been replaced by Farmington as the largest city in northwestern New Mexico. Gallup remains an important administrative and commercial center for McKinley County and nearby portions of Arizona. There are also a large number of Federal professionals and administrators serving Indian needs.
North Basin	Farmington (City), Aztec (City), Bloomfield (Village), Kirtland (Unincorporated); San Juan County possesses three major communities: Aztec Bloomfield and Farmington. They form an urbanizing triangle near the confluence of the Animas and San Juan Rivers. This area was settled by Mormon farmers who developed the bottomlands along the two rivers with irrigation systems in the late nineteenth century. Their settlements remained Mormon and agricultural until the 1950's when Farmington became a focal point of oil and gas exploration. The city's population increased by 654 percent in that decade, from 3,637 to 23,786 persons. After oil and gas production peaked in the 1960's, growth slowed and there was a net migration from the area. However, the more recent development of coal-fired power plants like the Four Corners and San Juan Generating Stations, and of nearby coal mines, has prompted new population increases.	East Basin Hispanic Towns	Cuba (Village): A fourth community which has grown in recent years due to mine investment is the Village of Cuba in Sandoval County. However, the mineral resource which was developed at Cuba was copper, not coal or uranium. The 1971 opening of the Nacimiento Mine of Earth Resources Company stimulated the economy of the area significantly, and the population of the Village of Cuba increased by nearly 33 percent in the early 1970's. Operations of the copper mine have been discontinued, and there is apparently little likelihood that they will be resumed soon. However, even after the mine's closing, Cuba's growth has continued, due to the stimulus of minerals exploration in the region generally, and in the La Ventana and Star Lake coal fields in particular. Others; San Rafael, San Fidel, Cebolleta, LaVentana San Mateo, Cubero, Bibo, Blanco, San Ysidro
Navajo Reservation	Shiprock (Unincorporated): Shiprock, a reservation agency town set up to centralize administrative services to Navajos, has become the largest town on the Navajo Reservation. This is due to the recent migration of Navajos from western Chapters seeking energy related employment in the area.		Crownpoint (Unincorporated): For many years the headquarters of the Eastern Navajo Agency of the Bureau of Indian Affairs, and the trade center for the 12,000 Navajo who live in northern McKinley County, Crownpoint has grown recently with mine investment in the vicinity.

Source: Adapted from Harbridge House, 1978.

commercial and recreational areas, where they most frequently come into contact with each other.

One reason for conflict in Indian-Anglo relationships is variance in economic and political interests, with Indians often regarding themselves as at a relative disadvantage. Additionally, Anglo residents include recent arrivals who are unfamiliar with the region and its cultural history. To them, the values, beliefs, and customs of the Indians often seem alien and incomprehensible (New Mexico Advisory Committee, 1975). Some Anglos may feel that public assistance, medical care, and other benefits received by Indians constitute preferential treatment at the expense of non-Indian taxpayers, rather than treaty and legal rights.

One factor that promotes negative attitudes among some non-Indians is alcohol abuse (Table VIII-10). Liquor is illegal on the Navajo reservation by vote of the tribal council. The heavy public drinking in and near the border towns makes non-Indian observers particularly conscious of the problem and leads to many law infractions and arrests. Non-Indian drinking, by contrast, is more likely to occur in homes, clubs, or bars than on the streets. While both non-Indian and Indian residents acknowledge the existence for some two decades of a serious problem (delegations of Navajo parents have futilely petitioned the New Mexico legislature for relief), a political consensus on the solution has never been reached.

Key Ethnic Values and Lifestyles: Anglo. In this brief discussion of cultural characteristics of key ethnic groups, differences in values and attitudes are stressed since these often represent underlying causes for friction and misunderstanding.

Pre-energy development (1950) Anglo residents are largely ranchers, farmers, and retail traders in the towns. They value independence, self-sufficiency, equality, hard work, and asceticism. Often the ranchers take part-time jobs in times of economic trouble.

Energy related Anglo in-migrants include "Easterners," professional managers. Others from the East include federal employees serving the Indian communities. They often have urban values and high expectations of the public infrastructure and services. Other energy related in-migrants include blue collar tradesmen and construction workers from eastern states. The northern half of the basin has also seen a large influx of oil and gas workers from Texas and Oklahoma. The latter two categories often lack experience in a diverse ethnic setting.

Uranium Miner Subculture--An effort to determine the effect of uranium mining on a miner's values and behavior led to a decision to give special attention to this subculture (Gibson, 1979, No. 44) which comprises up to half of the population of Grants. Attracted by high wages, the miners include local Indians, Hispanos, Anglos and migrants from Canada, West Virginia, Missouri, and copper mines in the West. At work, they have the reputation for being tough, resilient, hard working, risk taking and isolated.

The incoming Anglos retain close ties to their places of origin, are highly mobile among companies and towns, and tend to be mobile home dwellers. Relatively young, they rely on their own families for social support. They are relatively integrated at the work sites. Politically, they are not opinion setters but are active voters and are respected as the backbone of the Grants economy. Off duty, many miners drink socially and after work in bars; they are sometimes criticized as "heavy drinkers and free spenders."

Key Ethnic Values and Lifestyles: Hispanic. The Hispanic people of the area are traditional longtime residents, many of whom own small stores, ranches, and farms. They move from rural areas to find work. They experience close family ties, and the Roman Catholic Church is often the social focus of the town. The Spanish language symbolizes a strong cultural bond. These residents are experiencing a growing awareness of their minority status. (Gibson, 1979, No. 62)

Key Ethnic Values and Lifestyles: Navajo. The Navajo are essentially rural dwelling but with increasing tendency to live in or near communities where work may be found. Their orientation is to their extended family and clan. Often the extended family is headed by traditional grandparents living on the reservation, with younger skilled and semi-skilled children

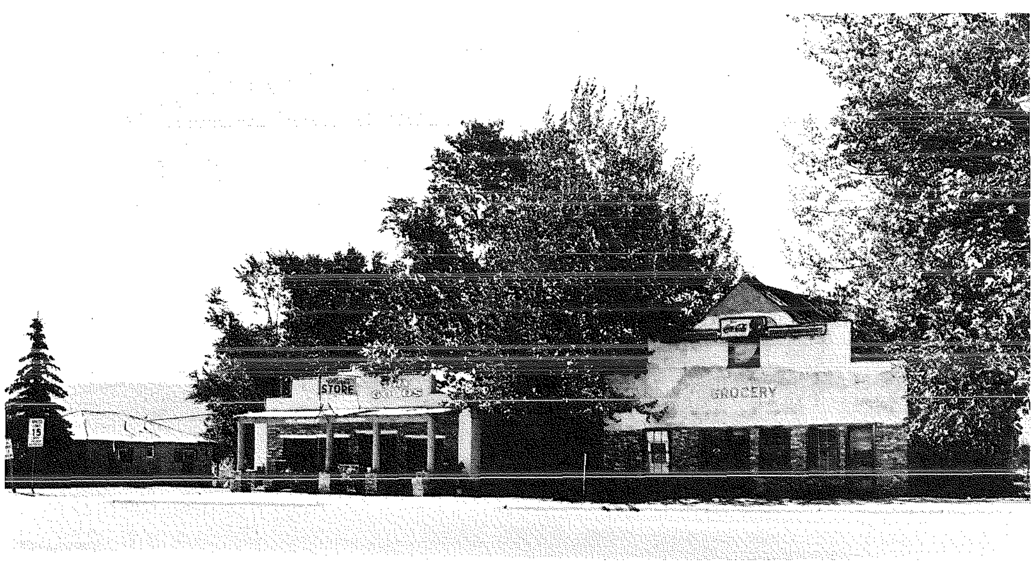


Figure VII-7.--Hispanic influence seen in the buildings of Cuba, N.M.

working off-reservation. Extended families are stressed by but also adapting to incursions of the modern wage economy. These families are linked to specific territorial areas.

Individually, Navajos can be highly communal, individualistic, or opportunistic, depending on circumstances. There is a tendency to spread "decision" and "blame" risk, and to be non-confrontational in interpersonal relations; to withdraw and await clues to an outcome before commitment.

Local autonomy is valued, and authority is not readily delegated to distant organizations. Authority in general is distrusted. This leads to heavy grassroots criticism of tribal government. There is a general tendency to feel alienated from decision making over their lives, but they are very aware of Indian "self-determination" and "sovereignty."

Among Navajos, promises are rarely made and are expected to be kept. There is a reluctance to predict the future. People are expected to share material goods.

A revitalization of Navajo culture is causing some people to return home, increasing the pressure on the land base. There is high unemployment. Title to the land is identified with preservation of their identity and way of life. Sheep raising not only supplies meat but also is a type of "bank account" and provides a significant role for elders.

Navajo Sociocultural Landscape--Non-Indian newcomers to the reservation often lack understanding of the complexities of Navajo kin relationships as they relate to local territory. These newcomers may rely on visiting meetings of the chapter as a means of making connections in an area. This may not suffice, however, since extended family networks may cross-cut chapter boundaries. Also, one or two influential family networks may be choosing not to participate in their local chapter at the time.

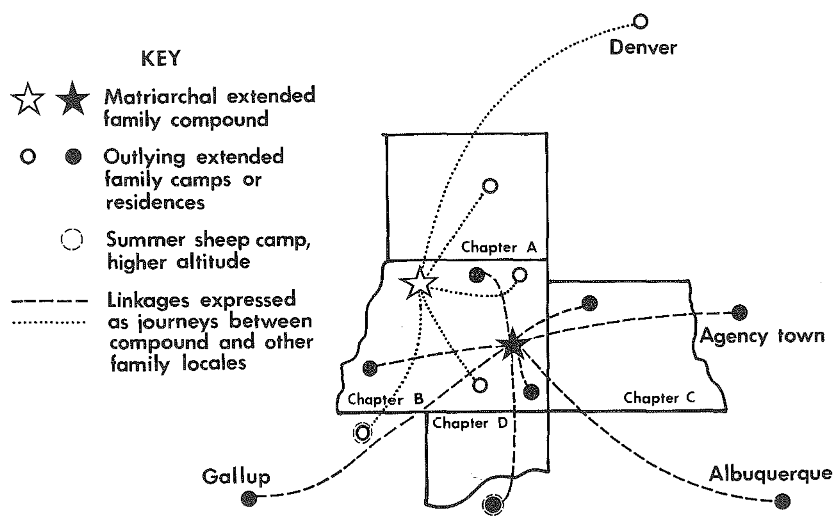


Figure VII-8.--Typical residence patterns of Navajo extended family

Figure VII-8 shows the extended family living in several camps, which may or may not lie in one continuous area of land. These rural networks have outposts of relatives living in the reservation border towns, or farther away in Albuquerque, Los Angeles, or Denver. These are the younger skilled workers who left for financial opportunities but maintain their family ties by visiting, sending money for aging parents, moving home between jobs, and so on. Typically several matrilineal extended families

live in a chapter area. Marriages between families in different chapters widen the network of kinsmen.

On the reservation, the area occupied by a Navajo extended family is called a "customary use area." The tribe holds title to the land and gives permission for its use. Off-reservation Navajo family holdings may be a composite of leased lands and owned allotted lands. "Allottees" participate in the chapter system and are members of the tribe.

In small chapters one or two families may dominate, whereas in larger chapters personality becomes more crucial. While factions are found, they tend to be unpredictable. Navajos reserve the right to change their minds and swing back and forth as different facts are presented and viewpoints evolve.

Linkages within the Basin

Residents of the sociocultural landscape are connected to governmental politics and service by voting, lobbying, and the demand for public services (Figure VII-2). On the Navajo reservation and on allotted lands, politics is important at the chapter and tribal levels. There are increasing demands on the reservation for consideration of grassroots needs in tribal government. Elsewhere, county and municipal politics is paramount. The off-reservation local political scene experiences pressures for more social controls such as planning.

General awareness of energy developments in the basin depends mainly on the press and informal information networks. The Gallup Independent, Navajo Times, Grants Beacon, and Farmington Times give extensive coverage to local energy development (Myers and Silva, 1980, No. 55). Until recently, however, there was a lack of factual, in-depth research and of educational programs on the complexities behind reported events. This may have contributed to an apparent tendency to polarize into pro and anti energy development camps.

Linkages to State and Nation

Politically, the residents of northwest New Mexico do not represent a power bloc in New Mexico. However, the Navajos are the largest and most influential tribe in national inter-tribal affairs.

National attention has been drawn to New Mexico on such uranium-related matters as the nuclear waste disposal site selection, the Peshlakai lawsuit questioning environmental reviews, radiation exposures affecting uranium miners near Shiprock in the 1950's, the Church Rock tailings dam break, and demonstrations for or against nuclear power in the Grants area. People on the scene expressed considerable dissatisfaction with the quality of some reporting on their affairs at the national level.

IMPACT ANALYSIS - KEY CAUSES OF IMPACTS AND SUBSEQUENT RESPONSES

Impacts from uranium exploration, mining, and milling on the sociocultural landscape would be caused: 1) by the presence of these operations

in specific rural areas; and 2) by the resulting population increases in nearby towns.

Map VII-4, compared with Map VII-1, shows projected expansion of uranium development activities on Navajo lands to the northwest, Hispanic lands to the east, and the largely Anglo lands in the center by 2000. This expansion is based on the assumed levels of uranium demand outlined in Chapter II.

Impacts can be viewed subjectively, in terms of ethnic reactions to the presence of the activity and possible conflicts with values or life-styles, for example, or objectively, centering around population growth-related aspects.

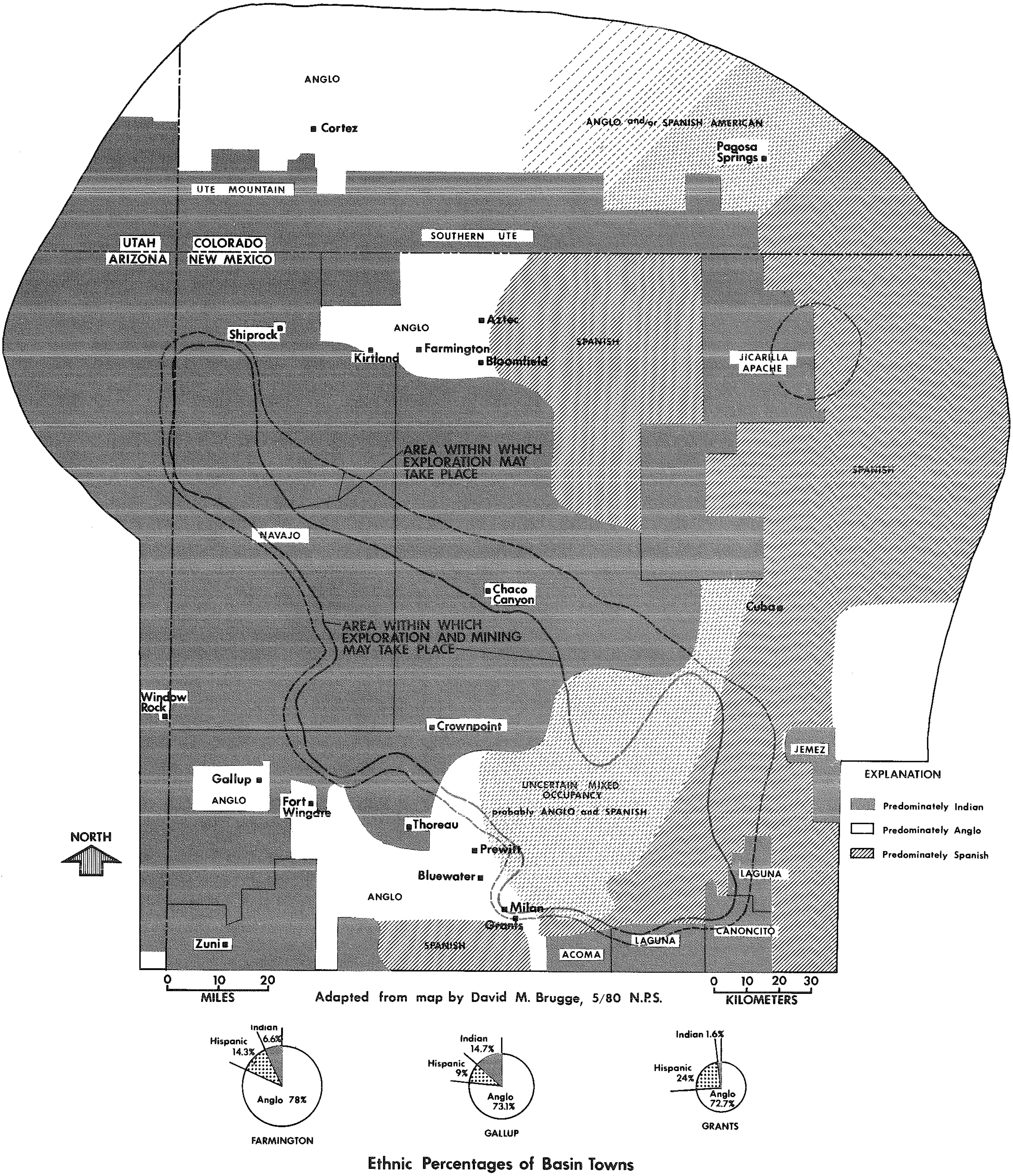
Subjective reactions can be predicted based on an ethnic group's previous experience with uranium development cycles and whether there is a predisposition to welcome the possible economic benefits of jobs, wages, and royalties (Knight, 1980, No. 49).

Non-Indian urban areas such as Gallup and Grants generally welcome development and understand its implications from past experience. In Anglo rural areas, the reception of possible development hinges a good deal on whether ranchers or farmers will benefit from purchase of water and mineral rights or must share public land grazing areas with mining companies. Perhaps a majority in small Hispanic towns welcome development as offering employment, although with reservations about Anglos living in their communities (Gibson and Leonard, 1980, No. 62).

Some Navajos in Shiprock display a no-growth attitude resulting from unpleasant experiences with early uranium mining and current coal related development. Navajos around Crownpoint and the eastern Navajo country have had limited experience with uranium. Their outlook is ambivalent; they express strong distaste for the effects of exploration on their lands but are interested in future prospects for much needed jobs. They also worry over the effect of large numbers of outsiders on their way of life (George, 1979, No. 36).

Concern over population growth or objective-numerical impacts is evidenced by all towns in the area. Towns such as Grants and Gallup have experience with cyclical planning problems. Reservation towns such as Shiprock, Crownpoint, and part of Thoreau, however, have the added anxiety of dealing with this for the first time.

This distinction thus emerges. For Anglo urban areas, it is the pace of development that is crucial. Uranium development can be expected to be welcomed if rapid enough to provide economic growth but slow enough to avoid unfavorable side-effects associated with the boom syndrome. For the rural Navajos, by contrast, the intrusive presence of the activity in itself, the feeling of not understanding what it entails, and the attitudes thus engendered are crucial.



Map VII-4.--Sociocultural landscape affected by uranium development, 2000

Population Growth Impacts for Three Energy Growth Levels

Table VII-9 indicates energy related population growth figures for various parts of the study area assuming three potential levels of development: Without further uranium or coal development (a baseline projection for comparison purposes); Moderate uranium and mid-level coal development; and High uranium and high coal development. Most town growth in the north part of the basin would result from coal-related development. Most of the southern growth would be due to uranium, although coal would be a factor.

The population projections result from a computer analysis which produced trend lines. Growth rarely falls into such neat patterns, subject as it is to unpredictable factors and decisions. Hence, actual populations for any locality may fall above or below the trend line for a given year. The upswinging curve indicated by the computer should emerge in time, however. As in the case of uranium projections, for advance planning purposes specific time periods are less significant than the level and rate of population growth.

Key Growth Patterns

As summarized in Tables VII-10 and VII-11 derived from the computer projections, population growth is not expected to alter the basin's relative standing populationwise in the state of New Mexico.

Figure VII-9 indicates San Juan, McKinley, and Valencia counties would experience some growth stress between 1980 and 1990 at the High level of development, and Valencia and McKinley counties would do so between 1985 and 1990 at the Moderate level.

Table VII-12 shows where the most significant growth impacts, with growth rates greater than 15 percent per year, could be expected among the smaller basin towns along the I-40 corridor. Percentages shown are for a 5-year span. Figures above 100 percent indicate growth exceeding 15 percent annually, with population doubling in five years.

Small Town Growth Stress

Uranium-stimulated growth could occur along the I-40 corridor due to the opening up of uranium development more closely to the center of the basin than has occurred in the past. Growth stresses could result in small towns located between future mines or mills and Gallup and Grants, the leading sources for goods and services short of Albuquerque.

With Moderate development, Prewitt, Bluewater, and Thoreau might experience growth rates exceeding 15 percent per year in the latter 1980's. At the High level, Prewitt, Thoreau, Crownpoint, Fort Wingate, Milan and Bluewater might experience growth rates greater than 15 percent in the mid-1980's. The character of these communities would change rapidly, and they would emerge from small villages to a status more nearly that of outlying suburbs to Gallup or Grants.

Table VII-9

PROJECTED SAN JUAN BASIN AREA POPULATION GROWTH
1978-2000
Without further development; Moderate U_3O_8 and Moderate Coal, etc.; High U_3O_8 and High Coal, etc.

Towns:

McKINLEY COUNTY

	GALLUP			THOREAU			PREWITT			FT. WINGATE			CROWNPOINT		
	W/O	Medium	High	W/O	Medium	High	W/O	Medium	High	W/O	Medium	High	W/O	Medium	High
1977	17,600	-	-	700	-	-	300	-	-	800	-	-	3,100	-	-
1980	18,463	18,470	19,319	706	710	1,105	412	416	824	1,117	1,121	1,560	3,234	3,245	3,937
1985	19,908	20,894	24,178	761	1,397	3,736	444	1,139	3,790	1,205	1,728	3,446	3,487	5,134	10,235
1990	21,352	24,065	27,501	816	3,302	6,159	476	3,058	6,131	1,292	2,857	4,888	3,740	8,959	16,094
1995	22,451	25,994	29,933	858	4,556	8,205	500	4,371	7,918	1,358	3,568	6,161	3,932	11,501	20,395
2000	23,581	27,284	30,412	901	5,014	7,983	526	4,814	7,639	1,427	3,827	5,974	4,130	12,617	19,731

SAN JUAN COUNTY

	FARMINGTON			BLOOMFIELD			AZTEC			KIRTLAND			SHIPROCK		
	W/O	Medium	High	W/O	Medium	High	W/O	Medium	High	W/O	Medium	High	W/O	Medium	High
1977	29,700	-	-	2,200	-	-	6,400	-	-	4,060	-	-	5,100	-	-
1980	31,345	31,349	31,950	3,142	3,143	3,360	6,783	6,785	7,040	4,213	4,215	4,565	5,284	5,286	5,443
1985	34,944	35,392	38,707	3,502	3,673	5,014	7,562	7,769	9,303	4,696	4,888	7,080	5,890	6,013	7,282
1990	37,403	38,812	44,705	3,749	4,352	7,380	8,094	8,867	12,033	5,026	5,744	9,506	6,305	6,994	9,742
1995	39,290	41,908	48,106	3,938	5,137	8,474	8,502	10,001	13,404	5,280	6,702	10,893	6,623	8,299	12,291
2000	41,310	44,063	49,203	4,140	5,469	8,434	8,940	10,561	13,578	5,552	7,106	10,850	6,963	8,714	12,143

VALENCIA COUNTY / SANDOVAL COUNTY / BERNALILLO COUNTY

	GRANTS			MILAN			BLUEWATER			CUBA (SANDOVAL COUNTY)			ALBUQUERQUE (BERNALILLO COUNTY)		
	W/O	Medium	High	W/O	Medium	High	W/O	Medium	High	W/O	Medium	High	W/O	Medium	High
1977	11,700	-	-	3,500	-	-	300	-	-	1,200	-	-	(78) 326,042	-	-
1980	12,657	12,668	13,955	3,766	3,774	4,717	366	370	880	1,362	1,366	1,617	347,500	347,512	348,429
1985	15,125	17,429	23,946	4,500	6,200	11,239	438	1,356	4,640	1,795	2,025	3,413	410,500	411,996	417,463
1990	17,254	24,421	27,029	5,134	10,596	13,684	499	4,087	7,346	2,025	2,558	4,853	456,168	461,772	464,228
1995	18,513	27,055	30,600	5,508	12,332	15,466	536	5,913	9,305	2,183	3,327	6,122	506,347	512,363	515,530
2000	20,014	28,717	31,192	5,954	12,991	15,218	579	6,462	8,939	2,351	3,578	6,049	562,045	568,202	570,605

Counties:

	McKINLEY COUNTY			SAN JUAN COUNTY			VALENCIA COUNTY		
	W/O	Medium	High	W/O	Medium	High	W/O	Medium	High
1977	58,000	58,000	58,000	68,700	68,700	68,700	49,900	49,900	49,900
1980	58,800	58,830	61,613	71,400	71,411	72,991	52,300	52,323	55,063
1985	63,400	67,087	82,980	79,600	80,741	90,392	62,500	67,422	82,262
1990	68,000	82,565	101,089	85,200	89,392	107,989	71,300	87,517	97,272
1995	71,500	92,390	115,012	89,500	97,914	119,115	76,500	97,213	107,314
2000	75,100	98,091	116,247	94,100	103,108	121,403	82,700	104,323	111,502

Larger Areas:

	TOTAL GROWTH: 14 Basin Towns excluding Albuquerque			TOTAL BASIN AREA: Including 14 Towns, Albuquerque and rural		
	W/O	Medium	High	W/O	Medium	High
1977	87,300	-	-	413,347	-	-
1980	92,850	92,918	100,272	440,350	440,438	449,520
1985	104,257	115,032	156,009	514,757	528,243	579,146
1990	113,165	148,672	197,851	569,333	614,382	670,795
1995	119,472	170,664	227,353	625,819	688,412	753,741
2000	126,368	181,217	227,345	688,413	755,093	807,489

	STATE POPULATION		
	W/O	Medium	High
1978	1,212,600	-	-
1980	1,266,600	1,266,680	1,275,770
1985	1,403,100	1,416,591	1,467,489
1990	1,539,000	1,584,049	1,640,462

Source: Gibson, No. 16.

Table VII-9

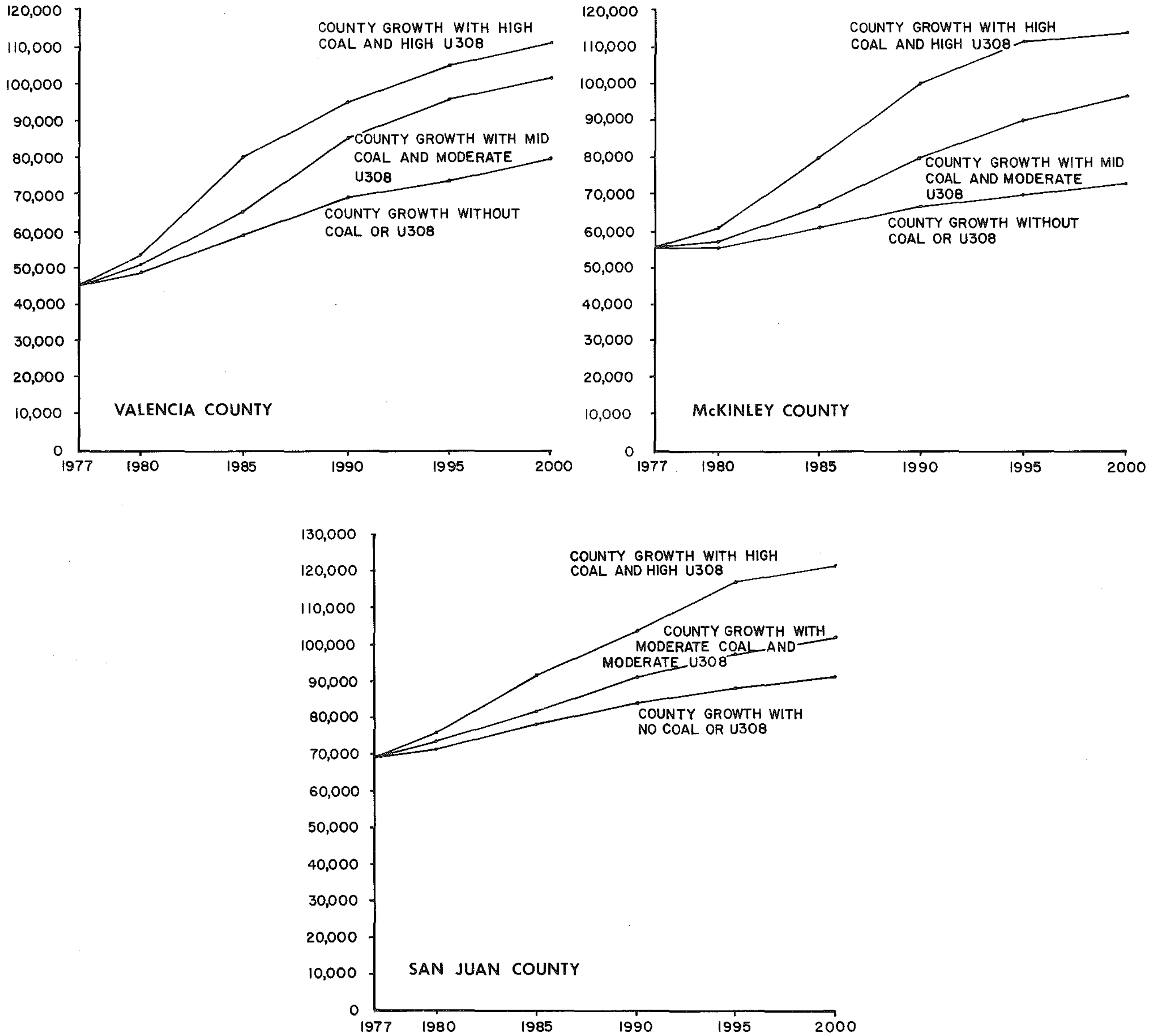


Figure VII-9.--San Juan Basin county population curves

Table VII-10

Growth Rate of 14 Basin Towns As Percent of State Population

	W.O.	Moderate	High
1977±	7%	--	--
1980	7%	7%	8%
1985	7%	8%	11%
1990	7%	9%	12%

Table VII-11

Growth Rate of Albuquerque As Percent of State Population

	W.O.	Moderate	High
1977±	27%	--	--
1980	27.4%	27.4%	27%
1985	29%	29%	28.4%
1990	30%	29%	28%

Table VII-12

BASIN TOWN GROWTH STRESS CHART
(Towns with greater than 15% growth rate per year)

MODERATE DEVELOPMENT - U_3O_8, Coal, etc.	McKinley County	Valencia County	HIGH DEVELOPMENT - U_3O_8, Coal, etc.	McKinley County	Valencia County
1980 to 1985	Prewitt (174%)	Bluewater (266%)	1980 to 1985	Prewitt (360%) Thoreau (238%) Ft. Wingate (121%) Crownpoint (160%)	Milan (138%) Bluewater (429%)
1985 to 1990	Prewitt (168%) Thoreau (136%)	Bluewater (201%)	1985 to 1990		
1990 to 1995			1990 to 1995		
1995 to 2000			1995 to 2000		

The degree of stress caused by the changes would depend largely on the inhabitants' ability to mobilize resources for such greatly increased community needs as streets, sewers, water supplies, housing, and local government. One intangible that could accentuate pressures on the rural communities of Thoreau, Prewitt, Bluewater, and Milan and cause them to grow even more rapidly might be constraints imposed on development of Crownpoint and Fort Wingate by a shortage of non-Indian lands suitable for development.

The development of Crownpoint is difficult to project with any assurance of accuracy. Growth there would probably be mostly Navajo. Companies seem sufficiently aware of the racial and service delivery difficulties in subsidizing "new towns" for non-Indians on the reservation (Gibson, Rev. 1978, No. 16).

Accurate growth projections for Crownpoint would require administrative decisions on questions such as: What is the present natural growth rate? What is the current skilled-unskilled Navajo labor pool? How rapidly could unskilled workers be trained for skilled openings? What percentage of on-reservation jobs will be filled by Navajos? To what extent will Navajo miners choose surface coal mining over underground uranium mining? How many western Navajos will be drawn to the area to seek work, and where will they live? How many extended family members will come live with Navajo uranium miners?

In view of the many imponderables, the study team feels the Crownpoint population projection is uncertain, and the eventual growth could vary downward from the levels cited.

Impacts on larger towns of the lower basin are expected to be eased by the fact that most have previously experienced the growth-decline cycle in uranium activity. They tend to have some excess capacity in their services as a result. Partly because of this, a sudden drastic boomtown atmosphere

as attributed to Gillette, Wyoming, is not anticipated in the San Juan Basin. Nor are the basin towns isolated. (Gibson and Knight, 1980, No. 67)

The cultural conflict seen in Wyoming between ranchers and miners or construction people is not anticipated in the San Juan Basin. The towns generally favor development. Conflicts in rural areas would more likely be between Indian and mining interests.

<u>Changes in the Structure of Community Interrelationships</u>

The general relationships of smaller to larger towns cited earlier would be maintained; however, increased population would make the growth centers increasingly attractive in terms of amenities. By 2000 Gallup would be much like the Farmington of today (Gibson, 1979, No. 47).

These towns would grow horizontally along existing boundaries, creating a sprawl of subdivisions of houses and mobile homes, with outlying shopping centers. A need for planning and zoning controls would arise.

There would be no new towns, but a filling in of population corridors along highways.

Growth would bring possible socioeconomic and geographic stratification to the smaller areas; neighborhoods based on income, age, or perhaps race would develop along with a commercial sector. Shiprock and Crownpoint would probably continue to lag in complexity for their size due to the continuing higher percentage of low income people in their areas and the constraints imposed by a lack of development-worthy private land.

SOCIOCULTURAL LANDSCAPE WITHOUT FURTHER URANIUM DEVELOPMENT

A tapering off of uranium development in the San Juan Basin would inhibit or virtually end exploration activity, source of much of the discontent among Navajo rural residents. Construction of new mines and mills also would stop. A result would be elimination of employment opportunities projected with increased development, with blunting of the area's overall growth and the departure of many younger residents in search of employment.

Non-uranium development, including coal mining and electric power generation, would continue and would nullify any "bust" scenario until after 2000. The ethnic makeup probably would not change much from the present, although construction and coal mining workers from other areas could introduce frictions along the lines of those discussed under the Moderate projection. Table VII-13 summarizes impacts that could be expected from coal-related activity alone.

Possibly the most severe individual impact under this assumption would involve relocation of 500 to 600 families to permit stripmining of coal. To make coal mining and construction possible, about 250 to 300 families are expected to be moved from their camps on the Navajo reservation, primarily, and about the same number from off-reservation homes. Since much of the land is federal or Indian reservation, the dislocated

Table VII-13

Summary of Impacts on Socio-Cultural Landscape from Coal Activities Only

(Without further U_3O_8 Development)

Impact Evaluation Code: * Serious Problem, + Positive Outcome, - Negative Outcome, . Neutral Outcome, ± Both Positive and Negative, depends on viewpoint

			1978 ---------- SHORT RUN ---------- 1985±		1985 ---------- LONG RUN ---------- 2000 ±	
			EXPLORATION	MINING AND MILLING	EXPLORATION	MINING AND MILLING
NAVAJO	SHIPROCK AGENCY	SHIPROCK		± Strong anti-development faction presses Tribe for local control of development. + Employment in power related projects. - Feeling of crowding due to immigrant Navajos.		+ Economic benefits to employed Navajos.
NAVAJO	SHIPROCK AGENCY	RURAL CHAPTERS		+ Employment in power related projects. - Feeling of crowding due to immigrant Navajos.		+ Economic benefits to employed Navajos.
NAVAJO	EASTERN NAVAJO AGENCY	RURAL CHAPTERS		Coal Related Impacts: * Relocation of Navajo "squatters". * Surface rights conflicts with Navajos and Anglo grazing permit holders. + Some local employment.		
NAVAJO	EASTERN NAVAJO AGENCY	CROWN POINT		± Some town growth due to coal development.		
HISPANIC	S. BASIN URBAN	E. BASIN TOWNS				- Migration from Basin to obtain employment.
ANGLO	NORTH BASIN	URBAN		Coal and other developments: + Increased quality of life with more complex goods and services. - Resentment toward tribal policies controlling development that will slow economic growth.		+ Increased quality of life with more complex goods and services. . Farmington grows in relative importance.
ANGLO	NORTH BASIN	RURAL		Coal and other developments: - Threat to rural agrarian base, especially on BLM lands. - Competition with NIIP agricultural products produces resentment.		
ANGLO	SOUTH BASIN	RURAL				- Migration from Basin as ranching declines and urban economy slows.
ANGLO	SOUTH BASIN	URBAN	. Gallup: Loss of U_3O_8 opportunity will be absorbed by growth in other sectors (coal, govt., etc.). * Grants: Loss of economic "morale" and sense of growth.	+ Stabilization of demand for uranium workers will slow high mobility of newcomer Anglo miners.		- Quality of life - slower growth means slower rates of accumulation of urban amenities. - Local youth will migrate from Basin to obtain work. * Out-migration of miners and families. Will hurt quality of life in Grants unless economy diversifies.

Source: Knight, 1980, No. 49.

people--most of them Navajos--can expect no compensation for surface ownership. If this should occur, however, they could expect compensation for loss of livestock and improvements. Private owners and allottees are entitled to receive fair market value for their land.

It has not been determined where dislocated families would move. Since the land around them is already overgrazed, Navajos whose families have lived for generations as herders or ranchers might be forced to give up that way of life. The older people would feel most keenly the loss of what they consider their ancestral land. Even if temporarily better off financially, they could be resentful and dispirited at the thought of moving to a town. Younger people, on the other hand, might find increased opportunity upon leaving a rural area for a town or city.

It should be noted that the move would not necessarily be permanent. After five to seven years, when the reclaimed surface had become stabilized, the people would be permitted to return to their original homesteads. It remains to be seen whether they would do so.

SOCIOCULTURAL LANDSCAPE WITH MODERATE URANIUM DEVELOPMENT

Inter-Ethnic Relationships

Cultures in the basin would continue their basic pluralistic trends, but some shifts could be expected. Anglos, Hispanos, and Indians would work together at the mines and mills and form friendships. Work disputes might sometimes focus on cultural differences, however, and emerge as affirmative action problems or strikes if not deftly handled by management.

Over the short run, if Navajo tribal policies and actions by allottees were to slow uranium and energy related growth, current urban Anglo resentment at possible loss of economic opportunity would persist.

In the long run, creation of economic networks that might integrate Indian and non-Indian interests at the political, management, and administrative levels would be a possibility with properly paced development on Indian lands. Increased Navajo wage earner spending in the border towns would increase the trend toward greater appreciation from the commercial establishment. A challenge to ethnic identity would arise from improved wage earning opportunities and royalty income. Some members of all ethnic groups in the area have already demonstrated a capacity to integrate economically when given the opportunity, adjusting their lifestyles to their incomes. (U.S. Department of the Interior, Bureau of Land Management, 1979)

Racial incidents could be expected from time to time, due to population growth and makeup and to increased opportunities for confrontation. This would be confined to reservation border areas, since a movement of non-Indian residents onto reservations is not foreseen.

Land Status-Related Impacts

Intercultural resentment might arise as a byproduct of more formal land status-related conflicts and issues. The incursion of mineral and energy interests in the checkerboard area could accelerate the pressures from the Navajo tribe to exchange lands with the BLM. It would increase pressures on both Navajos and non-Indians holding BLM grazing permits and could raise the possibility of relocation of Navajo families defined as squatting on the public domain. Competition for water rights between Indian and non-Indian interests would be increased.

Jurisdictional disputes would arise over the question whether the Navajo tribal police should be empowered to arrest non-Indians in the checkerboard region, and over the tribe's power to apply its codes in border areas. Possible disputes between the tribe and Navajo allottees could arise over the application of the tribal code and entitlement of tribal services to holders of allotted lands.

Figure VII-10.--Grants-Milan mobile home areas, bisected by I-40, as seen from the air

Table VII-14.--Summary of Impacts on the Sociocultural Landscape from Uranium Activities (Moderate and High U_3O_8)
Source: Knight, 1980, No. 49.
Impact Evaluation Code: * Serious Problem; + Positive Outcome; - Negative Outcome; · Neutral Outcome; ± Both Positive and Negative; depends on viewpoint; ? Don't know outcome.

			1978 — SHORT RUN — 1985±		1985 — LONG RUN — 2000±	
			EXPLORATION	MINING & MILLING	EXPLORATION	MINING & MILLING
NAVAJO	SHIPROCK AGENCY (Past U_3O_8 Experience Negative)	Shiprock	* Strong anti-development faction, opposition to Exxon lease.	- Old tailings pile, question of environmental damage and future maintenance.	+ Attitude toward U_3O_8 growth will be obvious after Coal & NIIP are resolved.	
NAVAJO	SHIPROCK AGENCY (Past U_3O_8 Experience Negative)	Rural Chapters	* Concern over lung cancer in miners from 1950's. Who will pay disability benefits for them?		+ Strengthen chapter role re: Window Rock. + Attitude toward U_3O_8 development will be obvious after Coal & NIIP resolved & Crownpoint experience is evaluated.	+ Strengthen chapter role re: Window Rock. + Jobs and royalty money may strengthen Navajo Extended Family.
NAVAJO	EASTERN NAVAJO AGENCY (New U_3O_8 Experience)	Rural Chapters	* Local upset over bad behavior of crews. * Don't understand lease rights and mining process. * Fear loss of land & control over life. + Debate. - Factionalism. * Fear of radiation, water & livestock damage.	+ Jobs at home (Eastern Navajo). . Will live rurally or along I-40 in bordertowns, - crowding of rural landscape (Western Navajos). + Royalties to tribe, - not locally distributed. + Jobs & royalties (allottees). + Minimal relocation of families.	+ Strengthen chapter role re: Window Rock. + New experience with economic decisions.	+ Strengthen chapter role re: Window Rock. +? Reconciliation of Navajo culture with "outside" economic opportunity through informal debate. + Jobs and royalty money may strengthen the Navajo Extended Family. ± Adjustment to greater economic differences among local residents. - High level of development: Rapid pace may aggravate negative feelings & create "no growth" posture. - Money will leave the reservation economy. + Improved physical standard of living to economic beneficiaries. + Pressure for improved services for all. + Minimal relocation of families.
NAVAJO	EASTERN NAVAJO AGENCY (New U_3O_8 Experience)	Crownpoint	- Don't want boomtown: crime, alcohol, outsiders. + Ambivalent over development. + Debate. - Factionalism.	+ Jobs & royalties. - Assimilation of non-local Navajos taking jobs & moving in. - Some crowding. * Crownpoint lacks a way to officially plan and control its growth.	+ New experience with town planning decisions.	
HISPANIC	EAST BASIN (New U_3O_8 Experience)	Small Towns	-? Possible questions over fairness of land grant lease terms. Pro-development.	+ Job promises. * Lack of job skills, - unfilled job expectations, - community upset, - labor problems. -? Conflict with Anglo residential immigrants.		+ Strengthen economic base of Hispanic Extended Family. ± Increased awareness of minority status.
HISPANIC	SOUTH BASIN (Past U_3O_8 Experience Positive)	Urban (Gallup, Grants)	Pro-development.	+ Jobs = small town Hispanos don't have to leave Basin. -? May become smaller minority unless large number of Hispanos migrate in from Rio Grande area.		+ Strengthen economic base of the Hispanic Extended Family. ± Increased awareness of minority status.
ANGLO	NORTH BASIN	Urban & Rural	(Coal Related.)	(Coal Related)		
ANGLO	SOUTH BASIN (Past U_3O_8 Experience Positive)	Rural	- Conflict with BLM grazing permit holders.	+ Royalties & purchase of water rights. + Part time jobs in Basin will allow ranchers to retain life style.		
ANGLO	SOUTH BASIN (Past U_3O_8 Experience Positive)	Urban	+ Pro-development = economic growth - Some concern over pressure on human public services. - Some concern over inflation & old folks. * Concern over unsure future of Nuclear Power.			+ Quality of life will improve = more local goods & services, etc. + Shortages re: price rise for goods & services will level off = less hardship on older folks (- High: leveling delayed). + Local youth will not have to leave Basin for work. + As population of miners grows, influence of transient construction workers will diminish. ? As population of miners grows, unions will become more prominent.
ANGLO	SOUTH BASIN (Past U_3O_8 Experience Positive)	Urban	- Upset over economic loss if Navajo uranium slows.	* Small towns will have stressful growth. ± Small towns will become satellites of Gallup & Grants, ? = Unknown ethnic balance. + Large towns will incorporate growth, some stress adjusting to newcomers. + As supply of workers increases, extreme mobility of newcomer Anglo miner will slow down, allowing more assimilation into local culture. (- High level of development: adjustment delayed.) ? Source of newcomers (Recession, etc., may draw new type of miner.) - Transient construction workers, negative impression.		

Table VII-14

Spanish land grant problems could emerge if unanticipated negative impacts should cause grantees to question the fairness or terms of past negotiated leases. Any unfulfilled expectations of employment might also cause problems.

Impacts within Specific Cultural Groups

Table VII-14 lists some socioeconomic impacts that may be anticipated from Moderate and High levels of U_3O_8 development in the basin. Some are discussed below.

Anglo Residents

Longtime residents of Farmington, Gallup, and Grants would be faced increasingly with adjusting to an influx of newcomers to the communities. Many could bring with them high expectations of services structures which might not be feasible without tax increases.

Adjustments have already started, particularly in Farmington and Gallup, through existing voluntary associations of various types. Smaller towns would face this kind of situation for the first time.

Where organizations such as a city government or chamber of commerce exist, resident-newcomer adjustments would be facilitated. Such associations don't always exist in smaller communities.

Uranium Miner Subculture. Of more concern are social problems that could be brought into the south part of the basin by uranium miners and their families. Attitude surveys and studies available to the SJBRUS

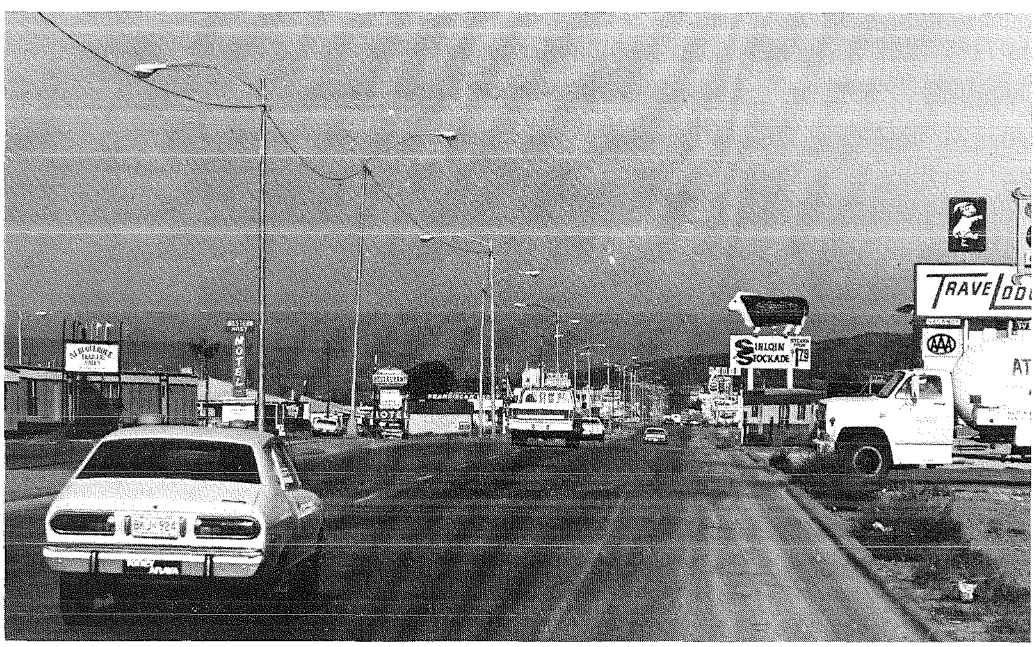


Figure VII-11.--A main street in Grants

indicate residents often have impressions of miners as "hard drinkers," "free spenders," and tending to be disrespectful. A review of local police records, however, does not show the incidence of crime is significantly higher among miners than among other groups. Gibson states:

> Child abuse, family neglect, fighting among husbands and wives and related crimes are popularly thought to be common although their incidence is difficult to document. Social workers, rather than the police, regard these as relatively serious problems. As a social worker employed in a public agency in Grants commented, "There doubtless are many cases of assault and abuse among the miner families of Grants but it is impossible to estimate the prevalence and frequencies of such abuse. Certain characteristics of miners would indicate that abuse is more common among them than among other groups in the population. These characteristics include the physical aspects of mining which motivate the miner to manifest force in the settlement of a conflict, drinking habits, a tendency to exercise authority over family members, and isolation from others who might sanction his actions." (Gibson, 1978, No. 24)

However, the following comments collected in Gibson, 1979, No. 44, reveal other viewpoints.

From a mine official: "They work hard, and they play hard." "The hardcore miner that has been with us quite a while is a fully integrated member of the community."

From a town official: "Every Friday was a payday and so maybe out of the whole group you might have 20 percent that do a lot of drinking, a lot of hell raising, but it's getting lesser and lesser. I can see it from our police reports."

From a miner: "I was raised this way and they (the children) got to be taught in order to make it. I'm putting up with all of this crap and my kid has got to be tough. I turned out ok. They will turn out ok."

From a social worker: "When I came to this town the population was about -- I don't know -- 16 or 1700 people. I think we had 23 bars then, 23 bars up and down this street. It was a main street on Highway 66 and we had 23 small bars and there was loud music and lots of drinking. It was a lumber town then -- and some mining. I don't think it's any worse now with uranium mining. In fact, I think it's better than it was then."

From a mine official: "I would say that the people that feel isolated would be people coming from say New Jersey, say miners from that area, maybe coal miners from West Virginia that haven't been exposed to the high percentages of Spanish Americans or Indians."

A mine official again: "Most of our problem element in town comes from a younger, totally irresponsible element rather than the miner."

And a social worker: "But I'm not sure that the child abuse problem is more severe with miners than it is with anyone (else)."

In the final analysis, systematic in-depth research is necessary before it can be said that in-migrant uranium workers would produce any increase in various social problems beyond those attributable to population increases alone.

Hispanic Residents

Rural Hispanic residents would no longer need to migrate from the basin to obtain work. This would strengthen the rural Hispanic extended family. However, unless skill training were provided, Hispanos might find themselves unqualified for the more skilled, higher paying positions. Training for uranium jobs is currently offered at Grants.

There is concern in small Hispanic villages that incoming residents might over-tax already cramped housing, possibly edging out locals and creating problems with waste disposal facilities, crowding of schools, and other facilities. Community members are concerned that transient single males living in the area would bring in undesirable and rowdy habits affecting younger people.

Some more traditional people fear the possible loss of their culture, but most seem to see the economic benefits of employment.

Although Hispanos have inherent trust in family members, outsiders must earn it. This leads also to a reluctance to be involved in community organization and to a tendency to leave such things to people of status such as a local priest. Thus these various concerns might not reach the stage that they would be communicated to the companies but would manifest themselves in mistrust, fear of challenging the companies, and formation of factions.

Companies might need to take the lead in explaining the implications of development activities, lease rights and lease terms as a step to alleviate distrust and encourage the airing of problems (Gibson and Leonard, 1980, No. 62).

Eastern Navajos

As shown in Table VII-14, uranium development at the Moderate projection level or greater would produce both positive and negative impacts among the Eastern Navajos. These impacts would result either directly from the presence of uranium activities, such as exploration, or indirectly as from increased employment and royalties paid holders of mineral leases.

Map VII-5 and Tables VII-15 and VII-16 indicate the gradual movement of the uranium impacted areas to the north and west. Eastern Navajo areas would feel the effects in the near future, while the Fort Defiance, Ariz., and Shiprock agencies would feel them toward the end of the century.

Navajo Chapters Affected by Uranium Development - 2000

Map VII-5

Table VII-15

Percentage of Navajo Agency Residents Affected by Uranium Development
(at both the Moderate and High levels of development)

	1980	2000
Eastern Navajo	44%*	58%
Shiprock	8%	59%*
Fort Defiance	19%	61%*

*Current and near future impacts are in Eastern Navajo. Future impacts will spread north and northwest in time.

Table VII-16

Navajos Affected by Uranium Development - 2000
-Based on 1978 population-
(All Chapters affected in 1980 will continue to be affected (See Table VII-5).

Eastern Navajo Agency			13,339
Additional Chapters affected by 2000:			
Torreon-Star Lake	1,718		
Pueblo Pintado	952		
50% Nageezi	670		
Lake Valley	618		
White Rock	399		
50% Huerfano	1,525		
			4,164
	Total affected by 2000	=	17,503
Fort Defiance Agency			1,414
Additional Chapters affected by 2000:			
50% Tohatchi	1,706		
50% Naschitti	1,502		
			3,208
	Total affected by 2000	=	4,622
Shiprock Agency			2,347
Additional Chapters affected by 2000:			
Burham	1,235		
50% Sheep Springs	731		
Two Grey Hills	2,612		
50% Shiprock	7,006		
Red Valley	2,406		
50% Beclabito	971		
			14,961
	Total affected by 2000	=	17,308
	Total Affected (3 Agencies)	=	39,433

Key Social Trends. To recapitulate, Navajo values and cultural aspects pertinent to analysis of impacts include a sense of powerlessness over major decisions affecting them, increased demands for local control, distrust of authority, use of gossip and rumor as social sanctions, and a lack of experience with leasing procedures and uranium development. A decade or more of community development by the BIA, Public Health Service, and tribal workers has created the expectation that bureaucracies and large organizations should be more responsive to local needs and wishes. It should be borne in mind that Navajos on tribal land receive no royalty benefits from mining in their areas, while those on allotments do. In the past, debate over controversial issues at the chapter level has tended to factionalize rather than unify communities.

Survey of Navajo Community Members. An intensive survey of 187 community members in 10 selected Eastern Navajo chapters tested sentiment concerning uranium development (George, 1979, No. 36). The number who mentioned specified benefits or problems they associated with uranium development are listed below.

Benefits from Uranium Development:

Employment	94
There are no benefits at all	64
Excellent salary and benefits	35
Royalties for allottees	32
I don't know of any benefits	21
More jobs and money in circulation increases standard of living	20
Companies reap all the profits	12
Uranium is needed to produce electricity	10

Problems with Uranium Development:

Worker Behavior	212
Radiation	165
Outputs from Mining Phase of Development	96
Damage to Vegetation and Rangeland	87
Pollution	84
Decline in Water Quantity and Quality	71
Leases and Leasing Procedures	70
Livestock Loss	65
Increased Population	63
Law Enforcement	42
Employment Practices and Working Conditions	31
Territorial Possession	27
No Problems	10

Cause and Effect Sequence of Impacts. The following discussion of the relationship between uranium development activities and actual or potential impacts is based on Knight, et al, 1980, No. 49. This sequence of events gives rise to the attitudes detected in the survey cited above. Negative

impacts illustrate some of the dynamics behind those items the people perceive as problems.

Pre-Exploration--Lease sales and negotiations for uranium mineral rights on tribal and allotted lands were conducted in the early and middle 1970's. Tribal leases were negotiated by the tribe at headquarters in Window Rock. Companies and BIA personnel informed large numbers of allottees of the sales, obtained 1,969 signatures and facilitated payment of bonuses to allottees.

Several years then passed before any exploration drilling took place. Subsequent exploration and mine development activity confronted both allottees and reservation residents with unexpected and undesired effects, resulting from the negotiation of leases a few years earlier. Despite reported company efforts to inform people of coming events, many people now contend "they were not told."

Exploration--In 1978 many contract drill crews were at work in the Eastern Navajo area, performing uranium company exploration tasks. This large scale activity in a rural life space which, though bleak looking is relatively heavily inhabited, created rumor and upset among enough local residents to create dissension. This surfaced at chapter meetings and EIS hearings and figured in the filing of two legal actions.

The following reactions among the Navajos may seem excessively negative; however, it may be noted that exploration brings few apparent benefits to local Navajos. It should be stressed that there are Navajo families who seem content, but it is the power of local dissent that has created the greatest attention. Furthermore, inability to communicate concerns to those in a position to answer or remedy them is a source of difficulty. Here, then, are some of the sources of discontent.

The presence of drilling activity in general is seen by some as a disturbing intrusion into people's rural lifespace. Noise, dust, and traffic are considered nuisances. Water coming out of drill holes is looked upon as wasteful and leads to dewatering rumors. Dead livestock are thought by some to be the result of water contamination. Water drawdown is construed as causing some dried-up springs and windmill failures. Unplugged holes are said to cause broken limbs in livestock. Radiation thought to be released by drill holes to air and water is feared. General surface disturbances by roads and exploration sites are thought of as destroying trees and grassland, and the accidental disturbance of sacred sites is extremely upsetting. Reclamation of exploration sites is sought by people fearful their land will be ruined for grazing purposes.

Some drill crew members' "offensive" behavior can cause great upset among Navajo people. Some crew members are accused of running over sheep, speeding, running people off the road, cutting fences to get access to drill sites, and disturbing sacred sites. Unsubstantiated rumors, not unusual in any situation where there is friction, have abounded. There are allegations of rape, shooting incidents, fights, and threats.

As indicated in the attitude survey (George, 1979, No. 36), all these circumstances tend to constitute a threat to Navajos; they wonder if they have lost control of their lands, or of their title to them, and if they will no longer be able to live in the area.

Local residents do recognize positive impacts coming from exploration: new roads, firewood, jobs, water wells, and revegetation of grazing land with reclamation.

Concerned Navajos sought information from several sources. If they knew English, they talked to drill crew members and company representatives. Many went to the BIA, to chapter and district council officers, to tribal offices in Window Rock, and to the local legal aid office of DNA. This approach that seems "hit and miss" resulted from their not knowing specifically their rights and what to do about them.

Frustration from a feeling that they were not being given satisfactory help or answers focused at local meetings, creating factions in chapters. Dissension spread over the Eastern Navajo grapevine.

Some perplexed and frustrated company people increased their community relations efforts by settling claims, sponsoring meetings, renegotiating leases, hiring Navajo representatives, and taking other steps. However, though exploration activity has virtually ceased, community concern continues.

Recent Developments: Since the market-related slowdown in basin exploration, other events have occurred that may affect community attitudes toward future mining and milling impacts in the Eastern Navajo area. The Navajo tribal council has called for a moratorium on future uranium leasing until tribal controls over development on tribal lands are in place, methods for treatment of community wishes and compensation are determined, and the newly created Navajo Energy Authority is in operation.

The mill tailings pond spill at Church Rock has challenged agencies concerning their provisions for adequate environmental monitoring, information, protection, and compensation. Recent expressions of concern over the Shiprock miner radiation exposures in the 1950's mentioned earlier have stimulated interest in occupational health.

Approval procedures for mine plans and lease renegotiations in the Eastern Navajo allotted area continue to generate pointed questions and concerns from allottees and chapter officials. The Navajo tribe has created an Eastern Navajo land commission to help process claims and resolve land status-related problems.

Mining and Milling--Assuming mining and milling will eventually proceed in the Eastern Navajo area, judging by known reactions to exploration and other events the presence and activity of a mine or mill site would initially upset local people as an intrusion into their environment.

Land displacement by mine and mill sites creates among Navajos a strong fear of losing ownership of the land (George, 1979, No. 36).

Multiple mine and mill sites would intensify these feelings. Such fears stem from a general lack of understanding of lease terms and of rights associated with various forms of land status. Many allottees are not aware of the implications of residence on allotted land as compared with public domain or other types of jurisdiction. Pressure on government agencies to supply needed information can be expected to increase.

Dewatering of mines would be regarded as waste unless the water was treated and put to beneficial use. There is great concern that mining will dry up the Eastern Navajo area and make the land uninhabitable.

Concerns about radiation in uranium ore or in water are strong. The local grapevine has spread word, originating from the more educated people, that there are particles emitted from mining. Traditional people do not yet understand the concept, and analogies are drawn between nuclear weapons and electric power plants. Here again word of mouth recalls stories of miners from Shiprock dying from lung cancer (Chapter IV).

Shaft development, blasting, dust, trucks, ore transportation, yellowcake transportation, speeding, road deterioration, running over sheep--all of these would be regarded as annoyances. Reclamation of tailings piles is of concern to residents who worry that radioactivity could make the land uninhabitable.

Local Navajos know that work at mine and mill sites would create many new jobs, for which contracts on Indian lands give preference to Indians. Many local Navajos would be able to take jobs, and many other Navajos could be expected to migrate in from other areas in search of work. The majority of this work force would be young people. Due to shortage of Indian workers, non-Indians also would be employed. The local Navajos for the most part probably would qualify for unskilled jobs.

Migration of Navajos from other areas could cause local resentment, some of which could be eased by kin and clan ties. Housing could cause problems for Navajos moving into the Crownpoint area and some would probably commute.

Increased inhabitation of the Eastern Navajo area would not necessarily mean increased identification with Crownpoint and local problems, nor increased urbanization of the area. Incoming Navajo workers would identify with and vote only in their home chapters and return there for frequent visits.

A parallel situation is Shiprock, which is comparatively sizable but has little new development of crosstown networks. The large in-migrant population live more or less in a rural manner in a town setting. This bears resemblances to large mining towns in Third World countries, which often have this rural characteristic; they consist largely of ethnic and tribal neighborhoods, and ties to the village of origin are more important than a sense of being a local resident.

Navajo wage workers would tend to acquire heavy industry work habits. Successful performance would mean more understanding of and mobility in the outside wage work economy. Navajos would see the jobs as the chance for betterment of life. Newly employed Navajos would demand more goods and services, ask organizations to be more responsive to local needs and demands. Money and roads would allow more access to off-reservation life and should stimulate understanding. Raised expectations would stimulate assertions for more rights to jobs and security of title to the land. There would be vocal affirmative action hiring concerns, especially if Navajo expectations of employment and promotion were unfulfilled.

Since some costly services, particularly health care, are subsidized from the outside and taxes are lower, Navajos would have more free income to spend. Some income could be expected to be shared with the extended family, and some would be spent on home and land improvements. Most money would leave the area (Chapter IX).

There are some small Navajo-owned businesses in the Crownpoint area. There is a question as to the local stores' ability to respond to increased demand or to compete with outside chains.

Companies would probably not build towns in the Navajo impact area but would encourage non-Indians to live in company housing in border town areas.

Employed Anglos living in the Navajo area in small numbers probably would not greatly affect Navajo social life, although there could be some interaction. Anglos would add to a demand for goods that did not exist there before. Some of the Navajo community, it appears, would probably tend to view any influx of non-Indian workers as an intrusion by the whites, reinforcing a sense of powerlessness and perhaps — whether justified or not -- feelings against the companies, BIA, and Navajo tribe. Nevertheless, the Navajo residents would not leave the area. Brugge writes:

"An influx of non-Navajo workers into Navajo areas may be expected to create conflicts in a number of areas; in school, both between students in the classroom and between parents with regard to educational policies and control of the schools. The lack of medical facilities open to non-Indians could be a major cause of inter-ethnic resentment. Law enforcement can easily become another cause of inter-ethnic disputes." (Brugge, 1980, personal correspondence)

Increased wage and royalty affluence has the potential to increase extended family strength. It also could create a wealth differential among families that could lead to jealousy and social isolation. Some allottees stand to become multimillionaires (Griffith, 1979, No. 41). Extended family adjustment to effluence probably depends upon a past history of cohesiveness and successful experiences in similar situations.

With growing realization that allottees receive royalty payments but that royalties on tribal land go to the tribe and not to local residents,

it would seem that pressures on the tribal government to balance the score would be inevitable.

With the growth of Crownpoint and its drawing power in the area, visible evidence of social pathology such as public drinking and vandalism would increase. Social welfare needs would rise. It would be necessary for responsible agencies to monitor conditions to determine whether population increases or increased life stresses were responsible for any increased social pathology.

How Eastern Navajo Leaders View Uranium Development. Current Navajo attitudes and emotions were again sounded in a survey of selected leaders in the prospective uranium country. The following summary was taken from Griffith, 1979, No. 48, a detailed report on the findings. The sentiments expressed below are believed by study team specialists to be probably widespread, reflecting a strong sense of distrust and powerlessness. Leaders expressed the following views:

(1) there has been insufficient open communication among all parties involved in uranium development;

(2) the companies, the BIA, and the Navajo tribe are viewed as secretive and perhaps deceitful in their dealings with local Navajos;

(3) there exists a lack of respect for Navajo traditional beliefs and sacred places;

(4) uranium development has been destructive to land, water, vegetation, and livestock, and Navajos have been inadequately compensated for damages;

(5) the leasing process is poorly understood and insufficient effort is exerted to clarify lease terms and the responsibilities of individuals, the companies, the BIA, and the Navajo tribe;

(6) uranium development is not totally unacceptable but may lead to community improvements and increases in standards of living for local Navajos;

(7) an opportunity exists to restore decisionmaking to the people involved at the local chapter house level;

(8) Navajos want to work but want guarantees of mine safety, training, equal opportunities, promotions, administrative positions, and participation as equals in decisionmaking;

(9) uranium development will inevitably bring change and social problems to the Navajo but the end result is problematical and the Navajos want greater control over the impacts;

(10) the Navajos need and demand an objective, non-partisan educational program at the local community level on the merits and disadvantages of uranium development.

Overall Implications: Summary. The prospects for increased uranium development contribute one more element to the open debate among Navajos over possible loss or enhancement of the Navajo way of life. (George, 1979, No. 36, and 1980, No. 64) Older and younger Navajos may subscribe to one of these positions: Assimilate, incorporate the change, or "it is all lost anyway" (fatalism).

This debate over uranium could result in the Navajo people demanding and receiving a political way to control resource development choices, but it might also aggravate the problems inherent in arriving at chapter level consensus on a controversial technical issue. Consensus approval, rather than majority rule, is necessary on major decisions.

If development should become thought of as externally forced and heavy-handed, it could wind up in the same category as grazing reduction of the 1930's, still criticized by some Navajos as a distant Anglo government's forcing people to graze fewer sheep and horses "for your own good." (For overgrazing effects, see Chapter VI.) The most optimistic prediction is that a controlled pace of development and adequate information would ultimately result in the Navajos' looking upon uranium as contributing to and being a natural part of the Navajo way.

Changes in Linkages within the Basin

While the numerical balance would shift in favor of Anglos with Moderate or greater uranium development, political power would continue to remain largely with the established tri-ethnic networks. Political distance could grow between Indians and non-Indians, in time, with increasing tribal sovereignty struggles. Companies would have economic power in both Indian and non-Indian areas and would maintain or increase their political influence at the state level.

Old-time Anglo and Spanish families would continue to determine political issues for the large uranium miner voting bloc. Navajo chapters could be expected to demand and achieve greater response from the tribal government, with a result that tribal links with the grassroots would be reinforced in the long run.

Information, factual and otherwise, about uranium and other development would continue to flow to basin residents through the Indian and non-Indian grapevine, newspapers, Navajo radio station, chapter meetings, and environmental hearings. Much of the information has been fragmented or overly technical. Demands for additional information would continue.

Changes in Linkages outside the Basin

As demand for energy grows, access to resources of the Navajo tribe, New Mexico, and the West will doubtless be viewed by some from the standpoint of "what shall the East Coast and the nation give us for what we supply them?" Any tradeoffs on this question would be handled at the national level.

Until more definitive information is derived concerning the safety of nuclear fission electricity generation, northwest New Mexico and the Navajo people should continue to be of interest to national media, interest groups, and some scientists, scholars and citizens.

After the Uranium Boom Period

The eventual economic downturn of uranium development following a climb to the Moderate level has not been considered in detail by the study due to the likelihood of its occurrence after 2000, the cutoff date for the study. However, this prospect does deserve mention.

All ethnic groups of the southern basin would again see departure of families seeking employment elsewhere. The hardest hit community would be the Grants-Milan center unless the economy were to be greatly diversified in the meantime.

Anglo nuclear families would move elsewhere for work, a not-unusual aspect of mining employment. Some Hispanic and Navajo residents would stay because of family ties to the land but would be faced with a drastic lowering of their standard of living. This would apply especially to the Navajos due to their decreasing land base and growing tribal population. This would once more aggravate the welfare burden.

The Navajo tribe and federal government should not overlook this distant but inescapable fact in the development of tribal natural resources.

SOCIOCULTURAL LANDSCAPE WITH HIGH URANIUM DEVELOPMENT

If uranium development were to achieve the levels projected under the High assumption, sociocultural impacts would be quite similar to those cited for Moderate development but intensified by the greater volume and the increased development pace. Boomtown conditions considered unlikely under the Moderate projection would become highly probable with High development. Impacts upon the Navajos from stepped-up exploration and mining activity would increase sharply, probably creating a politically intolerable situation. The influx of greater numbers of workers from outside the basin would exacerbate the impacts discussed earlier, both in affected communities and across the enlarged rural landscape.

EVALUATION AND MITIGATION OF PROBLEMS IN SOCIOCULTURAL LANDSCAPE

Few easy legal or scientific solutions are available to address the kinds of problems that arise in conflicts of values and stressful town growth. The pressure for solutions to these problems is more political in nature, through the media, organized interest groups, and leaders. The response lies in laws, increased services, or changes in company behavior. Little can be done in the way of altering values or strong longterm historical trends.

Public administrators have the option of requlating impacts on lifestyles by: 1) planning and zoning laws affecting the timing and location

of large energy developments to take into account local values and town growth problems and/or 2) the application of more services personnel and budget to attempt to solve social problems.

Beyond the Basin: Cooperation and Information

National legislation could be passed or federal intercabinet agreements could be made that would bring key actors together to attack problems in the area. This would help eliminate overall stress and current inefficient and marginal solutions.

Energy impact assistance measures should be examined for their adequacy in relation to need as a means of augmenting the operating budgets of small towns, Indian or non-Indian, faced with heavy growth.

The prospect of increased uranium development, combined with national nuclear development debate, appears to create a need for neutral, non-technical, and comprehensive information that should be made available to the general public in the San Juan Basin region.

The federal presence in the area should generate the development of a central data base that could provide up-to-date projections on uranium and other energy development, along with expected population growth and natural science impacts. This would provide necessary information for all involved, including town planners and companies, enhance general awareness, and help bring people together on neutral ground.

It would appear advisable for the federal government to continue to fund some clearinghouse effort much like the SJBRUS, for the purpose of maintaining a forum of debate and source of information until questions surrounding uranium are resolved. This effort would include a library and educative materials, such as a radiation primer and a continuing explanation of radiation and nuclear issues. Among educational materials might be presentations similar to the narrated slide program developed for the SJBRUS in the Navajo language and discussing uranium development. Others might deal with the obligations of leasing and the complexities of land status. (George, 1980, No. 61)

Growth Problems: State, County, City and Reservation

The State of New Mexico might well maintain a population growth model for northwest New Mexico. This would allow for allocation of state resources to areas with growth problems and timely adjustment of projections to changing conditions. Attention should be focused on the I-40 corridor between Gallup and Grants, and north to Crownpoint.

All governments should consider planning and zoning to control expansion pace and impacts. Severance tax money and post-boom planning are among further contributions the State could make to the quality of life in the area. Research to define Indian "boom" town conditions is needed.

At both the Moderate and High levels of assumed development, the larger towns in the basin would be able to absorb newcomers. However,

smaller towns could experience problems for a time in assimilating miners and construction workers in proportion to the pace of development.

Growth problems for the small towns along I-40 and for Crownpoint could become serious if local leaders failed to incorporate, where feasible, and obtain the money needed for increased public services. Leaders also could relieve growth difficulties by setting up associations and, perhaps, recreation that would bring newcomers together with older residents and facilitate their developing a commitment to the community. The Heritage Conservation and Recreation Service of the Department of the Interior should be funded to help towns determine recreational needs, plan for the future, and build facilities.

A need exists for Crownpoint to find a way to plan its future in an organized way that allows for citizen input and control. With an expanding private sector, informal government should be taken out of the federal agencies and transferred, perhaps, to the local chapter or to a new corporate-town structure. Companies should encourage non-Indians to live in off-reservation towns, since non-Indians have no vote in tribal affairs.

Thoreau has a difficult situation. Half of the town cluster is Navajo allotted land, the other half private land. Some type of quasi-legal entity might also be established there.

Social service professionals are concerned that semi-transient newcomers, suffering social isolation and stresses of hard and dangerous physical labor, might bring along family problems including marital conflict, child abuse, and excessive public drunkenness. Social isolation can be handled through civic projects such as recreation, associations, and churches, but some evidence indicates the uranium miner is not a "joiner." If the nature of the work creates stress, company personnel departments should provide counseling, but this would be successful only if the miner considered his behavior a problem and accepted intrusion into his personal life.

Social work solutions work best when voluntarily sought out by a couple in trouble. Social work as legal intervention in a crisis should be the last resort. However, Grants and Gallup agencies should prepare to increase their staffs for both of these purposes, and small I-40 towns should start planning for such services.

Further research is needed on the "Uranium Miner," like that on the "Construction Worker Profile" done for the Old West Regional Commission. Social service agencies should be funded for better data collection in the area.

Ethnic Conflicts

Job-related ethnic conflicts could be handled at the work site through management methods and research. Uranium companies and the Navajo tribe might find it useful to start accumulating and analyzing data relevant to the role of ethnic differences at the work place. (See Steenrod, 1979.)

Companies hiring minorities and women should have an affirmative action plan agreeable to both companies and local interests to provide common understanding and realistic goals. Border town communities, especially along I-40, could prepare in advance to handle off-hours ethnic incidents through a citizens human relations commission or through community relations efforts by official agencies.

Hispanic

More research is needed on the impacts of uranium development on small Spanish American towns and non-Indian rural dwellers. Little is published on the special problems of these groups, in contrast to federal administrative concern received by tribes in the area.

Small Hispanic communities appear to need an education program, co-sponsored by companies and a government unit, addressing their concerns and fears.

The Harbridge House attitude survey among Hispanic peoples indicates high expectations of jobs from uranium mining (U.S. Department of the Interior, Bureau of Land Management, 1979). Care should be taken by companies not to raise the level of expectation of employment beyond the current level of skills of the Spanish-speaking labor pool without providing the necessary skill training or apprenticeships. Companies would be advised to be especially alert for this situation at Spanish land grant mine sites.

Eastern Navajo

All organizations involved in uranium activity should increase their community and informational efforts and expand their understanding of common purposes and individual viewpoints. One recourse could be forums between company operating personnel, the BIA, Navajo tribal personnel and local people to arrive at mutual guidelines for "good conduct." Public meetings and hearings should be conducted in a manner that provides education and a forum for Navajo debate.

Companies and government agencies new to the area would do well to familiarize themselves ahead of time with Navajo culture, history, and politics, the role of sovereignty and self-determination, and the history of past economic development on the Navajo reservation. This would enable a company to decide whether it could operate profitably on the reservation and how. Companies and agencies could use a community development staff with a local office. Companies should maintain stricter controls over worker and contractor (drill crew) behavior.

Community people need assurances that with increased development environmental monitoring (data collection) and enforcement of standards would be carried on by the appropriate agency and that adequate procedures and regulations exist. They also need assurances that companies and regulatory agencies would respond to crises with the goal of protecting community health and well being.

Navajo complaints and claims should be handled locally and expeditiously. The BIA and Navajo tribe should increase staff and pay closer attention to current trust responsibilities and bureaucratic functions.

The BIA and the U.S. Department of the Interior solicitor might well consider an increase in staff at Crownpoint and Window Rock to handle communication with allottees. Efforts by the newly created Eastern Navajo land commission in settling of claims should continue.

So far as coping with Eastern Navajo misgivings and complaints is concerned, companies and government administrators should gain an understanding of how the local Navajo extended family and chapter systems interrelate and operate, as well as keeping in touch with Window Rock. They should inform not only the chapters but also the family networks and maintain a constant visible presence with the purpose of raising the levels of both trust and understanding among all factions. Though this is sometimes difficult for public agencies constrained by limited time and personnel, any efforts along this line should help resolve Navajo ambivalence and reduce political instability.

National legislation might be considered aimed at clarifying title under various public land orders and executive orders, so that Navajos can receive assurance or a definition of their occupancy rights to these lands.

With more information and more sense of control, along with an acceptable pace of development, local people would have a chance to understand this form of economic development and adapt to it. Otherwise, current ambivalence could crystallize into strong anti-development sentiment.

CHAPTER VIII

IMPACTS ON THE PUBLIC INFRASTRUCTURE

Chapter VIII

IMPACTS ON THE PUBLIC INFRASTRUCTURE

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Chapter VIII

Summary

Population growth accompanying uranium development at the assumed Moderate level or higher would significantly challenge local, tribal, state, and federal entities responsible for supplying public services in the San Juan Basin. Severe but short-lived stresses could be imposed in localized areas.

Ample resources would be available from state and federal sources with which to solve the capital needs for additional water, sewer, school, medical, and other public facilities. However, a serious shortage of operating funds is predicted.

Taxes on uranium development itself are projected to grow under Moderate development from an estimated $14 million annually in 1980 to nearly $800 million (in 1978 dollars) annually in 2000. The State government would receive from 90 percent of this in 1980 to 98 percent in 2000. Receipt of these large sums would appear to impose a responsibility on New Mexico authorities to monitor public service conditions and future needs in the basin carefully. With advance planning and action, many social needs should be met before becoming critical.

Public infrastructure problems that would need prompt attention and careful monitoring are the basin's roads and municipal water systems, the Grants and Cuba school systems, the Shiprock and Crownpoint tribal police and social services, the Crownpoint outpatient facilities, and the Shiprock fire facilities.

Chapter VIII

Impacts on the Public Infrastructure

EXISTING ENVIRONMENT

Introduction

There is no escaping the checkerboard phenomenon when considering public services in prime prospective uranium areas of the San Juan Basin.

The jumble of land and mineral ownership which gives rise to the commonly used checkerboard label is discussed in Chapter XI and therefore is mentioned here only in passing. In viewing the public infrastructure, it should be understood that the patchwork land heritage from pre-statehood times greatly complicates the determination and exercise of governmental responsibilities and delivery of human services.

Much uranium production has occurred outside the roughly 4,000 square mile expanse generally regarded as the checkerboard area, but the problems of multiple ownership and jurisdictional questions are farflung. Uncertainty sometimes exists over which of four active levels of government, if any, is responsible for taking the initiative on a specific matter. Administrative units are hampered in their performance at times. A lack of systematic collection of reliable information is found in prospective uranium country.

As a report from the field to the Secretary of the Interior during discussions that led to this study remarked: "No one entity has a complete handle on the situation." (U.S. Department of the Interior, 1976)

The reader may find it useful at this point to familiarize himself with certain material contained in Chapter XI: land ownership information in Map XI-1 and Tables XI-1 and XI-2, and county and Indian land data in Table XI-3.

Some states control environmental and growth impacts with planning and zoning restraints on the siting and timing of energy development facilities. This controls the number of new people coming into an area. Such action is not currently possible in the primary study area.

Even if appropriate laws were enacted, the checkerboarded mix of Indian and non-Indian land ownership would prevent the uniform application of planning and zoning techniques unless an intergovernmental agreement was worked out. Jurisdictional questions relative to law enforcement are also a problem in the checkerboard (Chapter XI).

The Shaping of Needs for Services

The needs for public services in northwest New Mexico are influenced and generally dictated by the nature of the populace and the geographical setting. Half of a comparatively sparse population is concentrated, the other half dispersed across a sizable region. The area most involved in prospective uranium activity features chronically high welfare burdens, high unemployment, and low per capita income.

The estimated 200,000-plus population of the New Mexico part of the San Juan Basin in 1977 provided a nominal population density of 8 persons per square mile, but due to distribution the actual density is much less than this in most of the basin.

A New Mexico agency estimated that about half of the 1976 population of northwest New Mexico lived in and around Farmington, Gallup, and the Grants-Milan adjoining community population center (Governor's Energy Impact Task Force, 1977). Attention to the needs for public services thus tends to focus first on those three towns because of the larger numbers of people affected and the problems created by growth.

Traditionally the main service centers for the Navajos, these towns in recent years have become the major focus for economic opportunity. Many people, including Navajos, have moved closer to them for employment. As the state task force report pointed out, population and other figures for incorporated areas fail to account for thousands of additional people living in mobile homes, trailers, and pre-fabricated houses in the outskirts.

"These auxiliary demands on city businesses and services create tremendous pressures that these cities already have a difficult time dealing with," the report said. "The expected impacts from pending energy developments will heighten and complicate these difficulties." (ibid)

Other demographic factors also figure in defining the kinds and quantities of public services demanded from governmental entities. The long distances from county seats Gallup and Los Lunas to remote parts of McKinley and Valencia counties, the counties most heavily affected by uranium development, are accompanied by uncertain roads in many places and limited or non-existent public transportation. More than three-fifths of McKinley County's population was Indian in 1970.

Forty percent of all Navajos in the New Mexico portion of their reservation were carried on the public assistance rolls in 1976, and unemployment among Navajos in the Eastern Navajo Agency was shown as 40 percent overall in 1977. Per capita income in northwest New Mexico regularly ranks among the lowest in the United States, though it is climbing, largely because of energy-related development.

The situation is further complicated by dependence on the public infrastructure itself for employment, as well as services. Government at all levels accounted for more than one-fifth of all employment and nearly one-fourth of all income in northwest New Mexico in 1977. In McKinley

County, government provides nearly one-third of all jobs (Governor's Energy Impact Task Force, 1977).

Two separate but sometimes overlapping service delivery systems exist in the basin: one to serve the population in general, except for Indians living on a reservation, with services coming from municipalities, counties, and the State of New Mexico; the other for Indians residing on a reservation with services coming from the tribe, BIA, PHS, counties and state. This situation creates the problems of an area receiving impacts from the same sources but needing to request funds from two separate and relatively unrelated, perhaps mutually unsympathetic, sources.

Figure VIII-2.--Grants confronts renewed growth as uranium activity expands

A phenomenon unique to the reservations, and a part of augmenting tribal sovereignty, is to turn over administration and control of BIA and Indian Health Service delivery functions directly to the tribes on a contract basis.

It is in such circumstances as these that governmental entities are faced with meeting needs for police and fire protection, medical services, schools, water and sewage disposal facilities, and other items commonly left to government.

Fiscal Concerns

Rising demands for services and increasing costs have led to increased pressures on government spending. In fiscal 1977, for example, local government budgets in five northwest New Mexico counties were up by 51.1 percent over the preceding year and were projected to exceed revenues by 12.8 percent, or $14.8 million (Table VIII-1).

During the year deficits were projected in three of five counties, four of seven municipalities, and in the school districts. Governmental

Table VIII-1

GOVERNMENTAL REVENUES AND EXPENDITURES

Government	Budgeted Revenues	Budgeted Expenditures	Budgeted Surplus Balance	(Deficit) Percent of Revenues
State of New Mexico 1/	$667 299,000	$611,214,000	$56,085,000	8.4
McKinley County 2/	1,922,829	1,905,586	17,243	0.9
Rio Arriba County	1,892,392	2,063,555	(171,163 5/	(9.0) 5/
Sandoval	1,333,808	1,666,867	(333,059)	(25.0)
San Juan County	4,667,355	5,096,305	(428,950)	(9.2)
Valencia County	2,660,846	2,565,043	95,803	3.6
City of Aztec 2/	1,485,649	1,674,910	(189,261)	(12.7)
Village of Bloomfield	2,632,198 4/	720,221	1,911,977	72.6
Village of Cuba	976,633 4/	273,453	703,180	72.0
City of Farmington	19,715,336	21,287,083	(1,571,747	(8.0)
City of Gallup	11,123,900	12,229,086	(1,105,186)	(9.9)
City of Grants	3,628,512	3,572,227	56,285	1.6
Village of Milan	634,325	667,791	(33,466)	(5.3)
Aztec Public School District 3/	3,564,852	3,878,603	(313,751)	(8.8)
Bloomfield Municipal School District	4,661,074	5,661,979	(1,000,905)	(21.5)
Central Consolidated School District	9,602,501	15,054,627	(5,452,126)	(56.8)
Cuba Independent School District	2,023,814	2,076,170	(52,356)	(2.6)
Farmington Public School District	10,772,264	13,001,575	(2,229,311)	(20.7)
Gallup-McKinley School District	22,258,458	26,013,182	(3,754,724)	(16.9)
Grants Public School District	8,373,014	9,217,819	(844,805)	(10.1)
Jemez Mountain School District	1,488,455	1,608,312	(119,857)	(8.1)
All local governments	$115,418,215	$130,234,394	$14,816,179	(12.8)

Sources: U.S. Department of the Interior, Bureau of Land Management, 1979.
1/ N.M. Dept. of Finance and Administration, New Mexico State Budget, 1977-1978, 1977.
2/ N.M. Dept. of Finance and Administration, Local Government Division, County Governments and Municipal Governments, 1977.
3/ N.M. Dept. of Finance and Administration, Public School Finance Division, Statistics: Public School Finance, 1977.

Notes:
4/ Extraordinary source of revenues budgeted.
5/ Deficits indicated by parentheses.

revenues and expenditures for fiscal 1977 or fiscal 1978 in important areas are shown in the table, included here to give a general idea of public finances in the area as a whole. Only San Juan and McKinley counties, it will be recalled, lie wholly in the uranium study area.

As may be deduced from Table XI-2 (Chapter XI), in some counties the large proportion of land in public or Indian ownership reduces the property tax base with resulting effects on the state and county governments and on the school districts. Of the two counties most involved in uranium activity, McKinley County is two-thirds owned by Indians, with just 15 percent of the county privately owned. Thirty-four percent of Valencia County is privately owned. Municipalities have a special financing problem in that they receive neither property tax revenues from uranium production nor revenues from the severance and resource excise taxes levied on uranium production. These factors are discussed later under the Moderate and High uranium development assumptions.

As would be expected, sources and methods of raising revenue differ greatly on and off the Indian reservations. Off-reservation, towns and counties tax locally, float bonds (debt instruments), and receive state and federal funds. On-reservation, bonding is not allowed as a method to finance service facilities. Tribal taxation is fledgling and minimal at this point, with a possibly poor tax base. There is heavy dependence on federal budgets (PHS, BIA) and grants, supplemented by tribal mineral income. Off-reservation, risks (public debt) can be assumed for future returns. On-reservation, risks are not taken and budgeting is slow and unresponsive, a condition not likely to change greatly in the face of pressures for federal cutbacks. Also, on the reservation many facilities and services are operated by joint arrangement, the tribe entering into many projects with the support of the BIA.

Public Services

Education. Public school districts in northwestern New Mexico are headquartered at Grants, Gallup, Farmington, Aztec, Bloomfield, Shiprock, and Cuba. They vary greatly in size and composition. The Gallup district covers all of McKinley County and contains about one-third of the area's total student enrollment in its 28 schools.

Table VIII-2 shows a 40 day average daily membership (ADM) of 36,541 for the seven districts. This is 13 percent of the total state ADM.

Personnel numbers given in Table VIII-3 are roughly proportional to the ADM and show the schools are a major employer. McKinley County, for example, has few employers that can match the public schools' employee count of 995.

Enrollments in public schools have increased rapidly since 1970, due mainly to arrivals of new families in the area and to Indian children transfers. The BIA has the primary responsibility for educating Indians living on reservations. In recent years increased employment opportunities have induced Indians to move from outlying areas to the vicinity of the larger towns. This produced a drop in enrollments at the BIA-operated day schools

Table VIII-2

Average Daily Membership (ADM) in Northwestern New Mexico*

County/District		40 Day ADM, 1977-78
Western Valencia County:	Grants #3	5,885
McKinley County:	Gallup #1	12,406
San Juan County:	Aztec #2	2,150
	Farmington #5	7,282
	Bloomfield #6	2,522
	Central Consolidated #22	5,320
Western Sandoval County:	Cuba #20	976
Subtotal		36,541
New Mexico State Total		272,596

*Statistics, Public School Finance Division, State of New Mexico, December 1978. Figures cover 1977-78 year.

Source: Gibson, 1979, No. 45

Table VIII-3

Northwest New Mexico Certified and Non-Certified Public School Personnel*

			Total Personnel	
		Teachers Only	Certified	Non-Certified
Western Valencia:	Grants #3	285.38	327.68	132.00
McKinley:	Gallup #1	610.50	706.83	287.83
San Juan:	Aztec #2	110.67	128.17	40.04
	Farmington #5	349.50	405.00	127.40
	Bloomfield #6	123.00	139.60	57.88
	Central Consolidated #22	235.00	270.00	99.75
Western Sandoval:	Cuba #20	52.00	60.33	19.50
New Mexico State Total		13,271.39	15,535.17	5,762.24

*Statistics, Public School Finance Division, State of New Mexico, December 1978. Figures cover 1977-78 year and describe full-time equivalent employees.

Source: Gibson, 1979, No. 45.

and boarding schools and an increase in student numbers at public schools, particularly in San Juan County.

Pupils in the BIA schools throughout the region are usually Navajo; in 1977-78 these schools enrolled nearly 7,000 students. Twenty-one private and parochial schools enrolled an additional 4,500 students, many of them Indians attending mission schools near the Navajo reservation.

All public school districts in the area have had difficulties accommodating to growth; as indicated in Table VIII-1, every district listed had some difficulties matching spending plans with income in 1977-78. In 1977,

every district except Cuba and Jemez Mountain reported enrollments were exceeding design capacity in one or more schools. In the Gallup-McKinley school district, 28.7 percent of the classrooms in use were temporary facilities.

School districts also face the problem of obtaining qualified teaching personnel. Pupil-teacher ratios in the Bloomfield, Central Consolidated, Farmington, and Grants systems exceeded the accepted standard and state average in 1977. In all but the Farmington district, teachers' qualifications fell beneath the New Mexico average, according to the state index of training and experience (U.S. Department of the Interior, Bureau of Land Management, 1979).

The four public institutions of higher education also have grown rapidly. The Gallup branch of the University of New Mexico, established in 1968, had more than 900 students and 40 faculty members in 1977. The San Juan and Grants divisions of New Mexico State University had a combined 1,325 students and 95 faculty members, and the Shiprock branch of Navajo Community College enrolled an estimated 300 served by a faculty of 23.

Navajo Indian school enrollments are shown in Table VIII-4, with breakdowns for Crownpoint and Shiprock in Table VIII-5.

Table VIII-4

Navajo Area Total Education Enrollment for the Years 1970-1978

	Actual Enrollment					Average Daily Membership		Actual Enrollment	
	1970	1971	1972	1973	1974	1975	1976	1977	1978
INTERMOUNTAIN									
Agencies:									
Eastern Navajo	4113	4599	4597	4447	3919	3723	3723	3817	4272
Shiprock	3262	3349	2973	2836	2629	2306	2369	2444	2590
Tuba City	4677	4740	4763	4723	5067	5093	4982	5076	5143
Chinle	3599	3980	3917	3630	3472	3212	2890	2890	2824
Fort Defiance	4479	4597	4630	4431	4318	4018	3928	3832	3713
Grand Total	20130	21265	20880	20067	19405	18352	17892	18059	18542
Contract Schools:									
Borrego Pass	51	55	51	77	97	124	102	114	124
Rock Point	307	340	347	351	347	311	315	345	327
Rough Rock Elementary	328	368	294	347	279	263	327	316	357
Rough Rock High	-0-	17	95	56	115	132	74	92	119
Kitsillie (Black Mesa)	----	----	----	----	----	----	----	----	40
Grand Total	686	780	787	831	838	830	818	867	927

Source: Bureau of Indian Affairs, Branch of Education, 1978.

Table VIII-5

Crownpoint and Shiprock Total Education Enrollment
(BIA and Public) for 1977-78

	Grades	Enrollment	Teacher-Pupil Ratio
Crownpoint			
BIA Boarding School	1- 8	535	1.22
McKinley County High School	7-12	600*	1.20
McKinley County Elementary	1- 6	528	1.18
Crownpoint Pre-School (ONEO)	Preschool	22*	1.7
Total		1,685	
Shiprock			
BIA Boarding School	1-12	250	1.20
Mesa Elementary (Public)	1- 5	560	1.20
Nizhoni Elementary (Public)	6- 7	330	1.20
Tsa Bit al Middle (Public)	8- 9	---	1.21
Shiprock High School (Public)	8-12	900	1.22
Shiprock Preschool (ONEO)	Preschool	406	1.22
Total		2,446	

*Estimated Figure.
Source: Bureau of Indian Affairs and Department of Public Education, 1978.

Health Services. Northwest New Mexico is served by four general hospitals open to the public, with a fifth operated in Gallup by the Indian Health Service (IHS) and serving only Indians. These institutions are listed in Table VIII-6. The Gallup Indian Medical Center serves not only the Indian population of the area but also Indian patients from a much larger region, as well. To include the enlarged region in the area's bed count would distort the local health needs picture. As shown in Table VIII-6, Cuba also has a small health center, and diagnostic or treatment centers exist in several communities. The hospitals operated well below capacity in April 1979.

Table VIII-7 points to a lack of nursing home beds in the area and describes the availability of intermediate care beds, clinics, and pharmacies. It should be noted that the figures on short-term beds are at odds with those in Table VIII-6 because they include total beds rather than just licensed beds. The differences come with the USPHS Indian hospitals in Gallup, Zuni, and Shiprock, which require no state licenses.

Health Services Manpower: The number of physicians and other health services personnel are shown in Tables VIII-8 and VIII-9. These figures describe total county resources, with no distinction between general practice and those who are often devoted to serving Indians from outside the area.

Levels of medical service are highly variable in spatial terms. For the most part, such centers as Gallup and Farmington enjoy high quality medical service. Dispersed rural populations, on the other hand, are frequently not well served. Because of these disparities, entire counties

Table VIII-6

Medical Facilities in Northwest New Mexico

General Hospitals		Licensed Capacity*
Gallup:	Gallup Indian Medical Center	152 beds 1/ 24 mental
	McKinley General Hospital	80 beds (34%) 2/
	Rehoboth Christian Hospital	41 beds (59%)
Farmington:	San Juan Regional Medical Center	144 beds (62%)
Grants:	Cibola General Hospital	43 beds (44%)

*Note: April 1979 occupancy in parentheses.

Special Hospitals		
Cuba:	Cuba Health Center	12 beds

Diagnostic and Treatment Centers	
Gallup:	Gallup Family Health Center
Cuba:	Presbyterian Medical Services (D.B.A. Checkerboard Area Health System)
Farmington:	Family Planning and Home Health Agency
	Presbyterian Medical Services - Farmington Medical Services
Grants:	West Valencia County Health Office
	Grants Hura Medical Associates

1/ Bassinets omitted.
2/ Occupancy based on current use of only 42 of the 80 licensed beds.

Source: Gibson, 1979, No. 45.

may be designated as "shortage areas" or "underserved areas" by official agencies.

Service Levels: Three basic measures of service level are appropriate topics of a discussion which focuses on either current or future needs for medical facilities and services in the SJBRUS study area. Populations will create demand for short-term beds, physicians, and dentists, and it is reasonable to expect that much of this demand should be met at the local level.

In terms of short-term beds per 1,000 population, only McKinley County exceeds the state average of 4.1. At first glance, McKinley County would appear to be overserved but facilities in Gallup draw clients from a much larger area. Nevertheless, the low occupancy levels in Gallup's non-Indian general hospitals indicate that unused capacity is substantial.

The 1977 data which describe San Juan County suggest that the county now meets the minimum requirements for beds per 1,000 population; 1978 data would include the increases in beds that came with the new San Juan

Table VIII-7

Medical Facilities in Northwest New Mexico

	McKinley	Sandoval	San Juan	Valencia	State Total
Short-Term Hospitals	5	0	2	2	50
Number of Beds[1/]	354	0	193	62	4,658
Beds/1000 Population	6.9	0	3.0	1.3	4.1
Nursing Homes	0	0	0	0	13
Number of Beds	0	0	0	0	376
Beds/1000 Population over 65	0	0	0	0	5
Intermediate Care Facilities	1	0	1	1	36
Number of Beds	62	0	62	344	3,051
Beds/1000 Population over 65	28	0	19	134	39
Clinics and Pharmacies[2/]					
Clinics	6	15	6	7	200
Pharmacies	5	3	11	12	265

1/ Slight increases were subsequently reported.
2/ Clinics include military and civilian. Generally, private physicians' offices were not defined as clinics. Pharmacies do not include military.

Source: Health Resources Registry-1977, New Mexico Statistical Summary, Max Bennett et al, University of New Mexico, 1977.

Regional Medical Center. San Juan County now has some unused capacity over "minimum requirements."

Sandoval and Valencia counties are well below state averages. Some parts of Valencia and Sandoval counties are underserved, but residents in the eastern parts have access to hospitals in Albuquerque.

The distribution of primary care physicians is similar to the pattern described for short-term beds. Only McKinley County has a ratio of primary care physicians per 1,000 population that exceeds the state average. San Juan County's ratio is about two-thirds of the state ratio, Sandoval and Valencia's about one-half. All four counties are below the state average for dentists per 1,000 population, although only Valencia and Sandoval are designated as underserved areas.

Accidents are the leading cause of deaths among the Navajos, running more than three times the national rate (Table VIII-10). This is attributed largely to poor roads, active outdoor living, and alcohol abuse. Many health problems on the Navajo reservation are related to transportation, poor housing and sanitary facilities, and social problems such as alcoholism (U.S. Public Health Service, 1976).

Table VIII-8

Physicians in Northwest New Mexico

	McKinley	Sandoval	San Juan	Valencia	State Total
Number of Physicians* (MD's and DO's) -	83	11	57	22	1,744
Phys/1000 Population	1.62	0.49	0.87	0.48	1.54
Number of MD's	82	9	54	16	1,628
MD's/1000 Population	1.60	0.40	0.83	0.35	1.44
Number of Primary Care Physicians	50	10	35	19	956
Phys/1000 Population	0.98	0.44	0.54	0.41	0.84
Number of Family and General Practice Physicians	26	8	25	16	441
Phys/1000 Population	0.51	0.35	0.38	0.35	0.39
Number of Internal Medicine Physicians	9	1	3	4	279
Phys/1000 Population	0.18	0.04	0.05	0.09	0.25
Number of OB/Gyn Physicians	7	0	3	1	151
Phys/1000 Population	0.14	0.00	0.05	0.02	0.13
Number of Pediatric Physicians	11	1	4	1	151
Phys/1000 Population	0.21	0.04	0.06	0.02	0.13

*Data describe civilian physicians only. New Mexico has 84 military physicians.

Source: Health Resources Registry - 1977, New Mexico Statistical Summary, Max Bennett et al., University of New Mexico (1977).

Table VIII-9

Dentists and Nurses in Northwest New Mexico[1/]

	McKinley	Sandoval	San Juan	Valencia	State Total
Number of Dentists	19	7	23	15	504
DDS/1000 Population	0.37	0.31	0.35	0.33	0.44
Number of Dental Hygienists	1	4	2	7	221
DH/1000 Population	0.02	0.18	0.03	0.15	0.19
Number of Nurses (LPN)*	65	41	80	48	1,946
LPN/1000 Population	1.26	1.81	1.22	1.04	1.71
Number of Nurses (RN)*	99	78	99	75	3,544
RN/1000 Population	1.93	3.45	1.51	1.63	3.12

*Note: Figures exclude those not employed in nursing.

1/ Statistics on additional health services personnel are contained in Gibson, 1979, No. 45.

Source: Health Resources Registry-1977, New Mexico Statistical Summary, Max Bennett et al, University of New Mexico, 1977.

Table VIII-10

Navajo and U.S. Death Rates (100,000)

Cause of Death	Navajo Rate	U.S. Rate	Ratio
Alcoholism	26.6	2.1	12.7 to 1
Disease of Liver	7.5	1.0	7.5 to 1
Gastroenteritis	7.5	1.1	6.8 to 1
Tuberculosis	5.5	1.8	3.1 to 1
Accidents	162.9	55.2	3.0 to 1

Source: U.S. Public Health Service, Indian Health Service, Window Rock, Arizona.

Police. Law enforcement in northwest New Mexico presents an extremely complex pattern because of the large number of agencies and the frequently overlapping jurisdictions. Perhaps the most complex problems in this respect involve law enforcement on Indian lands. (Further information on the subject is found in Chapter XI.)

The agencies charged with law enforcement in the study area include seven municipal police departments, four county sheriffs' offices, the New Mexico state police, Indian tribal police, BIA law and order service and the FBI. Agencies responsible for enforcement outside reservations are shown with the locations of their main offices and their manpower strengths in Tables VIII-11, VIII-12, and VIII-13. Jurisdictional areas are portrayed on maps in Gibson's Infrastructure Atlas: Selected Services in Northwestern New Mexico, 1979, No. 53.

Municipal police operate mainly within their communities but occasionally cross city lines in the course of duty. Sheriffs' deputies often live in isolated communities and work out of their homes. The sheriffs generally confine their activities to county areas not controlled by Indian or municipal governments. However, because of the great distances and low population densities, jurisdictional boundaries are sometimes breached by mutual agreement in the interests of efficiency and expediency. The state police focus on traffic duties and cover federal and state highways both on and off reservations.

Other law enforcement activities are primarily oriented toward Indian jurisdictions. Some tribes, such as the Navajo, have their own police. Other tribes have tribal police provided on a contract basis by the BIA, while some tribes have no tribal police but receive BIA law and order service protection as needed. Tribal officers have jurisdiction only over minor crimes. The federal government reserves jurisdiction over major crimes on Indian lands. (See Chapter XI.)

BIA officers are sometimes assigned to specific tribes and in other instances serve several tribes from a central base such as Albuquerque or Bernalillo. In either case they focus on serious crimes. Data collected by the study team in the fall of 1978 indicated a total of 230 sworn officers for Indian jurisdictions in northwest New Mexico. Among these

Table VIII-11

Municipal Police Personnel (Fall 1978)

City	Sworn Officers	Total Employment
Aztec	12	18
Bloomfield	9	16
Farmington	80	115
Gallup	41	62
Grants	20	31
Milan	6	9
Cuba	3	6

Source: Gibson, 1978, No. 27.

Table VIII-12

Sheriff's Department Personnel (Fall 1978)

County/Station	Sworn Officers	Total Employment
San Juan County	23	38
Aztec	23	38
McKinley County	14	18
Gallup	10	14
Thoreau (Substation)	4	4
Valencia County	26	46
Grants (Substation)	8	12
Los Lunas	18	34
Sandoval County	16	24
Cuba (Substation)	1	1
Bernalillo	12	20
Cochiti (Substation)	2	2
Jemez Springs (Substation)	1	1

Source: Gibson, 1978, No. 27.

Table VIII-13

State Police Personnel (Fall 1978)

District		Sworn Officers	Total Employment
District 6 :	Gallup	16	26
	Grants	10	11
District 10:	Farmington	17	23
	Cuba	3	3

Source: Gibson, 1978, No. 27.

Table VIII-14

Indian Area Police
(Fall 1978)

County/Base/Tribe	Sworn Officers	Fulltime Tribal Police	BIA Officers
San Juan County			
Shiprock-Navajo	36	33	3
McKinley County			
Zuni Pueblo	19	15	0
Crownpoint-Navajo	58	55	3
Valencia County			
Ramah-Navajo	7	1	6
Acoma Pueblo	9	6	0
Isleta Pueblo	9	4	4
Laguna Pueblo	14	14	0
Sandoval County			
Cochiti Pueblo	20	0	0
Jemez Pueblo	10	3	0
Sandia Pueblo	2	1	0
San Felipe Pueblo	17	0	0
Santa Ana Pueblo	6	1	0
Santa Domingo Pueblo	6	0	0
Zia Pueblo	17	2	0
	230	135	16
Albuquerque-10 Pueblos			3
Bernalillo-10 Pueblos			10
			13

Source: Gibson, 1978, No. 27.

were 135 fulltime tribal police and 16 BIA personnel assigned to various areas. An additional 13 BIA officers based in Bernalillo and Albuquerque were assigned to the 10 Southern Pueblos. The distribution of these police is shown in Table VIII-14. (Additional manpower details are available in Gibson, 1978, No. 27.)

The FBI covers some of the same functions as the BIA officers but has much more limited representation in the region. Within the New Mexico part of the study area, three FBI agents are stationed in Farmington and four in Gallup. Other FBI agents work out of Albuquerque, as well as Moab, Utah, and Flagstaff, Arizona.

The figures in the tables here indicate that most police departments, especially the larger ones, seem to be prepared to meet the immediate needs of their service areas. Reported crimes in the area have been increasing, and San Juan and Valencia counties were designated Class II High Crime Areas in the 1977 governor's council on criminal justice planning comprehen-

sive plan. Local officials suggest, however, that actual crime rates may be nearly equal among the area's counties because many crimes against Hispanos and Indians in rural areas go unreported. In McKinley County, for example, the sheriff's department has estimated that 50 to 75 percent of crimes committed outside Gallup are not reported. Local police departments meet national standards in number of residents per officer except in the rural parts of Rio Arriba, Sandoval, and Valencia counties. Misdemeanors and alcohol abuse among Indians elevate the arrest rates in some areas. A compilation of crimes per thousand inhabitants and the number of police compared with population may be found in the BLM's Star Lake-Bisti EIS (U.S. Department of the Interior, Bureau of Land Management, 1979).

Fire Protection. Fire protection, like police protection, is complicated in northwest New Mexico not only by the number of agencies and poorly defined jurisdictional lines but also by the difficulty in evaluating the effectiveness of non-professionals who make up a large share of the manpower.

Four kinds of fire departments are found. The only fully paid department, in Farmington, is the largest, best equipped and most professionalized operation in the area. It has 87 paid firefighters.

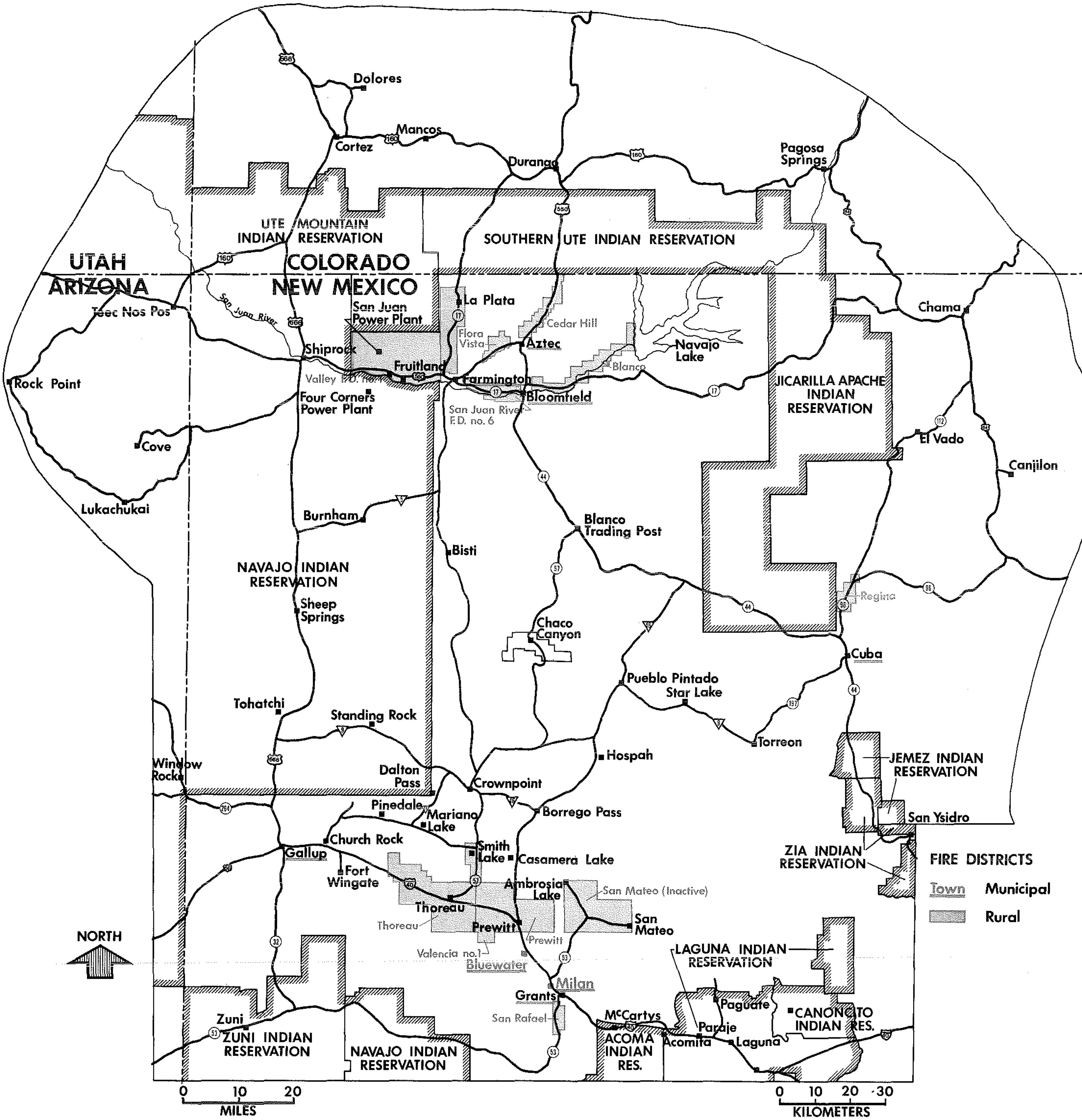
Two other municipal departments use both paid and volunteer firefighters. Gallup and Grants are professional operations, although neither has the recommended number of paid firefighters; equipment is adequate but less sophisticated than that in Farmington. Gallup had 32 paid firemen and 10 volunteers at last count; Grants had 13 paid firemen and 28 volunteers. Primary jurisdiction is localized, but both departments are available to outlying areas. The Gallup department, for example, serves a 25-mile radius.

The Bloomfield, Aztec, Milan and Cuba departments use volunteer firemen, and volunteer rural departments cover much of the remaining non-Indian territory in the study area. Coverage by rural departments varies largely with population density. San Juan County has six rural departments, while McKinley County has just one, at Thoreau. Coverage is spotty in western Valencia and Sandoval counties. Federal agencies join in fighting fires that threaten broad areas. The BLM has fire stations at Cuba and Farmington, and the Forest Service has stations near Fort Wingate, El Morro, and Grants.

In general, most of the fire departments of the area, especially the larger ones, appear well prepared to meet their immediate needs.

Fire districts are shown on Map VIII-1. Details on the staffing of various fire departments are contained in Gibson, 1978, No. 27.

Public Works. Northwestern New Mexico is well acquainted with sharp rises and falls in population. In recent years talk has focused on the population boom expected to accompany development of coal and uranium resources. Those charged with the operation of local water systems and wastewater treatment facilities have taken the initiative to plan for this anticipated growth.



(OFF RESERVATION)
FIRE DISTRICTS
NORTHWEST NEW MEXICO

Map VIII-1

Figure VIII-3.--A touch of the old and new in firefighting equipment at Aztec in San Juan County

They have been aided by three factors. First, residents appreciate the need to prepare to cope with possible increased populations. Second, the State of New Mexico has recognized a need to improve and expand water and sanitary services in the region and has made funds available. Third, independent of the exceptional situation the area may face, the federal government through the EPA and other agencies has made large amounts of money available to communities that wish to develop or improve water and wastewater systems.

In short, resources have been made available, and communities have taken advantage of them. This does not mean there are no service provision problems, nor is there any guarantee that the future will be trouble free. The publicly-owned wastewater treatment plants for this area, in general, are becoming prepared to handle the demand imposed by the existing population; any increased waste load to a few of these plants, however, would aggravate existing wastewater disposal problems.

There are, in effect, two jurisdictions that provide water to individuals and commercial operations that do not have their own private source. First, there are seven major municipal systems: Farmington, Bloomfield, Aztec, Cuba, Gallup, Grants, and Milan. Second, there are dozens of water users associations and similar jurisdictions that pump their own water or buy it from an established system and distribute it to a usually small localized clientele.

A brief overview follows. (Further information may be found in Gibson, 1979, No. 38.)

The Farmington water system is clearly the largest in northwest New Mexico, serving an estimated 37,700 people not only in Farmington but also in Shiprock and the area served by the Lower Valley Water Users'

Association. Its capacity is huge, with 23 MGD (million gallons per day) maximum production, 10 MGD current average production and an unused capacity of 13 MGD. Farmington gets its raw water from the Animas River, Farmington Lake, Butler Pond, and Hydroplant, like Aztec and Bloomfield depending on surface water.

The following summarizes municipal water situations at a glance:

Farmington: Officials feel the supply of raw water will be adequate to accommodate substantial future population growth.

Bloomfield: Officials feel they have enough water rights to serve greatly expanded future populations. Current pump storage capacity meets both peak day and peak hour demands, and tentative plans are to expand treatment and storage facilities. A sizable population growth probably could be accommodated.

Aztec: Water rights appear sufficient for foreseeable needs. Pump storage meets peak day demand levels, but storage facilities are unable to meet peak hour demand.

Gallup: The Gallup system has a maximum production of 5.9 MGD of ground water against a current average production of 3.1 MGD. Pump storage capacity, at 15.8 MG, is huge--both peak day and peak hour pump storage demands can be met by the present system with ease. A possible constraint could be water rights. A study is in progress to determine whether ground water supply could be a limiting factor for future growth. The present production system itself could support a sizable additional population.

Grants: Local officials are confident they have both the ground water supply and the plant and equipment that will permit them to serve substantially increased populations. At the assumed probable level of demand of 125 GD/person, water could be produced to supply an additional 35,200 people. Current per capita production is about 110 GD; at this rate the system could handle another 40,000 people.

Six major municipal wastewater treatment systems serve the area, with several smaller systems in operation or planned. Unlike the water systems, wastewater systems frequently are at or near capacity. Some communities face significant disposal problems, even though certain systems are in the process of being expanded and upgraded. The larger systems are expected to handle a significant share of the new growth in the region, with on-site liquid waste disposal systems serving the rest of the new growth. Municipal systems are found in Farmington, Aztec, Bloomfield, Cuba, Grants-Milan, and Gallup. Many of the on-site disposal systems will be installed in the Animas, La Plata, and San Juan River valleys in the Farmington, Aztec, Bloomfield area, and a ground water pollution problem could rapidly develop.

Farmington: The wastewater system is much more localized than the water system, serving only residents of the legal city. The system employs a trickling filter type plant with a design flow of 4.5 MGD and an average flow of 4.5 MGD. The plant does not meet NPDES permit requirements.

Figure VIII-4.--Liquor establishments, sometimes remote from populated areas, are frequent gathering centers for Navajos

Local officials have applied for an EPA grant to upgrade the plant. The new system would have a design flow of 7.0 MGD and an estimated average flow of 4.75 MGD. Estimated unused capacity at time of completion is 2.25 MGD--enough to support an additional 22,500 people at probable levels of water demand (150 GD/person production of treated water) or 12,700 new people using the current figure of 265 gallons of treated water/person.

Bloomfield: The system utilizes an activated sludge plant with fixed aerators in the aeration tanks. The present plant was placed on-line in July 1978 and appears to meet NPDES permit requirements. The excess capacity of 0.45 MGD should be adequate to support an additional 5,000 to 6,000 people.

Aztec: Aztec has outgrown a trickling filter type plant built in 1954 which does not meet NPDES permit requirements. Aztec has submitted a grant application to replace the plant. With a design flow capacity of 1.2 MGD against an average flow of 0.52 MGD, the proposed excess capacity of 0.68 MGD would accommodate 8,000 new people at a probable level of water consumption of 125 GD/person.

Gallup: The wastewater treatment plant meets NPDES permit requirements. It is an activated sludge plant with aerated ditch and surface brushes with pressure filters. Improvements are under construction. The plant has an average flow of 2.1 MGD, a design flow of 2.5 MGD, and an excess capacity of 0.4 MGD. At a probable water consumption level of 125 GD/person this system could accommodate almost 5,000 new people.

Grants-Milan: Probably the most consistently malfunctioning wastewater treatment system in the area is the Grants-Milan shared system. It is an activated sludge type plant with aerated ditch and surface brushes.

The plant does not meet its NPDES permit requirements consistently and bypasses frequently due to mechanical malfunctions; the mechanical malfunctions recur with steadily increasing frequency, resulting in serious wastewater disposal problems.

An additional problem is the inability of the city to maintain adequate staffing at the wastewater treatment plant, due, in part, to the higher salaries paid by the uranium companies. The design flow is 2.5 MGD and the average flow is 1.7 MGD.

Until the mechanical malfunctions are corrected and an adequate operation and maintenance program is initiated by the city to keep all operational units functioning, any increased sewage added to the system would just further aggravate the already existing waste disposal problem.

Long range plans call for replacement of the Grants-Milan system with a $7.5 million plant having a 3.7 MGD capacity. If approved and funded, the anticipated date of completion of the new plant would be December 1983. A major obstacle is the fact that bonds used to pay for existing facilities would still be outstanding, so the new plant would be constructed before the existing plant was paid off, significantly increasing the user charges for the community. An alternative proposal calls for construction of holding tanks that would allow Milan's wastewater to be stored and processed during off-peak hours.

Solid waste disposal in the area is not a major problem. Sanitary land-fills are located near urban communities.

The area is well supplied with energy from the Colorado River Storage Project, from various power companies, and from natural gas distributors. Electricity is delivered from the Colorado River project and the Four Corners and San Juan generating stations. Electric consumption in 1977 was estimated at 868.3 million kilowatt hours (KWH), or 5,348 kwh per resident. Demand for electricity and natural gas is on the increase.

More information on transportation, welfare, mental health, and recreation can be found in Gibson, 1979, No. 39, and Gibson, 1980, No. 62.

Detailed information on Eastern Navajo roads, social services, general assistance, mental health, law enforcement, fire protection, education, health, and housing can be found in Gibson, 1980, No. 70, and Griffith, 1980, No. 52. Unfortunately, the latter was submitted too late for extensive inclusion in this document.

PUBLIC INFRASTRUCTURE WITHOUT FURTHER URANIUM DEVELOPMENT

Fiscal Concerns

If uranium development were permitted to phase itself out as assumed under this scenario, the population of the New Mexico part of the San Juan Basin region could be expected to grow from approximately 200,000 in 1977 to about 300,000 by 2000. This growth is estimated mainly on the basis of

such other development as coal mining and electric power generation, largely impacting the northwest corner of this part of the basin.

Hence, fiscal impacts on agencies charged with providing public services would be mixed. On one hand, services would probably be needed for about 100,000 additional inhabitants, about half the increase anticipated with Moderate uranium activity. This more modest growth rate would ease expansion pressures considerably. As pointed out earlier, with state and federal help communities have already moved to accommodate larger populations in some respects, though serious short-term problems could appear in some areas if not forestalled by appropriate advance planning. Loosely organized rural communities faced with quick growth would be particularly vulnerable.

On the other hand, a winding down of uranium development would reduce prospects for what would assuredly be the greatest economic boom in New Mexico history. One direct result would be the ruling out of huge tax revenues destined overwhelmingly for coffers of the State of New Mexico with Moderate or greater uranium development. (Potential costs and potential revenues are discussed under the Moderate projection.)

The Navajo tribe would receive royalties from coal, oil and gas, and perhaps other resources but could be affected in service delivery by cutbacks in federal spending.

Public Services

Projected needs are summarized from Gibson, Nos. 45, 38, and 27, where greater detail and specific figures may be found.

Education. Enrollment in public and private schools is estimated to grow under the no-further-development assumption by 12,000 students or 33 percent over the 1978 level by 2000. As Table VIII-15 shows, all districts

Table VIII-15

Estimated Total School Enrollment
Without Further Uranium Development

District	1985	1990	1995	2000
Grants #3	7,460	8,359	8,806	9,343
Gallup #1	13,730	14,447	14,897	15,322
Aztec #2	2,448	2,600	2,653	2,767
Farmington #5	8,330	8,848	9,029	9,417
Bloomfield #6	2,882	3,061	3,124	3,258
Central Consolidated #2	6,080	6,458	6,590	6,873
Cuba #20	1,399	1,500	1,535	1,566

Source: Gibson, 1979, No. 45.

would share in the increase, with the Grants system expected to lead the way. By the late 1980's, student growth is expected to be reflected in a demand for more teachers.

Health Services. It can be assumed that such a major center as Albuquerque would continue to draw off many northwest New Mexico residents, reducing the demand for locally provided health services. Grants, for example, lies within a 90-minute drive of Albuquerque and its major medical facilities.

No county in the study area appears to face a shortage of short-term hospital beds under the no-further-development assumption, although the growth in demand should be closely watched. Current numbers of primary care physicians should be adequate to maintain at least minimal service levels in the region through 2000. If higher service levels were required, San Juan County would be among the first to feel the need, and McKinley and western Valencia and Sandoval counties would encounter shortages by the mid-1980's. The number of dentists would be adequate to meet the minimum requirement of area populations until at least the late 1980's.

Police. The professional police departments should face little trouble adjusting to future manpower requirements. Because plant and equipment vary in qualitative terms, no estimates of future requirements in that connection were made. Demand for new vehicles and for expansion of physical plants is expected to grow.

Farmington and Gallup are unusual in being trade centers that serve large surrounding populations, mostly Indians. In both, it is estimated that the number of people actually in town often are two or three times the resident population. Estimated growth needs are shown for municipal police in Table VIII-16 and for sheriffs' departments and Indian tribal police in Table VIII-17.

Fire Protection. Estimates of future needs for firefighters are risky because of the many variables. However, figures here provide a rough idea of the outlook. In McKinley County it appears likely that the Gallup and Thoreau departments both would experience substantial growth as needs increase. The Farmington department is assumed to require little expansion of manpower under foreseeable circumstances. Estimates for the three paid fire departments are shown in Table VIII-18.

Public Works. If population growth follows the baseline scenario, no problems are anticipated for existing water production systems. All have enough unused capacity to accommodate growth at this level through 2000.

Shiprock, Cuba, Farmington (when its new treatment plant comes on line), Bloomfield and Gallup's wastewater treatment plants should be able to handle increases through the 1980's. Aztec and Grants-Milan wastewater treatment plants cannot handle any population growth without aggravating existing waste disposal problems.

As mentioned earlier, detailed information on Eastern Navajo roads, social services, general assistance, mental health, law enforcement, fire

Table VIII-16

Estimated Demand for Police Manpower
Without Further Uranium Development

		1985	1990	1995	2000
Aztec	- Sworn Officers	18	19	20	20
	Total Employment	23	24	26	26
Bloomfield	- Sworn Officers	9	9	9	10
	Total Employment	16	16	16	16
Farmington	- Sworn Officers	92	99	104	109
	Total Employment	133	143	150	157
Gallup	- Sworn Officers	46	49	52	54
	Total Employment	69	74	78	82
Grants	- Sworn Officers	24	28	30	32
	Total Employment	32	36	39	42
Milan	- Sworn Officers	11	12	13	14
	Total Employment	13	15	16	18
Cuba	- Sworn Officers	44	5	5	6
	Total Employment	6	6	7	7

Source: Gibson, 1978, No. 27.

Table VIII-17

Estimated Demand for Sheriff-Tribal Police
Without Further Uranium Development

		1985	1990	1995	2000
San Juan County	- Sworn Officers	44	47	49	52
	Total Employment	54	58	60	64
McKinley County	- Sworn Officers	57	61	64	67
	Total Employment	70	75	78	82
Valencia County	- Sworn Officers	40	46	49	53
	Total Employment	50	57	61	66
Sandoval County	- Sworn Officers	33	38	41	44
	Total Employment	41	46	50	54

Source: Gibson, 1978, No. 27.

Table VIII-18

Estimated Demand for Firefighters
Without Further Uranium Development

	1985	1990	1995	2000
Farmington (includes rescue units)	87	87	89	92
Gallup*	50	53	56	59
Grants*	28	32	35	37

*Both Grants and Gallup have paid and volunteer firefighters. Figures given are estimates for a fully paid department.

Source: Gibson, 1978, No. 27.

protection, education, health, and housing can be found in Gibson, 1980, No. 70, and Griffith, 1980, No. 52.

PUBLIC INFRASTRUCTURE WITH MODERATE URANIUM DEVELOPMENT

Fiscal Concerns: Key Problems

With uranium development at the assumed Moderate level, the area's population by 2000 could grow to 400,000 or 415,000, approximately double the 1977 level (Chapters II, VII). In this circumstance, too, development could be a mixed blessing for communities in the San Juan Basin. Incoming residents would expect services received elsewhere. Federal and state grants would help with capital costs, that is, construction costs for schools, roads, and sewage treatment plants.

Operation and maintenance, however, would be borne by local governments through property taxes, gross receipts taxes, revenue sharing, and other sources. With so much federal and Indian land in the area, the tax base would be limited. There would be one very important new fiscal factor entering the picture: greatly increased tax revenues from uranium production.

As is brought out subsequently, the potential uranium-impact areas face the prospect of rapid growth in population and demands for services but must look beyond their own financial resources to meet these needs. The municipalities, which will bear the brunt of population expansion if it occurs, stand to receive no tax money--at least directly--from levies on uranium production. The largest beneficiary of uranium taxation, by far, would be the State of New Mexico. Its share would range upward from 90 percent of the severance, resource excise, and property taxes paid by uranium companies in 1980 to 98 percent in 2000, when the total could approach $800 million annually in 1978 dollars.

Growth Stress: Key Problem. Particularly susceptible to the adverse effects of a "boomtown" syndrome would be small, unincorporated communities

such as Prewitt and Thoreau. Lacking planning agencies and the resources to anticipate the impacts of an influx of newcomers, small communities such as these might well suffer from lack of sewers, water supplies, electricity, paved streets, or other amenities that make life tolerable in populated areas.

If capital outlay funds were made available to supply needs in this respect, still remaining would be the question of operating funds. State agencies would appear to be a primary source to whom such communities should look. In some cases, a mixture of Indian and non-Indian residents and jurisdictions would make it necessary for federal and state authorities to cooperate in foresighted action to forestall boomtown conditions in advance.

Tax Revenue on Uranium. Two major taxes are levied by the State of New Mexico on uranium as a depletable resource. They are the severance tax and the resource excise tax. In addition, a special version of the property tax which includes a tax on production is levied by local governments as well as the State.

The severance tax currently in force, enacted in 1980, uses the gross value of U_3O_8 as the tax base, applying a rate structure which in effect ties the tax per pound to the price of U_3O_8. As indicated in Table VIII-19, when the price exceeds $40 the tax per pound is $3.15 plus 12.5 percent of that part of the price above $40. For instance, the tax per pound when U_3O_8 is worth $100 per pound is $3.14 plus $7.50, or a total of $10.64, amounting to 10.6 percent; at a price of $200 per pound the tax is $3.14 plus $20, totalling $23.14, or 11.6 percent.

Table VIII-19

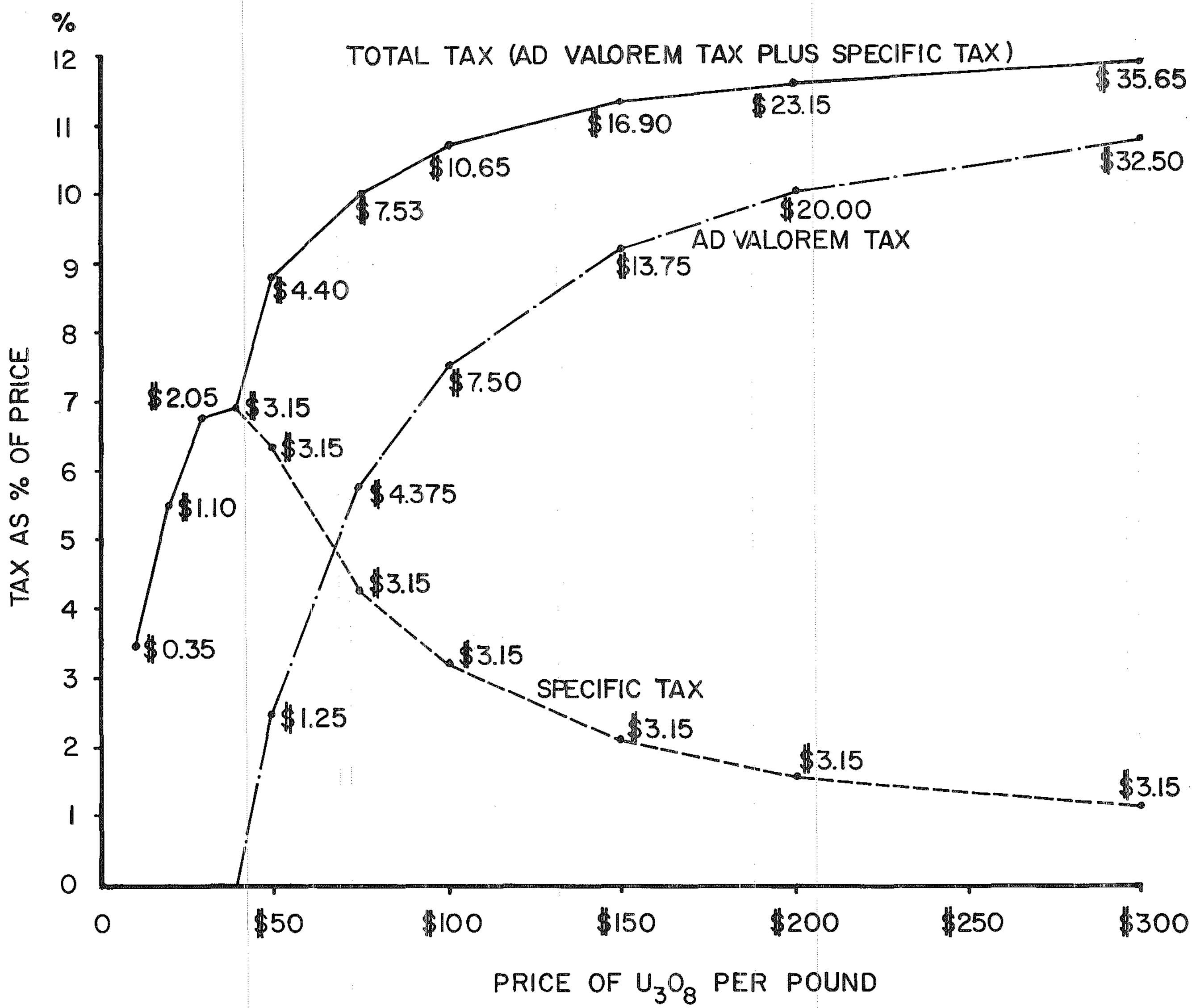
New Mexico Uranium Severance Tax Rates

If Taxable Value per pound of U_3O_8 is:

Over	But Not Over	The Tax Per Pound Shall Be:
$ 0	$ 5	2.0%
$ 5	$ 7.5	$ .10 plus 4.0% of excess taxable value over $ 5
$ 7.5	$10	$ .20 plus 6.0% of excess taxable value over $ 7.5
$10	$15	$ .35 plus 7.0% of excess taxable value over $10
$15	$20	$ .70 plus 8.0% of excess taxable value over $15
$20	$25	$1.10 plus 9.0% of excess taxable value over $20
$25	$30	$1.55 plus 10.0% of excess taxable value over $25
$30	$40	$2.05 plus 11.0% of excess taxable value over $30
$40 and over		$3.15 plus 12.5% of excess taxable value over $40

Source: Boyle, Rev. 1980, No. 51, based on New Mexico Laws of 1980, Chapt. 62.

If the price continues to rise the rate will approach but never reach 12.5 percent. (These relationships are illustrated in Figure VIII-5.)



<u>SOURCE</u>: BOYLE, 1980 NO. 51

EFFECTIVE SEVERANCE TAX RATES AT SELECTED PRICES (PER POUND U_3O_8)

Figure VIII-5

Severance taxes on uranium, as on other production, are earmarked and paid into the severance tax bonding fund. The law states that up to one-half the annual revenues accruing to this fund may be used for payment of principal and interest on bonds issued for capital improvements. Once debt service for the year is paid and an amount set aside equal to the following year's debt service, the remainder is transferred to the severance tax permanent fund.

A constitutional amendment approved by the voters in 1978 made this a "permanent" fund by requiring at least a two-thirds vote of the legislature to use the fund for any purpose other than debt service. Finally, the revenue from the permanent fund is paid into the severance tax income fund and is available for general purposes. The amounts and relationships among these funds, along with additional detail, are given in Boyle, Revised 1980, No. 51.

The resource excise tax, levied at the rate of 3/4 percent, allows deduction from the tax base of royalties paid to federal and state governments. It is deposited in the state general fund, against which general appropriations are charged. Therefore, unlike the severance tax, it is available for general purposes.

A property tax is levied both on the value of mining assets and on value of annual production. The tax ordinarily is levied by school districts, counties, state, and cities, which benefit in that order. While millage for general purposes has an over-all constitutional limit of 20 mills, additional millage (such as for capital outlay) can be authorized by referendum. The average property tax rate in New Mexico is about 35 mills but varies among jurisdictions. In 1978 it was estimated that property tax amounted to \$0.2025 per pound of U_3O_8 based on an average price of \$29.04 per pound. (Total taxes then came to \$1.9165. For 1979 figures reflecting a lower uranium price see below.)

Since no uranium mining or milling occurs within city limits, city governments receive no property tax revenue on uranium. The state levy of 2.850 mills is paid into the general fund and is available for general purposes. The 6.000 mills levied by the county is available for general purposes in the county budget. Although the largest millage (8.925) is available to school districts, the school equalization formula prevents school districts from gaining significantly from uranium tax growth.

In summary, only the state and county would benefit from additional property tax from increased uranium mining and milling. Cities would receive no revenues, and school districts would gain property tax revenue but "lose" 95 percent of that by corresponding reductions in state aid.

A minor conservation tax and a "radiation protection continued care fund" fee round out the picture. The over-all tax burden on uranium in the first half of 1979 was as follows:

Taxes	Amount Per Pound of U_3O_8
Severance & surtax	$ .8942
Resource excise	.1836
Property	.1790
Conservation	.0109
Continued care	.0920
Total	$1.3597

This estimate is based on an average price of $24.83 per pound and represents an over-all tax burden of 5.5 percent. As prices rise, the overall rate will rise due to the severance tax; also, when special treatment of contracts signed prior to Jan. 1, 1977, expires on Dec. 31, 1984, the over-all rate will increase substantially.

As may be seen, severance tax dominates the uranium tax scene. Estimated revenues from this source in New Mexico are shown in Table VIII-20, but it should be understood that uncertainties in demand, prices, and other factors as outlined in Chapter II render such projections exceedingly precarious.

The estimated annual severance, resource excise, and property tax revenues are combined in Table VIII-21. As indicated, total revenues would reach $740 million in 1978 dollars by 2000.

Distribution of Receipts. While total revenues would be abundant for any purpose related to uranium development, the revenue distribution under present law does not match with the location of the burden of development. As indicated in Table VIII-22, by far the largest share of revenues accrues to the state; in 1980 the state is estimated to receive 90 percent of the cited taxes on uranium mining and milling, while by 2000 the state share could be 98 percent.

The revenue that would be generated by the severance and resource excise taxes on uranium on the assumed Moderate production level would come to $723 million in 1978 dollars in the year 2000. If the 5-year increments occurred evenly, the cumulative total from 1980 to 2000 for the severance tax alone would amount to about $5.1 billion. However, while the amounts would be very large, the revenues would go mainly to the state and the burden of the development would be borne mainly by the cities.

The severance tax goes into the bonding fund, as noted earlier, with half of the fund available each year to service debt. Since 1977, bond issues have been authorized amounting to about $100 million. These funds have been made available to energy impacted communities for construction of such facilities as water and sewer systems and highways. Such funding for capital outlay would no doubt continue and would go a long way toward meeting the requirements for capital outlay.

Table VIII-20

Estimated Annual Severance Tax Revenues from Moderate Uranium Production
(Current and 1978 Dollars)

Year	Average Price 1/ (1978 dollars)	Price Inflation @ 6% per year	Average Price (current dollars)	Tax per Pound 2/ (Current dollars) Specific	Advalorem	Total	Estimated Production 3/ (Millions/lbs.)	Severance Tax (Millions of dollars) '78 dollars	Current dollars
1980	$ 18	12.4%	$ 20.23	$1.10	$ 0.03	$ 1.13	18.5	$ 18.6	$ 20.9
1985	29	50.4	43.62	3.15	0.45	3.60	23.6	56.5	85.0
1990	46	101.2	92.55	3.15	6.57	9.72	36.7	177.3	356.7
1995	65	169.3	175.04	3.15	16.88	20.03	48.5	360.8	971.5
2000	105	260.4	378.42	3.15	42.30	45.45	54.0	681.0	2454.3

1/ D.R. de Halas, Natural Uranium, Demand, Supply and Price, 1978: Monument, Colorado, May 1978.

2/ Based on State of New Mexico, 34th Legislature, 2nd Session, Laws 1980, Chapter 62.

3/ Based on Department of Energy forecast of October 1979 (See Chapter II of San Juan Basin Study).

Source: Boyle, Rev. 1980, No. 51.

Table VIII-21

Severance, Resource Excise and Property Taxes on Moderate Uranium Production (Thousands of 1978 Dollars)

Year	Severance	Resource Excise	Property: Real Property	Property: Value of Production	Total
1980	$ 18,594	$ 2,475	$ 2,326	$ 554	$ 23,949
1985	56,489	5,008	2,966	1,140	65,603
1990	177,286	12,533	4,612	2,814	197,245
1995	360,733	23,400	6,096	5,254	395,483
2000	680,993	42,097	6,786	9,450	739,326

Source: Boyle, Rev. 1980, No. 51.

Table VIII-22

Distribution of Annual Severance, Resource Excise and Property Taxes on Uranium (Thousands of 1978 Dollars)

Year	State: Severance Tax Funds	State: General Funds: Resource Excise	State: General Funds: Property	Counties	School Districts
1980	$ 18,594	$ 2,475	$ 461	$ 973	$1,446
1985	56,489	5,008	657	1,388	2,061
1990	177,286	12,533	1,188	2,510	3,728
1995	360,733	23,400	1,816	3,836	5,698
2000	680,993	42,097	2,598	5,488	8,150

Source: Boyle, Rev. 1980, No. 51.

In addition, some federal funds are provided under the Energy Impact Assistance Program. In the first year, fiscal 1980, New Mexico was allocated $1.1 million. These funds can be used by any local government impacted by coal and/or uranium development. Funds may be used for acquisition and

improvement of sites for public facilities of all types from firehouses to school houses. Such funds have been made available for capital needs and will presumably continue to be available in the future.

Local governments in New Mexico depend on the property tax base for bond issues in support of capital outlay. School districts can issue debt which is equivalent to 6 percent of assessed value, while counties are allowed 1 percent of assessed value.

The assessed value generated by uranium development would be located within the counties and school districts in which the development took place. Therefore, for these governments there would be some correspondence between benefit and cost, with respect to both capital and operating expense. In addition, the state would indirectly make a large contribution to alleviating problems by supporting the operating expense of school districts. As explained previously, about 85 percent of operating expenditure of school districts is supplied out of the state general fund.

While the degree to which benefits and costs are balanced for counties and school districts would require an extended analysis, New Mexico's local finance system does tend to match up costs and benefits for counties and school districts.

Shortfall of City Operating Funds. Funds have been made available for municipal capital needs from severance tax revenues and would presumably continue to be available in the future. However, the needs are great and would necessitate continual additions of capital. Data in Table VIII-23 indicate that investment to support the five basic services of police, fire, streets and roads, general government, and utilities in 1978 amounted

Table VIII-23

Investment in 1975 for Five Basic Services in Five Cities in the Northwest Energy Quadrant
(Dollars in Thousands)

Municipalities	Police	Fire	Streets	General Government	Utilities[1]	Total	Population
Aztec	$ 94.0	$ 140.2	$ 536.2	$ 457.4	$ 1,168.2	$ 2,396.0	5,900
Bloomfield	35.3	81.7	1,007.7	172.6	775.7	2,073.0	2,400
Farmington	1,031.2	213.6	4,512.2	2,194.4	12,866.7	20,818.1	27,300
Gallup	1,095.6	363.0	1,291.0	552.7	6,455.9	9,758.2	19,000
Grants-Milan	363.3	223.3	1,236.2	526.7	2,421.4	4,770.9	13,835
Total	$2,619.4	$1,021.8	$8,583.3	$3,903.8	$23,687.9	$39,816.2	68,435
EXHIBIT:							
Per Capita, 1975	$38.27	$14.93	$125.42	$57.04	$346.14	$581.81	
Per Capita, 1978[2]	$51.55	$57.50	$168.94	$76.83	$466.25	$783.70	

[1]Includes solid waste water and sewer.
[2]Inflated from 1975 by the implicit deflator for state and local government purchases.

Source: Boyle, 1980, No. 51, taken from A.F. Mehr and R.G. Cummings, "A Time Series Profile of Urban Infrastructure Stocks in Selected Boom Towns in the Rocky Mountain States", Los Alamos Scientific Laboratories, Los Alamos, New Mexico, April 1977.

to $783.70 per capita[1/]. In 1995, for instance, if the investment per capita were to be maintained at 1978 levels for an additional population of 17,401 (Table VIII-24) an investment of almost $14 million in municipal infrastructure would be necessary.

Table VIII-24

Estimated Increments of Population and Employment (Direct and Indirect) Due to Uranium Development for Five Cities in the Northwest Energy Quadrant

	1985			1990		
		Employment			Employment	
Cities	Population	Direct	Indirect	Population	Direct	Indirect
Aztec	155	39	26	773	186	124
Bloomfield	126	36	18	603	165	85
Farmington	323	66	69	1,409	264	287
Gallup	911	208	178	2,713	555	534
Grants	2,253	641	314	7,167	1,464	1,429
Total	3,768	990	605	12,665	2,634	2,459

	1995			2000		
		Employment			Employment	
Cities	Population	Direct	Indirect	Population	Direct	Indirect
Aztec	1,499	375	257	1,621	373	277
Bloomfield	1,199	331	177	1,329	338	199
Farmington	2,618	475	607	2,753	479	608
Gallup	3,543	752	724	3,703	751	742
Grants	8,542	1,736	1,819	8,703	1,708	1,829
Total	17,401	3,669	3,584	18,109	3,649	3,655

Note: These estimates do not include existing or announced uranium exploration, mines and mills. Therefore, the full employment impact of industry expansion is not illustrated until 1990 or 1995.

Source: Boyle, 1980, No. 51, based on L.J. Gibson and D. Keen, Population Growth and Resource Development in the San Juan Basin, New Mexico Through the Year 2000, SJBRUS, September 1978; and J.P. Myers, Uranium Industry Labor Market Analysis: San Juan Basin, New Mexico, SJBRUS, May 1978.

1/ A.F. Mehr and R.G. Cummings, A Time Series Profile of Urban Infrastructure Stocks, Los Alamos Scientific Laboratory, April 1977, source of these estimates, define investment as: "...1975 infrastructure stocks for each town were based primarily on inventories from insurance schedules or on town inventories and audits. Such stocks were valued at their 1975 depreciated value which...is a rough surrogate for their 1975 market value" (pp.6-7). These 1975 estimates were raised to 1978 market values by the implicit deflator for state and local government services.

While the state and federal governments are providing assistance for capital outlay, cities are forced to meet the increased operating expenditures by themselves. Of the hundreds of millions of dollars in tax revenues that would be derived from the uranium industry under projected development levels, none would go to cities. As indicated in Table VIII-22, the severance and resource excise taxes go to the state while property taxes are collected by the state, counties, and school districts. With uranium mines and mills operating outside city limits, the cities are without taxing authority on their operations. Nevertheless, employees and their families would live in the cities and use their services. Table VIII-24 shows projected new residents for five cities. By 1995, for instance, they would gain an additional 17,401 people from direct and indirect employment.

While the cities would not receive tax revenue directly from the uranium industry, they would receive additional gross receipts tax from new residents. A rough estimate of this revenue for 1995 follows:

Type of Employment	Increment 1995	Average Wages	Total Wages ($000)	Local Taxable Consumption ($000)	Tax at 1 1/2% ($000)
Direct	3,669	$17,061 1/	62,597	$ 46,948	$ 704
Indirect	3,584	9,362 2/	33,553	25,165	378
TOTAL:	7,253	- - -	96,150	72,113	1,082

1/ Based on J.P. Myers, Uranium Industry Labor Market Analysis: San Juan Basin, New Mexico. SJBRUS, May 1978.

2/ Based on wage information for the 2nd quarter, 1978, in New Mexico Employment Security Commission, "Covered Employment and Wages." May 1979.

Therefore, in 1995 the estimated gross receipts tax revenue, the major source of city operating funds, resulting from new residents brought in by uranium activities would amount to almost $1.1 million in 1978 dollars.

In fiscal 1980, this tax accounted for 59 percent of state general fund revenues. If this relationship held, the incremental revenue in 1995 would amount to $1,834,000, or $105.40 per capita.

As Table VIII-25 shows, the 1978 per capita cost of providing operating services for five basin municipalities was $194.71. Thus, on the expenditure side, if these cities were to maintain the 1978 quality of services for the projected 17,401 additional residents in 1995, the total spending would be $3,388,148. Operating expenses for the expanded population thus would exceed revenues on a per capita basis by $89.31. Summarized, it would look like this for 1995:

Per capita:	Municipal tax revenue	$105.40
	Municipal operating expenses	194.71
	Municipal shortfall	89.31

Table VIII-25

Operating Costs in 1978 for Five Basic Services in Five Cities in the Northwest Energy Quadrant
(Dollars in Thousands)

Municipalities	Police & Fire	Public Works	Gen. Gov.	Parks & Recreation	Other	Total	Population
Aztec	$ 209	$ 70	$ 156	$ 51	-	$ 486	6,400
Bloomfield	185	59	153	15	-	412	3,600
Farmington	2,571	1,212	1,535	884	$677	6,879	30,000
Gallup	1,671	1,387	754	666	177	4,655	17,500
Grants	647	371	289	280	-	1,587	14,500
TOTAL	$ 5,283	$ 3,099	$ 2,887	$ 1,896	$854	$14,019	72,000
EXHIBIT:							
Per Capita	$73.38	$43.04	$40.10	$26.33	$11.86	$194.71	

SOURCE: Boyle, Rev. 1980, No. 51, based on municipal audits for 1978.

Population Estimates from Department of Finance and Administration, Local Government Division.

While this estimate is just approximate, it suggests the magnitude of the problem. Services financed from the general fund would cost substantially more than would be available from revenues generated by new population.

Several possible solutions are available, ranging between the following alternatives. At one extreme, the state could authorize municipalities to levy additional taxes, such as upon gross receipts, selective sales taxes, or even payroll taxes. At the other end of the spectrum the state could authorize a grant program in support of operating budgets for cities impacted by uranium development.

In summary, analysis of the taxation of uranium as a depletable resource indicates that large revenues would accrue to New Mexico from the development of its uranium reserves. By far the largest share would be generated by state taxes which are available, at state discretion, to support such development. Counties and school districts would benefit with respect to both operating revenues and bonding capacity from the location of mines and mills. However, employment and population growth would mainly be a burden of the cities which get no direct tax benefits from uranium development. Tax revenue from indirect sources, such as the gross receipts tax, would benefit the cities but still result in a serious shortfall in both capital and operating expenditures.

Navajo Services Network Problems

Structural Problems. Problems in delivery of public services on the Navajo reservation arise partly from structural causes, that is, the manner in which the government and service delivery systems are organized.

First, there is no provision on the reservation for town government as it is known elsewhere. Second, the BIA, Indian Health Service (IHS) and tribal services are not organized in the standard way. Third, the tribe is

in the process of gradually taking over service responsibilities from the BIA and IHS.

The only lawmaking entity is the Navajo tribal council representing the entire reservation spread over an area larger than several eastern states combined. Councilmen are elected from districts comprised of chapter clusters.

The standard division of government units into state, county, and town does not apply on the reservation, nor is there provision made for municipal government. Navajos participate in state and county government, but this is cross-cut by tribal affiliation. There is no official local mechanism, in short, that can regulate the affairs of growing areas such as Crownpoint, Shiprock, and Thoreau. Services are delivered largely by the tribe, the BIA, and the IHS. These functions sometimes overlap, and they are not divided into the traditional city-county dichotomy (streets and sewers, police, fire vs. social services, health, education).

The process in which the tribe, through contracting with the government, assumes services provided until now by the BIA and IHS might wind up taking precedence over planning to meet rapid growth needs, tied as it is to the defining of tribal sovereignty. Due to the slow change pattern involved, planners may find it difficult to get a fixed picture of which entity assumes responsibility for specific services at a given time now or in the distant future.

Services are provided according to five agency areas, each with an administrative center, set up to serve a largely rural population.

Specific Service-Related Problems. The BIA provides schools, social services, streets, fire protection, and zoning. The U.S. Public Health Service, through the IHS, provides hospitals, water and sewers. The tribe currently provides electricity, police, social services, telephone service, and zoning. All these organizations provide housing; counties also supply schooling.

Crownpoint would feel the pressure for increased services sooner than Shiprock, which has expressed a "no growth" policy. Crownpoint is divided on growth issues.

With Moderate uranium development, the Crownpoint area would need prompt help with its water and sewer system, housing, roads and streets, social service staffing, law enforcement facilities, and outpatient medical facilities. Shiprock would soon need help with roads and streets, social service staff, law enforcement facilities and staff, and fire equipment (Gibson, 1980, No. 70; Griffith, 1980, No. 52).

Successful solution of housing and other residential area problems (such as water, sewers, streets, and electricity) would require greater cooperation between the BIA, the IHS, and the tribe than has occurred in the past. It also would require participation by the energy companies. Crownpoint, in particular, would need to find a way to perform functions

commonly assumed by a town such as zoning certain areas and coordinating construction and maintenance of residential services.

Agencies would need to develop data collection and population projection capabilities to facilitate planning and budgeting.

Fiscal Problems. For the Navajos, budget advocacy is more of a problem than the overall supply of money. Since the tax base for the majority of their funds is federal, and most services are provided for by treaty or law, money would presumably be available. Due to the many other competing demands for federal funds, however, the Navajos' success in obtaining funds for increased levels of services could depend partly on their skill in making the needs known. The cumbersome task of lobbying for federal money is offset, in their case, by freedom from the necessity of capitalizing facilities in the way cities must do to finance bonds.

Staffing Problems. Even after budgetary and interagency coordination problems were solved, there would remain the problem of recruiting and hiring planners, administrators, teachers, doctors and other specialists to serve isolated areas. Federal hiring ceilings, Indian preference policies, and a shortage of qualified Indians might pose problems.

Conclusion. The end result is that Crownpoint, the Eastern Navajo agency, and Shiprock could be tardy in responding to growth problems unless emergency budget transfers were made and special energy growth monies set aside for Indian communities only.

Public Services

Public infrastructure problems that would need prompt attention and careful monitoring are the roads and municipal water systems of the entire basin, the Grants and Cuba school systems, the Shiprock and Crownpoint tribal police and social services, the Crownpoint outpatient facilities, and the Shiprock fire apparatus.

Education. Table VIII-26 shows the projected school enrollments at Crownpoint and Shiprock under two assumed conditions: with moderate development of both uranium and coal, and with high development of both.

Under the Moderate projection, the largest rise in school enrollments would come during and after the latter 1980's. Increases would vary from one district to another. For example, percentage increases in enrollment from 1980 to 2000 would include 139 percent for Grants, 65 percent for Gallup, 70 percent for Cuba, 42 percent for Aztec, 38 percent for Central, 36 percent for Bloomfield, and 32 percent for Farmington. For the most part, the demand for new teachers would parallel increases in enrollments (Tables VIII-27 and VIII-28).

Health Services. Population growth with Moderate uranium development could impose considerable strain on medical facilities and services in the next 5 to 10 years. However, many of the new people moving into the region would locate in major settlements or in smaller centers with ready access to the centers that have most of the medical facilities and services. Thus

Table VIII-26

Projected Indian School Enrollment at Crownpoint and Shiprock with Moderate Uranium-Coal and High Uranium-Coal*

	Population		Enrollment		P/T Ratio		Classrooms	
	1977-78	2000	1977-78	2000	1977-78	2000	1977-78	2000
Crownpoint								
Moderate	3,245	12,617	1,685	6,780	1:20	1:20	84	339
High	3,245	19,731		10,110		1:20		506
Shiprock								
Moderate	15,284	8,714	2,446	3,914	1:20	1:20	156	196
High	5,284	12,143		5,626		1:20		281

*Projections for population increases from: Gibson, 1978, No. 16. A constant proportion of school population to total population is assumed.

Table VIII-27

Estimated Public School Enrollment with Moderate Uranium Development

District	1980	1985	1990	1995	2000
Grants #3	6,362	9,023	13,050	14,545	15,186
Gallup #1	13,026	15,276	18,737	20,807	21,545
Aztec #2	2,259	2,516	2,831	3,091	3,207
Farmington #5	7,684	8,469	9,258	9,772	10,163
Bloomfield #6	2,658	2,940	3,246	3,472	3,615
Central Consolidated #22	5,610	6,186	6,899	7,486	7,768
Cuba #20	1,117	1,472	1,662	1,883	1,898

Source: Gibson, 1979, No. 45.

Table VIII-28

Estimated Demand for New Teachers With Moderate Uranium Development[1]

District	1985	1990	1995	2000
Grants #3	154	350	423	454
Gallup #1	134	302	403	439
Aztec #2	11	27	39	45
Farmington #5	63	102	127	146
Bloomfield #6	20	35	46	53
Central Consolidated #22	66	101	129	143
Cuba #20	20	29	40	40

[1]Number of new teachers required over 1977-78 benchmark levels.

Source: Gibson, 1979, No. 45.

at least in relative terms, the problems of providing health care to dispersed rural populations would become less conspicuous.

On the other hand, current services would become overtaxed in relatively short order, and the demand for locally provided medical services would increase. As facilities were expanded and upgraded they would become more competitive with facilities in Albuquerque and elsewhere. Larger populations would support more specialized facilities and services.

From 1980 to 2000, the demand for short-term hospital beds is estimated to jump by 149 percent in western Valencia County, by 68 percent in McKinley, by 46 percent in San Juan and by 85 percent in western Sandoval County. Some of this demand would be met by hospitals in Albuquerque. Existing facilities should be adequate to accommodate needs beyond the mid-1980's in western Valencia County and McKinley and San Juan counties.

In most of the area there now are enough primary care physicians to serve new populations. A possible exception is Grants-Milan, which could experience a shortage in the latter 1980's. Based on "recommended levels" which require more physicians per 1,000 population than do "minimum requirements," the shortfall could be expected by the mid-1980's or shortly thereafter in McKinley, San Juan, and western Valencia counties.

The number of dentists needed to assure at least minimal levels of health care to the area's population under Moderate growth assumptions should be adequate beyond the mid-1980's, though increased service demands are likely.

Table VIII-29 shows projected needs for hospital beds; Table VIII-30 shows need for physicians, and Table VIII-31 gives estimated dental requirements.

Table VIII-29

Hospital Beds Needed in Selected Towns for "Adequate Service" with Moderate Uranium Development

	1980	1985	1990	1995	2000
Milan	11	19	32	37	39
Grants	38	52	73	81	86
Gallup	55	63	72	78	82
Farmington	94	106	116	126	132
Aztec	20	23	27	30	32
Bloomfield	9	11	13	15	16
Cuba	4	6	8	10	11

Source: Gibson, 1979, No. 45.

Police. Estimates for manpower needs in municipal police departments are shown in Table VIII-32. The personnel needs for sheriffs' departments and Indian tribal police are given in Table VIII-33. Small increases could be expected in state police and FBI personnel.

Table VIII-30

Primary Care Physicians Needed in Selected Towns[1] with Moderate Uranium Development

	1980	1985	1990	1995	2000
Milan	1	2	3	3	3
Grants	3	5	6	7	8
Gallup	5	6	6	7	7
Farmington	8	9	10	11	12
Aztec	2	2	2	3	3
Bloomfield	1	1	1	1	1
Cuba	--	1	1	1	1

1/ Assuming "Minimum Requirements." For "Recommended Levels" see source.

Source: Gibson, 1979, No. 45.

Table VIII-31

Dentists Needed in Selected Towns with Moderate Uranium Development[1]

	1980	1985	1990	1995	2000
Milan	1	1	2	3	3
Grants	3	3	5	5	6
Gallup	4	4	5	5	5
Farmington	6	7	8	8	9
Aztec	1	2	2	2	2
Bloomfield	1	1	1	1	1
Cuba	--	--	1	1	1

[1]Assuming "Minimum Requirements."

Source: Gibson, 1979, No. 45.

Fire Protection. The fire departments at Gallup, Grants, Milan, and Aztec all are candidates for considerable growth if population increases in keeping with the Moderate scenario. The estimates in Tables VIII-34 and VIII-35 should be considered rough, at best, partly because of the variations that exist where volunteers are used partly or wholly. Nevertheless, they suggest the range within which solutions would be needed. The large Farmington department appears likely to need little if any enlargement. More details and statistics are found in Gibson, 1978, No. 27.

Public Works. The Moderate population growth projection calls for substantially more population than is expected without further uranium development. Nevertheless, all growth in six of the seven major centers could be accommodated by existing water production systems for 20 years or more. Cuba, the exception, should be able to handle such growth until the mid-1990's.

Table VIII-32

Estimated Demand for Police Manpower with Moderate Uranium Development

	1985	1990	1995	2000
Aztec				
Sworn Officers	19	20	20	21
Total Employment	23	24	24	25
Bloomfield				
Sworn Officers	9	11	12	13
Total Employment	16	16	17	17
Farmington				
Sworn Officers	94	103	111	117
Total Employment	135	148	160	168
Gallup				
Sworn Officers	48	55	60	63
Total Employment	72	83	90	94
Grants				
Sworn Officers	28	39	41	43
Total Employment	37	51	51	55
Milan				
Sworn Officers	15	17	20	21
Total Employment	19	22	26	27
Cuba				
Sworn Officers	55	6	8	9
Total Employment	6	8	10	11

Source: Gibson, 1978, No. 27.

Bloomfield, Aztec, and Gallup all have sufficient excess pump storage capacity to accommodate growth for 20 or more years, and Grants and Milan are in fairly good shape with capacity to carry them to the mid or late 1980's. The Cuba system is already at capacity and the Farmington area would be at capacity by the mid-1980's under the Moderate scenario. Farmington and Cuba have recognized the need to expand.

Less critical is the fact that most community systems do not have capacity for peak hour demands. Of the seven municipalities only Gallup, Grants, and Milan have such excess capacity, and the latter would exhaust the excess capacity by the early 1980's.

In wastewater treatment, Farmington is at capacity and seeking a solution. Bloomfield and Aztec have enough unused capacity to see them through the century. Gallup and Grants-Milan would be at capacity during the 1986-88 period, barring corrective action at Grants and Cuba by 1985.

Table VIII-33

Estimated Demand for Sheriff's Officers and Tribal Police with Moderate Uranium Development

	1985	1990	1995	2000
San Juan County				
Sworn Officers	44	49	54	57
Total Employment	54	60	66	70
McKinley County				
Sworn Officers	62	78	88	94
Total Employment	76	96	109	116
Valencia County				
Sworn Officers	42	52	58	63
Total Employment	52	64	72	78
Sandoval County				
Sworn Officers	33	38	41	44
Total Employment	41	46	50	54

Source: Gibson, 1978, No. 27.

Detailed information on Eastern Navajo roads, social services, general assistance, mental health, law enforcement, fire protection, education, health, and housing can be found in Gibson, 1980, No. 70, and Griffith, 1980, No. 52.

Table VIII-34

Demand for Paid Firefighters with Moderate Uranium Development

	1985	1990	1995	2000
Farmington	87	87	89	92
Gallup	54	62	67	70
Grants	34	47	53	56

*Grants and Gallup have paid and volunteer firefighters. Estimates are for a fully paid department. If they continue to use volunteers, figures may understate number needed.

Source: Gibson, 1978, No. 27.

Table VIII-35

Demand for Volunteer Firefighters with Moderate Uranium Development

	1985	1990	1995	2000
Bloomfield	35	35	37	35
Aztec	47	53	50	64
Milan	37	64	74	78
Cuba	20	20	20	22

Source: Gibson, 1978, No. 27.

PUBLIC INFRASTRUCTURE WITH HIGH URANIUM DEVELOPMENT

Fiscal Concerns

The discussion of problems of growth and the tax resources to deal with them under the Moderate assumption is basically applicable to the situation under the High one. Both the problems and resources would be increased. A factor which might be expected to be added under the High development level would probably be a high national priority attached to the production of uranium as an asset in the energy situation. This undoubtedly would be accompanied by a willingness on the part of Congress and executive officials to make available any resources required to meet national goals.

Public Services

Education. If population in the area grew at the rate projected with High uranium development, dramatic increases in public school enrollments and needs for new teachers would become apparent in the mid-1980's. Grants and Cuba would more than double their enrollments by 2000, with Gallup close behind. Large investments in capital and personnel would become necessary. Estimated enrollments are shown in Table VIII-36.

Table VIII-36

Estimated Public School Enrollment with High Uranium Development

District	1980	1985	1990	1995	2000
Grants #3	7,104	12,796	15,376	17,120	17,103
Gallup #1	13,777	19,045	23,377	26,610	26,400
Aztec #2	2,329	2,917	3,670	4,004	4,022
Farmington #5	7,847	9,350	10,826	11,403	11,545
Bloomfield #6	2,717	3,293	4,036	4,342	4,408
Central Consolidated #22	5,746	7,103	8,589	9,622	9,687
Cuba #20	1,184	1,837	2,258	2,604	2,566

Source: Gibson, 1979, No. 45.

Health Services. Growth at the High level would mean that western Sandoval County and McKinley and San Juan counties would face short-term bed shortages in the early 1980's. Between 1980 and 2000, demands for short-term beds would increase by 151 percent in western Valencia County, by 121 percent in lightly populated western Sandoval, by 94 percent in McKinley, and by 69 percent in San Juan. Albuquerque would meet some of this demand, but the need for additional facilities would be substantial.

There should be enough primary care physicians to offer service at minimal levels until the late 1980's in most of the region. The current stock of dentists should meet the region's basic needs until the mid-1980's. (Figures are contained in Gibson, 1979, No. 45.)

Police. The increase in population assumed under the High development level would mean modest increases in the number of police needed. For example, Gallup's needs would rise to about 70 sworn officers in 2000, compared with an estimated 63 officers needed in 2000 with Moderate development. Estimates are included in Gibson, 1978, No. 27.

Fire Protection. High uranium development would mean almost no change in manpower requirements for paid fire departments in the area but would necessitate moderate increases in the number of volunteer firefighters in some places.

Public Works. Even with high growth, water production systems should be adequate in most municipalities; Cuba would be the only potential trouble spot, with its system reaching capacity in the mid-1980's under this projected growth level. Pump storage is less bright. At peak demand levels, only Gallup could accommodate growth until the turn of the century. Cuba is at capacity and Farmington, Bloomfield, Milan, Aztec, and Grants would reach capacity by the mid-1980's.

Detailed information on Eastern Navajo roads, social services, general assistance, mental health, law enforcement, fire protection, education, health, and housing can be found in Gibson, 1980, No. 70, and Griffith, 1980, No. 52.

MITIGATION OF PUBLIC INFRASTRUCTURE PROBLEMS

Jurisdictional-Legal Problems

The multitude of ownerships and jurisdictional tangles is of long standing and seems destined to present a continuing puzzle to administrators, with Indian trust lands scattered among private, state, and federal lands. One legislative proposal under current study aims at easing the situation by a land exchange. It would authorize the BLM to exchange 241,808 acres of lands withdrawn under Public Law 2198 to the Navajo tribe for tribal land elsewhere. This acreage is contiguous to present tribal holdings.

Jurisdictional concerns over law and order in the checkerboard area might be worked out through a firm cross deputization agreement between Navajo tribal and off-reservation law enforcement agencies. Other states

have used planning and zoning techniques to control siting and timing of energy development facilities as a way to control impacts. The State of New Mexico, counties, cities and tribe might consider the feasibility and advisability of using these techniques.

Studies of alternate land and resource usage for the area could be undertaken, taking into account differing goals and priorities of the various land management interests in the checkerboard area, including the Navajo tribe, Indian allottees, BLM, and private land holders.

The Navajo tribal government and the BIA might well explore ways in which towns such as Crownpoint, Thoreau, and Shiprock might become legal entities and thus empowered to control quality of life for themselves.

Indian and non-Indian governmental entities should explore both formal and informal ways to perform coordinated social planning for population growth in the I-40 corridor area due to the checkerboarded nature of the land.

Fiscal Concerns

Communities in the area may be hard-pressed under current tax provisions to meet some of the needs of growing populations, but the problems are far from insoluble. While the area could be in for the greatest economic boom in New Mexico history, the prospects fall short of a boom from the social services supply standpoint.

Sociologically, the overall outlook appears to be for a period of rapid growth, rather than the explosive expansion which leads to boomtown conditions. Short-run dislocations could occur in some places, such as Thoreau and Prewitt, but the problems need not become severe if timely action is taken.

Large sums of money would flow into state coffers from taxes on uranium operations if development should achieve the Moderate level or higher. As discussed under "Distribution of Receipts," by far the largest share would be generated by state severance taxes, with some proceeds available to local governments at state discretion to support capital expenditures only. The community assistance council, a state agency, considers applications on an annual basis from local governments and entities for capital funding from the severance tax bonding fund.

Tax revenue from indirect sources, such as the gross receipts tax, would benefit the cities upon whom the burdens of population growth would largely fall. Nevertheless, a serious shortfall in operating expenditures, particularly, would be experienced by the cities.

Because of the specific distribution requirements attached to uranium tax income, particularly the large severance tax receipts that could ensue, New Mexico officials and legislators would be well advised to continue to keep an alert watch on basin developments.

State and municipal officials and planners should be alert to the potentials for future large shortfalls in operating and maintenance funds as indicated earlier. Advance planning to devise fiscal recourses to cope with such contingencies is advisable. The state could consider an in-depth study of possible dislocations of financial needs versus financial sources for the basin's public infrastructure.

An additional factor that should be considered is the lack of permanency in any uranium boom that might develop, regardless of size. The resource could be largely depleted within one generation, for example. Use of uranium tax funds, which would in that event amount to billions, conceivably could provide advance planning for an after-the-boom economy that would benefit the entire state.

The fiscal situation on the Navajo reservation probably would require that agencies be able to reallocate their budget quickly to areas faced with rapid growth. The appropriate federal authorities might consider congressional action to set aside special funds for reservation boom town needs, perhaps related to national energy fuel needs.

The Navajo tribe might consider expanding its taxing policies or examining the possibility of obtaining some state severance tax monies to provide rapid capital and operating funds. The tribe and BIA could consider requiring companies, through tribal codes and leasing procedures, to assist in bearing some of the socioeconomic costs.

It should be pointed out that companies have undertaken some such activities of their own volition. For example, several companies financed health facilities in the Grants area by arrangement with the Lovelace Medical Foundation at Albuquerque.

For administrative purposes, it could be useful to study the effect that energy development has had on the already existing administrative complexities of tribal self-determination, contracting to assume reservation social services, Indian preference hiring, growth of the Navajo government, and the effort to establish a cadre of Indian managers.

Public Services

In order to plan for human services expansion at the state, tribal, county or town level, an information office could be helpful. This office could track current and projected development for the area, could develop a central data base, and could develop indices of town growth stress.

Planning staff and capacities should exist at all levels. Technical assistance concerning planning and fund-getting should be provided to local areas by the state, tribe, BIA, councils of government, and related entities. Planners and professionals should also work on developing an adequate definition of the problems unique to an Indian boom town.

On and off reservation planners should carefully watch small towns along the I-40 corridor and around Mount Taylor for town growth stress

problems. Councils of government and counties might maintain watch for rural problems.

More research on the contribution of uranium mining work, boom town economy, and backgrounds of miners to social pathology such as divorce, child abuse, and alcohol abuse would be useful for social service professionals in the area.

As noted earlier, public infrastructure problems needing prompt attention or careful monitoring are the roads and municipal water systems of the entire basin, the Grants and Cuba school systems, the Shiprock and Crownpoint tribal police and social services, the Crownpoint outpatient facilities, and the Shiprock fire apparatus.

Increased budgetary support of the U.S. Public Health Service would be helpful relative to its expanding needs to monitor occupationally related health needs of Navajos, including potential radiation aspects.

Many federal programs exist that are of help to local social services. Unfortunately, most of them are not specifically designated for rapid growth problems and they take time and grant-seeking skills. More federal grant-giving institutions ought to become sensitive to the special needs of energy impacted towns. Perhaps more energy specific programs should be developed at the federal level.

Below are mentioned a number of specific programs available which could have a mitigating effect.

The Farmers Home Administration administers the "Section 601" or Energy Impact Assistance Program. This new source of federal funds, earmarked for energy impacted communities, can be spent locally on land acquisition and site improvements but not on construction or operations. These funds currently go through the states and are not available directly to tribes.

Planning grants are available under the HUD 701 Comprehensive Planning Assistance Program, and from the Farmers Home Administration, Economic Development Administration, and most other federal agencies funding human services.

The Partnership for Health, Education and Welfare between the IHS and the Navajo tribe provides project grants having the objective of supporting a full range of public health services to meet special needs at the community level, especially health problems of regional or national significance.

In addition to these programs, there is the Indian Health Service Program (P.L. 83-568, 42 U.S.C. 2001-2004a.) which provides specialized health services to Indians. This program, which includes planning assistance, can effectively mitigate any impacts on health services for Indians in the impact area.

For communities of less than 10,000 population, low interest loans administered by the Farmers Home Administration are available under the

Rural Development Act of 1972 (P.L. 92-419). These are to provide such community facilities as hospitals, clinics, and nursing homes.

Additional school facilities and programs would be a pressing need and would require large amounts of capital investment and operating funds. Two federal education assistance programs apply to federally impacted areas. P.L. 81-874, as amended, is designed to assist in the operation and maintenance of schools, and P.L. 81-815, as amended, provides funds for construction of facilities. These are expected to apply, at least to some extent, in the impact area. The eligibility of a school district and the level of assistance received depend on the number of children living on federal or trust property, the location of the jobs generated, and the residence of the employee's family. These factors would determine the extent to which these programs would alleviate educational programs.

Additional law and order requirements can be partly met if the tribe, county, and municipalities take advantage of law enforcement assistance discretionary grants under the Omnibus Crime Control and Safe Streets Act of 1968, as amended. This program provides funds for expanding law and order programs and the purchase of equipment. Technical assistance in the form of training can be provided under the act.

Municipal services would need to expand. On Indian reservations the Indian Sanitation Facilities Program (P.L. 86-121 Program) of the Health and Human Services department can be used as an effective mitigating measure for any impacts resulting in increased water supply and sanitation facilities that are directly associated with the Indian population.

The Farmers Home Administration also provides low interest rates, under P.L. 92-419, for communities of less than 10,000 population for the development of water and sewage facilities. This program is being used in various communities in adjoining areas.

The construction grants program for waste water treatment works under Title 2 of the Federal Water Control Act, as amended, which is administered by EPA, provides project grants to communities to assist and serve as an incentive to meet municipal water quality standards. A training program also is provided.

Companies

Large scale energy and industrial developers in the area might consider grouping together to provide technical assistance to the governments of the area. Small communities should consider approaching companies with specific requests for help. Also, companies may need some special assistance in devising methods to help with community impacts on the reservation. Preliminary steps have been initiated by several energy companies under the sponsorship of the new McKinley and Western Valencia County Energy Planning Council. About 30 companies, businesses, and other groups were involved in early planning.

CHAPTER IX

IMPACTS ON THE PRIVATE INFRASTRUCTURE

Chapter IX

IMPACTS ON THE PRIVATE INFRASTRUCTURE

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Chapter IX

Summary

This chapter looks at the economic future of the people and businesses of the San Juan Basin. Without further uranium development, the study team found, employment, personal income, and commercial activity would continue to increase but at a much lower rate. For example, personal income would increase between 1980 and 1990 by 75 percent, or about 5.8 percent per year compounded. By contrast, with Moderate uranium development growth of personal income between 1980 and 1990 would amount to 122 percent, or 8.3 percent per year compounded. Personal income generated annually by Moderate uranium activity could grow from approximately $270 million in 1980 to more than $770 million in 2000.

If existing uranium development were allowed to wind down without addition of new mines, business generated indirectly by uranium expenditures is projected to fall off 44 percent from $205.9 million in 1980 to $114.4 million in 2000. Comparable projections assuming the Moderate scale of uranium development, by contrast, show a 20-year increase of 182 percent in business volume attributed to uranium, from $285.4 million in 1980 to $805.8 million (in constant dollars) in 2000.

Many problems beset the industry, but from an economic standpoint northwest New Mexico's future would seem to be assured if uranium activity should reach the Moderate projection or higher.

Chapter IX

Impacts on the Private Infrastructure

INTRODUCTION

The formal market economy of the San Juan Basin is a mix that includes such components as agriculture, mining, commerce, households, and government; all acting in a somewhat orderly, dynamic fashion according to the dictates of the marketplace. A much less formal economy also exists in the basin. It consists of a subsistence life-style where barter, credit, and public assistance play a role equal to that of the marketplace. The formal economy is controlled by Anglo, Hispanic, and less traditional Indian people. The informal economy is the world of the traditional Indian and Hispanic family.

This discussion will analyze in some detail the sectors of the formal or conventional economy most important to uranium development: the mining-industrial, commercial, and household sectors. Others will be treated briefly. Also discussed here is the difference in impacts from uranium development on participants in the formal and informal economies, referred to for convenience as non-Indian and Indian after the dominant elements.

EXISTING ENVIRONMENT

Economy of the Basin

The most important sector in the economy of northwest New Mexico is government, which accounts for 21.2 percent of all jobs and 24.3 percent of all income in the five counties as a whole (Table IX-1). The major employers are the Bureau of Indian Affairs, the Indian Health Service, and the Wingate Ordnance Depot operated near Gallup by the Department of Defense. Indicative of the federal payroll importance, one of every 10 workers in Gallup was employed by the BIA or IHS in 1977. State, county, municipal, and tribal governments and other federal agencies also contribute to the government sector figures.

Tourism plays an important role in the trade and services sectors. Interstate 40, a major link between the east and west coasts, is a source of business opportunity across the southern part of the basin. The four national monuments in northwest New Mexico (Aztec Ruins, Chaco Canyon, El Morro, and Bandelier) registered more than 410,000 visitors in 1977. Other major attractions include Acoma, Laguna and Zuni Pueblos and the Navajo reservation. To the north, Mesa Verde National Park in southwestern Colorado attracts many. The manufacture and sale of Indian jewelry alone provides as many as 500 seasonal jobs in the San Juan Basin region.

Table IX-1

Employment in the Five County Area by Sector
(As of 1977)*

Sector[1]	McKinley County	Rio Arriba County	Sandoval County	San Juan County	Valencia County	Five Counties
Agriculture[2]	156	398	827	569	817	2,767
Mining	4,407	42	42	2,557	2,377	9,425
Construction	647	193	422	4,704	640	6,606
Manufacturing	1,155	420	1,022	1,114	274	3,985
Transportation, Communications & Utilities	1,015	231	153	2,821	857	5,077
Trade	3,750	1,064	391	5,270	2,283	12,758
Finance, Insurance, & Real Estate	337	207	249	713	428	1,934
Services and Miscellaneous	3,242	1,331	872	5,553	1,190	12,188
Government	4,527	2,400	1,104	4,110	2,625	14,766
Total	19,236	6,286	5,082	27,411	11,491	69,506

Sources:

1./ Harbridge House, Inc. estimates on the basis of New Mexico Employment Security Commission, "Table B-Labor Information Series, Non-agricultural Wage and Salary Employment, 3rd Quarter, 1977", 1978.

2./ Unpublished material from New Mexico Employment Security Commission, 1978. Agricultural employment on Indian reservations not included.

*Table excerpted, U.S. Department of the Interior, Bureau of Land Management, 1978.

Mining has become the largest basic sector in the economy. In 1977, minerals extraction provided 13.6 percent of total employment and 16.8 percent of gross personal income. The totals represent increases of more than 1,300 percent since 1950. Much of the growth of the transportation, communications, and utilities sectors is due to mining activity. Utilities are particularly important to San Juan County, where the Four Corners and San Juan power plants are located.

Throughout northwestern New Mexico, new industry has located near the urban communities. Mining is an exception to some extent, but since most mines are within commuting distance of towns, workers tend to settle there. Efforts to create employment in rural and reservation areas have met with minimal success. Mining plans have frequently proven controversial, and

Navajo leaders rejected a proposed coal gasification plant for the reservation. Operations once begun have sometimes failed, as with the Fairchild plant in Shiprock.

The actual unemployment rate among Navajos of the Eastern Navajo agency was approximately 40 percent in 1977. An unofficial 1975 survey of Navajo households showed joblessness to reach as high as 56 percent among male heads of household, and higher among young men and women. The official estimates (Table IX-2) are much lower. This is because many Navajos are either unable or unwilling to find employment in urban centers where most of the jobs are located and where the statistical data are taken.

The 1970 census showed 26.9 percent of all families in the five counties had incomes below the poverty level. Among some Indian tribes as many as 65 percent of all families were so reported. Of reported median incomes, Hispanic workers had 92.6 percent of the average for the five-county area, while Indians had as little as 37.7 percent of the average median income in San Juan County and 48.8 percent in McKinley County.

As Table IX-2 shows, per capita incomes rose by an average of up to 18 percent a year between 1970 and 1977. Although no estimates are made for ethnic groups in the vicinity, surveys suggest that Hispanic and Indian populations lag behind Anglos in income.

Industrial Sector

Industry Dynamics. Uranium mining and milling plays an extremely important role in the basin's current economic trends. Though some of the industry's impacts, such as the need for land, are insignificant compared to those of other sectors, the impact on the economy can be pervasive. However, the overall role of the industry in the basin economy is as much a function of each company's attitude and outlook as a response of the industry as a whole.

The uranium industry is made up of mining companies, oil companies, and public utilities ("The Uranium Industry" in Chapter I). While their decisions are based on the dynamics of the uranium market, their responses and methods of carrying out those decisions differ. Historically the hard rock mining companies have had to be more fiscally conservative in their outlook than the oil companies or utilities, due largely to their smaller size and less secure financial position (Knight, 1979, No. 56). As a result, most of the larger and deeper operations are being constructed by oil companies.

The costs of these operations vary widely and rise with inflation. Currently, exploratory drilling in the San Juan Basin is occurring in the 2,000 to 5,000-foot range, which costs $5.50 to $7 per foot. In 1974 the mean cost was $2.07 per foot (Adcock, 1979, No. 46). Mining costs for a mine that started construction in 1977 might range from $32 to $64 per ton of ore (Klemenic, 1978).

Whereas the mining cost per ton depends mainly on depth, the costs for milling depend upon ore grade. These milling costs range from $6 to $15

Table IX-2

Data on Employment in the Five-County Area*

Item	McKinley County	Rio Arriba County	Sandoval County	San Juan County	Valencia County	Five Counties
Total Unemployment in 1977 1/	6.7	20.0	8.1 6/	7.5	7.5	12.7
Hispanic workers 2/	5.6	27.0	9.6 6/	10.5	12.4	11.0
Indian workers	10.5	33.1	12.1 6/	14.7	18.7	13.5
Per Capita Income, 1970 3/,4/	$2,369	$2,172	$1,570	$2,549	$2,027	$2,238
Per Capita Income, 1977 5/	$4,362	$3,743	$3,481	$5,180	$4,620	$4,494

Sources:

1/ New Mexico Employment Security Commission, Affirmative Action Information, 1977, 1978.

2/ Harbridge House, Inc., 1978 estimates on the basis of formulae used by New Mexico Employment Security Commission for determinations of Affirmative Action Information Figures; formulae utilize 1970 census data to obtain minority employment ratios.

3/ University of New Mexico, Bureau of Business and Economic Research, New Mexico Statistical Abstract, 1975.

4/ Middle Rio Grande Council of Governments, Factual Digest of Bernalillo, Sandoval, Torrance and Valencia Counties, 1974.

5/ Harbridge House, Inc. estimates on the basis of U.S. Department of Commerce, Bureau of Economic Analysis, unpublished computer printouts, 1977, utilizing consumer price index to arrive at 1977 figure from 1970-1975 data.

6/ Data are reported for Albuquerque Standard Metropolitan Statistical Area which comprises Bernalillo and Sandoval Counties.

*Table excerpted, U. S. Department of the Interior, Bureau of Land Management, 1978.

per ton, with an average of about \$8 per ton of ore (Klemenic, 1978). The newer operations will average closer to the higher figures given above.

Adcock (1979, No. 46) estimates that the costs, including return on investment, of a typical mine and mill operation being planned today could range from \$57 to \$65 per lb. of U_3O_8 in concentrate at 12.5 percent compounded return by the time the complex begins operation in 10 years (Table IX-3). Because these figures are in 1979 dollars, the price of U_3O_8 would have to increase over and above the increase caused by inflation. (The spot price for U_3O_8 in 1979 was about \$45 per lb., although the contract price averaged much less. A 25 percent drop occurred in 1980.)

Employment and Income. The uranium industry is a major employer in New Mexico. Table IX-4 indicates that 7,274 persons were employed by the industry in New Mexico in 1977, a year unusual for the large amount of exploration. That was about 10 percent of the total work force in the state's northwest counties.

In that year the industry paid almost \$122 million in wages to miners, construction and mill workers, drillers, and other personnel. At the same time, it was spending about \$135 million for supplies, machinery, fuel, etc., and about \$80 million in capital expenditures (Adcock, 1979, No. 46, and Department of Commerce, 1979).

Labor. The uranium miner has built a reputation in the Grants area as being independent without strong community ties (Gibson, 1978, No. 24). A uranium mine official said of the miners, "They're proud people, they're independent people, they are physical people. A miner doesn't try to reach out and shake your hand, he stands close up to you and shakes it good. That's the kind of person they are." (Gibson, 1979, No. 44)

On the other hand, a social worker in the area said, "I come from a mining family, my dad always told five of us boys, I don't want any of you to go into mining and we haven't." (Ibid) And another quote, "He [my father] was hard of hearing and he had arthritis. The mines up there are awfully wet and stuff, you know and it was cold especially in the winter time. [He would come] out of that shaft and that cold air [was] coming down. His arthritis and his hearing was bad, his lungs were bad and he said I don't want you kids ever going into mines...he said you can find a better job than that. But yet he stayed at it for 45 years." (Ibid.)

Despite the ambivalence of the workers and in spite of the fact that the workers at United Nuclear's mine near Grants went on strike early in 1979, labor unrest has been relatively rare--certainly when compared to coal mining. Perhaps this is because of the independence of the uranium miner and his habit of quitting and looking elsewhere when faced with intolerable working conditions. A shortage of labor in the latter 1970's and high wages obtainable with or without union assistance may also have been contributing factors.

Two uranium mine officials pointed up the phenomenon. One said:
"[The] contract bonus system permits [a miner] to earn upward [of] \$50,000 a year if he's good and works both hard and smart. Yet we have a

Table IX-3

Price and Cost Components for an Integrated Firm
($/lb U_3O_8)

Depth Cost Component	Interest Rate 10%	 12.5%	 15%
1,000 Feet			
Capital	17.82	23.39	30.24
Operating	16.09	16.09	16.09
Tax	12.34	17.59	22.13
Price	46.25	57.07	68.46
2,000 Feet			
Capital	18.86	24.69	31.82
Operating	16.21	16.21	16.21
Tax	13.13	18.15	22.88
Price	48.20	59.05	70.91
3,000 Feet			
Capital	19.90	25.98	33.40
Operating	16.33	16.33	16.33
Tax	14.66	18.69	23.60
Price	50.89	61.00	73.33
4,000 Feet			
Capital	20.94	27.27	34.98
Operating	16.45	16.45	16.45
Tax	15.06	19.26	24.36
Price	52.45	62.98	75.79
5,000 Feet			
Capital	21.98	28.56	36.55
Operating	16.58	16.58	16.58
Tax	15.44	19.80	25.09
Price	54.00	64.94	78.22

Note: The values are for a project begun today and completed in 10 years. Ore grade is 0.15 percent for the typical mine-mill operation assumed in Chapter II. The figures were obtained by capitalizing forward each operation in sequence. If two opertions occurred simultaneously, such as mine construction and mill construction, the costs would be less.

Source: Adcock, 1979, No. 46.

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.

These figures include coal miners who suffer a higher accident rate than hard rock miners. When just uranium miners were considered for the year 1969, the fatality rate dropped to 1.5 per million man hours worked (12 deaths) and 31.4 non-fatal accidents per million man hours worked (245 injuries) (Moyer, 1971). Mining accidents are caused by faulty operation of equipment, blasting mishaps, cave-ins, and other less common factors.

However, uranium mining is recognized as a risky occupation, most of all by the miners themselves. As an ex-miner put it, "Well, here's what they [the supervisors] do--they want the production, they want all the production they can get so they ride you for production and yet you got another department. You've got your safety departments and all this and you got them down there and then you've got the mining inspector and they are all coming down there and they say you have to do this, this and this and the shift boss he comes by, [and he says] I got to have so much, where's it at, you better, you know, get with it. You can't please everybody. [That puts] the miner kind of in the middle." (Gibson, 1979, No. 44)

A social worker who constantly works around miners commented: "A lot of them try to cut corners. You know underground when they are on contract they try to make as much money as they can. When they're cutting these corners they're working dangerously and every once in a while you see in the paper where somebody got killed because they're out in the open stope where there's no support above them and the slide [falls] down and [kills] him. A lot of them don't have their mind on their job when they're doing these things." (Ibid)

The mills are less dangerous working places than the mines. There were no fatal mill accidents in the year noted above (1969) and only 17.30 injuries per million man hours worked (Moyer, 1971). A fire in the solvent extraction circuit represents the greatest potential danger because of the possibility of large volumes of smoke carrying noxious fumes and radioactive particles.

Commercial Sector

The commercial sector in the San Juan Basin is comprised of many relatively small businesses. These enterprises benefit considerably from uranium development. However, though the industry has infused large sums into the New Mexico economy, much of this money is spent outside the basin. Most construction materials and supplies for uranium mining and milling, for example, are purchased in Albuquerque or more distant centers.

Analysis of the uranium companies' expenditures provides further illustration of the leakage. About 62 percent of the companies' expenditures for mining are within the basin. About three-fourths (74 percent) of this is in the form of wages (Adcock, 1979, No. 46). However, more than one-fourth of this money for wages quickly leaks out of the basin into the surrounding economy. Miners buy most of their food and drink in the area's larger communities but often go to Albuquerque or beyond for clothing, home furnishings, and recreation.

By taking such factors into account, the analysis shows that less than half of a mining company's expenditures are ultimately spent at businesses in the basin. For mine construction, less than 25 percent of the companies' expenditures wind up with the basin's businessmen. For milling, the retained percentages are even less. Thus, while the commercial sector gains greatly from uranium development, businesses beyond the basin benefit even more. Indirect economic benefits also result from uranium activity, as noted below under "Household Sector."

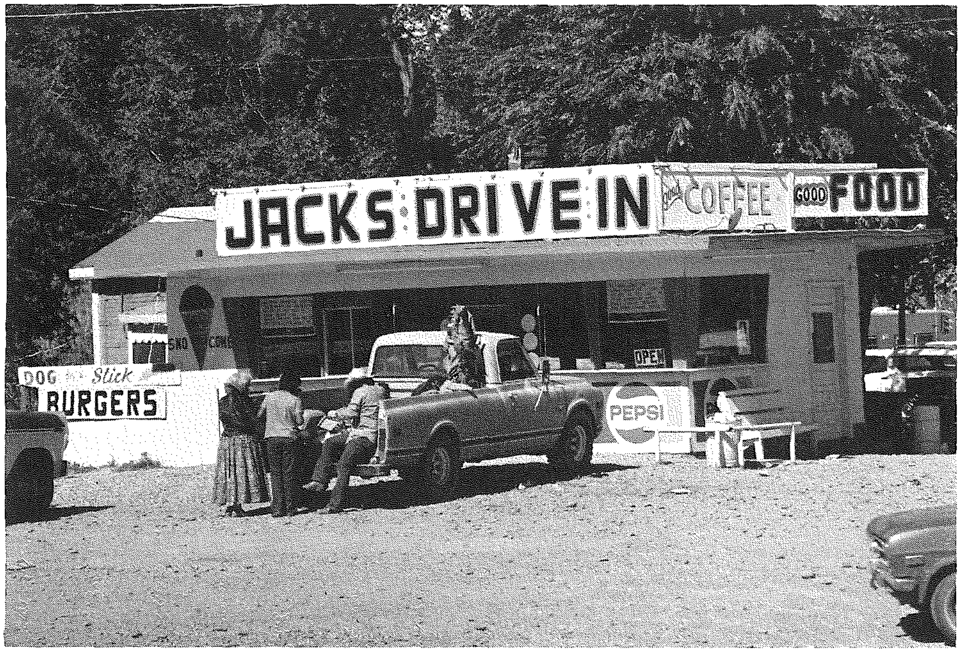


Figure IX-2.--Drive-in cafe east of Shiprock, near Waterflow, N.M.

The three major population centers--Farmington, Gallup, and Grants--each serves as the nucleus for a number of smaller places. Farmington has Shiprock, Kirtland, Aztec, and Bloomfield; Grants has Milan and Bluewater; and Gallup has Gamerco, Fort Wingate, and a handful of other small centers.

Only Farmington stands out as a mature, well-developed and well-balanced central place. Gallup has some of the attributes of a major trade center, but its importance is somewhat distorted by a relative handful of highly subsidized activities which serve the large Indian population. Grants and neighboring Milan have a population almost equal to that of Gallup, but the absence of federally funded Indian serving activities and loss of business to nearby Albuquerque have kept them from reaching the position achieved by Gallup (Gibson, 1979, No. 46).

Household Sector

Personal Income. The average wage received by uranium workers for 1978 is shown in Table IX-5. Each worker through his expenditures creates other jobs. Mining and milling purchasing also create indirect employment.

The total amount of wages and benefits generated by each uranium industry employee, directly and indirectly, amounts to almost $50,000 (Adcock, 1979, No. 46).

Table IX-5

1978 Average Wage Received By Uranium Workers

Subsector	Average Wage	Percent Fringe Benefits	Total
Uranium Mining	20,347	28.0	26,044
Uranium Milling	20,347	28.0	26,044
Mine Construction	19,486	19.0	23,188
Mill Construction	18,336	30.0	23,837
Exploration	17,157	16.0	19,902

Source: Adcock, 1979, No. 46.

Housing. Half of all dwelling units in northwestern New Mexico are detached, owner-occupied, single family homes. Rented homes, apartments and other multiple family units represent an estimated 30 percent of the housing stock. Mobile homes account for 20 percent of available housing units. The housing in five counties and its condition are shown in Table IX-6.

With population growth, a need for more and better housing exists. New construction has not kept pace with recent population increases, and such communities as Gallup experience a shortage of housing. As a result, substandard or overcrowded living conditions among lower income families persist in many areas.

Several factors contribute to the lag in new home construction. Land for subdivision and development is scarce because of the large federal and Indian land holdings in much of the area. This increases the prices on the property that is available. Building costs are high because of distances from Albuquerque, the state's distribution center for construction materials and the home base of most building contractors. In 1977, the average price of a new home in Gallup was an estimated $6,000 more than the price of a comparable home in Albuquerque. The cost differential was reported at $10,000 in Grants.

Lack of capital to finance builders and buyers also limits the availability of housing. There are about 20 financial institutions in the area, but their combined assets and outstanding loans are small in proportion to population. One study showed that in the area financial institutions loaned 30 cents per resident in 1976, compared with one dollar per resident in

Table IX-6
HOUSING IN THE FIVE COUNTY AREA, 1970*

County	Conventional Single-Family Homes Number	Conventional Single-Family Homes Percent	Multiple-Family Units Number	Multiple-Family Units Percent	Mobile Homes Number	Mobile Homes Percent	Units With More Than One Person Per Room Number	Units With More Than One Person Per Room Percent	Units Without Any Plumbing Number	Units Without Any Plumbing Percent	Substandard Units 1/ Number	Substandard Units 1/ Percent	Total Units
McKinley	8,302	79.0	1,428	13.6	776	7.4	4,027	38.3	3,830	36.5	2,698	25.7	10,506
Rio Arriba	6,501	88.1	330	4.5	550	7.4	1,873	25.4	2,798	37.9	950	12.9	7,381
Sandoval	4,205	91.4	158	3.4	239	5.2	1,468	31.9	1,535	33.4	946	20.6	4,602
San Juan	11,513	78.1	1,636	11.1	1,597	10.8	3,582	24.3	2,753	18.7	1,707	11.6	14,746
Valenica	9,341	82.2	634	5.6	1,388	12.2	2,616	23.0	2,039	17.9	966	8.5	11,363
Five Counties	39,862	82.0	4,186	8.6	4,550	9.4	13,566	27.9	12,955	26.7	7,267	15.0	48,598

Source: U.S. Department of Commerce, Bureau of the Census, 1970 Census of Housing, General Characteristics - New Mexico, 1972.

Note:

1/ Substandard units are defined as units with more than one person per room and without any plumbing.

*Table from U.S. Department of the Interior, Bureau of Land Management, 1978

the state as a whole. The difference in institution assets differed widely also, standing at $4.44 per inhabitant statewide and $1.89 per resident in the area. There are no savings and loan associations in Grants-Milan.

Mobile home sales are growing, partly because of relatively low cost. For many new arrivals, the choice in most communities appears often to center on buying a mobile home or none at all. The 1,542 mobile homes in McKinley County in 1976 marked a 98.7 percent increase from the 1970 level. In Sandoval County, the 1,281 mobile homes in 1976 represented a 527.9 percent increase over 1970 (U.S. Department of the Interior, Bureau of Land Management, 1979).

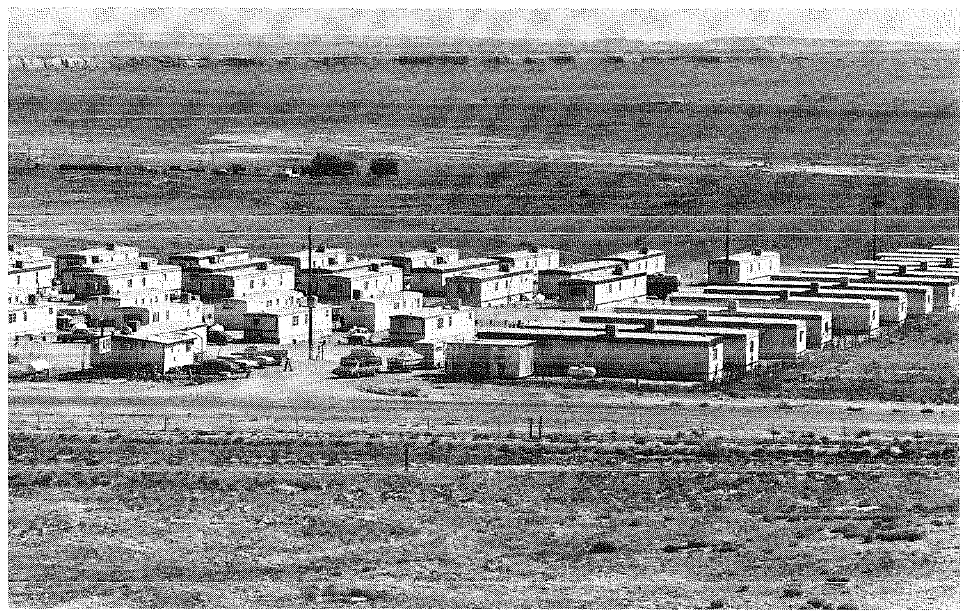


Figure IX-3.--Temporary uranium development housing near Crownpoint

There are other factors besides cost involved in the large percentage of temporary homes, as the following comments quoted by Gibson (No. 44) illustrate. A social worker said:

"We have people working in the mines here that live in Gallup. There's no hesitancy to move, you know. The pattern is usually the man, when he gets fed up or knows there's something better somewhere else, he takes off. A wife and kids stay put until he's got some money and settled somewhere. We get involved in this picture because the minute he's out, the wife and kids can come in here and are eligible [for public assistance]. Just that temporary separation makes them eligible."

A mine official said: "It's a traveling trade. You go where the mining's at and it's like anything else. It's always greener on the other side of that hillside. It [is] kind of a gypsy trade. Wherever it looks like you can make the easiest and best move, well you try to get there."

And another social worker told an interviewer: "There are people that have lived here for 16 or 17 years and still consider Grants as their temporary home. They really plan to leave when they retire. We have a large Canadian population, French Canadian population, and most of these people have taken their money and have purchased land...in Canada. Some of these people have lived here 20 years now and they may have a home here but when they retire they plan on going back to Canada."

Navajo Economy

The Navajo tribal economy in the study area consists largely of these elements: 1) extended families relying upon a combination of sheep raising, handicrafts, seasonal or semi-skilled labor, welfare support and some subsidized services such as education and health; 2) a small but increasing cadre of educated Navajos holding public service jobs with the tribe or federal agencies, and 3) corporate tribal income provided by development of oil, natural gas, coal, uranium, timber, agriculture, and other natural resources.

The subsistence economy of the past no longer supports the ever increasing population living on a finite area of land.

The Navajo economy resembles the rest of northwest New Mexico in that resources are exported and goods and services are imported. It differs in that there is a very small commercial-retail sector, compared to off-reservation areas. Thus, money that enters the reservation as federal grants or resource royalties goes out as wages spent off-reservation, with little internal benefit.

PRIVATE INFRASTRUCTURE WITHOUT FURTHER URANIUM DEVELOPMENT

Industrial Sector

Industry Dynamics. At least two eventualities might cause uranium companies to phase out operations in New Mexico in the manner shown in Figure II-3. As projected there, the industry would peak in 1985 and decline thereafter. One event that could lead to such a decline would be the discovery elsewhere of uranium in large quantities that offered the advantage of lower extraction costs. Because of the increasing depth of uranium ore deposits in the San Juan Basin--and the increasing costs involved--this scenario is conceivable, though unlikely.

A second contingency could be the growth of legal and political constraints to such a magnitude that the companies would be unable or unwilling to cope with them. Whether limited to the basin or affecting the entire nuclear industry, such constraints could conceivably cause production delays and drive costs to intolerable levels.

Perhaps it should be reiterated here that the study team adopted a basic assumption that a breakthrough in exotic new sources of energy would be unlikely to affect the uranium picture in this century (Chapter II). Nevertheless, this possibility cannot be altogether ruled out under the volatile conditions in the national and world energy crisis.

All in all, then, while the study team believes uranium mining and milling should continue to be a growth industry in northwest New Mexico for much of the time over the next 20-plus years, it recognizes the possibility that the inevitable decline might start long before the end of the century.

Employment and Income. No study summarizes entirely the employment and income growth for projects the SJBRUS views as most likely to be built before 2000 under the no-further-uranium-development hypothesis. The Star Lake-Bisti coal EIS, perhaps, gives the closest approximation. Its analysis is shown in Tables IX-7 and IX-8, as modified for the gasification project and Prewitt power plant assumed as in the works by the SJBRUS.

These projections are of academic interest only, since the figures do not purport to be precise. However, they do show the magnitude of economic activity anticipated in the area without an increase in uranium development. The employment table should be compared to Table IX-1, which gives

Table IX-7

Employment by Sector in Five Counties in 1990
Without Further Uranium Development

	Number of Workers					
Sector	McKinley County	Rio Arriba County	Sandoval County	San Juan County	Valencia County	Five County Area
Agriculture	160	400	565	2,385	635	4,145
Mining	6,840	40	370	4,587	7,085	18,922
Construction	1,175	200	1,515	8,780	1,450	13,120
Manufacturing	1,520	420	2,200	1,795	815	6,750
Transportation, Communications & Utilities	2,385	230	635	5,665	1,365	10,280
Trade	6,000	1,065	1,030	7,740	6,280	22,215
Finance, Insurance & Real Estate	600	310	430	1,540	925	3,805
Services	5,800	1,515	2,240	7,940	3,385	20,880
Government	9,800	3,700	1,825	7,970	5,280	28,575
Total	34,280	7,880	10,810	48,402	27,320	128,692

Source: Table IV-26 of the Star Lake-Bisti EIS (U. S. Department of the Interior, BLM, 1978) combined with Tables 3-36 and 3-37 of the El Paso Coal Gasification Study. It is assumed that the El Paso plant will be delayed until the late 1980's and will be built at about the same time as the Prewitt power plant.

Table IX-8

Estimated Personal Income in Five Counties
Without Further Uranium Development
(in thousands of 1975 dollars)

County	1977 Income	1980 Income	1985 Income	1990 Income
McKinley	$169,451	$233,291	$295,430	$ 399,744
Rio Arriba	49,701	57,535	79,216	104,065
Sandoval	31,833	38,656	50,927	66,174
San Juan	224,626	311,031	363,958	550,636
Valencia	88,137	108,285	139,696	192,510
Five County Area	563,748	748,798	929,227	1,313,129

Source: Harbridge House, Inc. estimates on the basis of 1970-1975 trends in data supplied by U.S. Department of Commerce, Bureau of Economic Analysis, and results of input-output model programmed by Larry Adcock & Associates, with factors added in 1990 for El Paso Gasification Plant and Plains Electric Plant.

1977 data. It is interesting to note in Table IX-8 that total personal income would more than double (in constant dollars) from 1977 to 1990.

Indian employment would benefit greatly. For projects on the Navajo reservation, the El Paso Gasification Plant EIS estimates that 57.7 percent of energy development personnel and 64.6 percent of plant operation workers could be Indians. By the late 1980's 9,600 Indians could be employed directly. Off the reservation, estimates are not available. However, the SJBRUS employment model assumes that energy development would cut unemployment among eastern Navajos (now estimated as high as 40 percent) on a descending curve toward full employment after 2000.

Commercial Sector. The approximate growth of the commercial sector without further uranium development can be estimated by comparing the growth in employment for the categories "Trade," "Finance, Insurance, and Real Estate," and "Services and Miscellaneous" shown in Table IX-1 with the same categories in Table IX-7. The growth in employment equals 20,020 jobs, or a growth of 43 percent from 1977 to 1990. Thus the commercial sector of the private infrastructure would grow without further uranium development but at a slower rate.

An input-output analysis was performed for the San Juan Basin (Adcock, 1979, No. 46). The analysis programmed the monetary contributions of

uranium development into a computer which produced a breakdown of how the money would be spent. The input-output analysis technique is a widely used economic tool for estimating magnitudes of spending patterns. While each figure in Table IX-9 may or may not be correct in itself, it is felt to give an accurate reflection of the general economic impact that could be expected with a winding down of uranium activity in the basin. As shown in the table, indirect dollar volume contributed to the economy by uranium activity would continue to climb to approximately $366 million annually in 1985 and would taper off thereafter to $114 million in 2000.

Household Sector

Personal Income. Table IX-10 indicates that per capita income in the basin should increase by about 50 percent between 1977 and 1990 without

Table IX-9

Dollar Volume Indirectly Generated by Uranium Mining and Related Activity Without Further Uranium Development (Millions of dollars)

Sector	1980	1985	1990	1995	2000
Agriculture	$ 5.1	$ 9.0	$ 5.3	$ 3.9	$ 2.9
Mining	6.1	10.9	6.5	4.1	3.4
Construction	7.6	13.5	7.9	5.1	4.2
Manufacturing	29.3	52.0	30.9	19.5	16.3
Transportation	12.8	22.8	13.5	8.5	7.1
Communications & Utilities	24.0	42.6	25.3	16.0	13.3
Trade	48.7	86.5	51.3	32.5	27.0
F.I.R.E.[1/]	45.2	80.3	47.7	30.1	25.1
Services	27.1	48.2	28.6	18.1	15.1
Government	N/A	N/A	N/A	N/A	N/A
TOTAL	205.9	365.8	217.0	137.8	114.4

1/ Fiscal, Insurance, etc.
N/A = Not Applicable.
Source: Adcock, 1979, No. 46.

Table IX-10

Estimated Per Capita Income in Five Counties, 1977-1990
Without Further Uranium Development
(Constant 1977 dollars)

County	1977 Per Capita Income	1980 Per Capita Income	1985 Per Capita Income	1990 Per Capita Income
McKinley	$4,362	$4,801	$5,525	$6,399
Rio Arriba	3,743	3,995	4,675	5,270
Sandoval	3,481	3,754	4,187	4,671
San Juan	5,180	5,761	6,744	7,895
Valencia	4,620	5,184	6,159	7,317
Five County Area	4,494	4,962	5,772	6,703

Source: Adcock, 1979, No. 46, based on 1970-1975 trends in unpublished computer printouts of U.S. Commerce, Bureau of the Census, and results of input-output model programmed by source.

further uranium development. This is about 3 percent per year. Many people in these northwestern New Mexico counties are unemployed and live on bare subsistence incomes. Consequently, for these estimates to be realized, unemployment would have to drop drastically.

Housing. The increase in population would be accompanied by a corresponding increase in housing. Gibson (1979, No. 39) projected the growth of housing for several communities in the basin. These are shown in Table IX-11 and summarized in Table IX-12. Currently, about 20 percent of the housing is made up of mobile homes or trailers. For this scenario, the percentage should not change.

Navajo Economy

The loss of uranium development would mean the loss of the opportunity for employment, royalty earnings, and the possible establishment of a nonrenewable resource fund that could provide capital for future tribal investment. Also, the stimulus for a possible increase in the commercial-retail sector would disappear.

Table IX-11

Demand for Housing Without Further Uranium Development

	Housing Units		
San Juan County	1980	1990	2000
Shiprock	1,174	1,433	1,658
Kirtland	936	1,142	1,322
Farmington	9,219	11,334	13,326
Aztec	1,995	2,453	2,884
Bloomfield	827	1,013	1,183
Remainder of County	4,585	5,596	6,475
Total	18,736	22,971	26,848
McKinley County			
Gallup	5,430	6,470	7,607
Ft. Wingate	228	269	310
Thoreau	144	170	196
Crownpoint	660	779	898
Prewitt	94	110	128
Remainder of County	7,115	8,400	9,681
Total	13,671	16,198	18,820
Western Valencia County			
Bluewater	94	131	161
Milan	1,076	1,510	1,861
Grants	3,164	4,424	5,409
Remainder Western Portion of County	2,283	3,191	3,896
Total	6,617	9,256	11,327
Western Sandoval County			
Cuba	332	506	619
Remainder Western Portion of County	669	925	1,013
Total	1,001	1,431	1,632

Source: Gibson, 1979, No. 39

PRIVATE INFRASTRUCTURE WITH MODERATE URANIUM DEVELOPMENT

Industrial Sector

Industry Dynamics. Growth of uranium development means that the companies would operate in closer contact with several different social environments. These environments have differing modes of government and regulate uranium development in different ways (Chapters XI and XII).

Table IX-12

Summary of Housing Needs
Without Further Uranium Development

County	Increase in 2000 Over Baseline Scenario of 1980
San Juan	43%
McKinley	38%
Western Valencia	71%
Western Sandoval	63%

Source: Gibson, 1979, No. 39.

Management decisions successful in a non-Indian area might not meet with the same welcome responses and eventual adjustment in Indian areas.

Exploration, mining, and milling have long taken place in the rural Anglo and Hispanic areas of the San Juan Basin. These areas are familiar with uranium development, having accommodated to it in the 1950's and 1960's. The rural non-Indian areas are sparsely inhabited by ranchers, with miners living in towns such as Gallup and Grants. Many of the inhabitants of the basin non-Indian towns welcome the prospect of another uranium boom. Exploration and mining have also occurred continuously on the Laguna reservation since 1950.

Exploration has taken place on Navajo tribal and allotted lands, but there has been little mining. The Navajo lands represent a dispersed but long occupied rural area, accustomed to local community decision-making and little intrusion from the outside. As pointed out in Chapter VII, unrest has developed in the Eastern Navajo area as a result of misunderstanding and poor communications.

Interested parties in companies and in tribal and governmental agencies are reexamining the leasing process to see whether it might be improved. The companies have stepped up their community relations efforts, taking such measures as settling claims, sponsoring meetings, employing Navajo representatives, and generally learning techniques from one another's successes and failures. Informal sources say companies initially felt it was wise to proceed quietly without calling organized gatherings but later found themselves called upon to explain their activities publicly. According to these sources, some company personnel concede they did not at first appreciate the complexities involved in operating on Indian lands.

To paraphrase one mine official, "If we could have known what we were getting into, we should have been preparing the people eight years ago."

Recent increased cooperation and contact with the people may ease anxiety over a possible large increase in operations.

Employment and Income. Moderate uranium development would create some 18,000 additional jobs in the New Mexico uranium industry by 2000 compared with 1975. More than two-thirds of all employment in the industry by 1995 would be connected with operating underground mines. (A breakdown is shown in Table II-7.)

The projections indicate that between 1990 and 1995 total uranium employment would probably account for the arrivals of about 9,000 to 14,000 employees from outside the region. As in the case of other impacts, the direct effects from these in-migrants would be felt initially in the mining and milling areas of McKinley and western Valencia counties. The necessity of commuting to and from work would help spread the impacts beyond the working zones, as discussed elsewhere.

Total uranium employment is projected to reach 18,171 by 1990. This would approximately double the mining employment expected in the New Mexico part of the region without including uranium. The impact of uranium with Moderate development is suggested in Table IX-13 for the five counties wholly or partly involved. This is based on Table IX-7 and Table II-7.

Uranium related jobs would, therefore, account for more than one-fifth of employment in the basin under the Moderate projection. This ratio roughly continues through 2000. Most of the employment would occur in McKinley and Valencia counties as shown in Table IX-14.

When indirect employment is included, uranium development would account for more than one-third of all jobs in McKinley and Valencia counties in 1990. This ratio would continue through 2000.

The study team estimates that perhaps 5,000 Indians might work in the uranium industry in 1995 (Chapter II, "Basic Uranium Development Projections"). This could mean that at that time Indian workers would hold about 23 percent of the uranium positions. Four-fifths of the Indian employees are expected to be Navajos.

If Indians comprised a reasonable 20 percent of the work force prior to that time, the uranium employment roster would approximate the figures in Table IX-15. (Also see "Personal Income" and "Navajo Sector.")

Labor. As Table IX-15 suggests, uranium development would have a growing beneficial impact on Indian employment. Leases covering reservation lands stipulate that uranium companies would hire and train as many Indian workers as possible. This Indian preference would not be limited to common labor but would extend into management positions for those qualified.

Commercial Sector

Using the input-output analysis described earlier, the projected increase in dollar volume of business in the basin with Moderate uranium development is shown in Table IX-16. In sharp contrast to the picture

Table IX-13

Employment in the San Juan Basin
with Moderate Uranium Development

	1990	
Coal Mining Employment with Mid-level Coal	18,922	
Total Employment with Mid-level Coal	128,692	
Mining's Proportion of Total Employment		14.7%
Uranium Employment (Direct only)	18,171	
Mining Employment including Coal and Uranium	37,093	
Total Employment including Coal and Uranium	163,986	
Total Increase due to Uranium (Direct and Indirect)	35,204	
Mining's Proportion of Total Employment		22.6%
Uranium's (Direct and Indirect) Proportion of Total Employment		21.4%

Table IX-14

Employment in McKinley and Valencia Counties
with Moderate Uranium Development

	1990	
Coal Mining Employment with Mid-coal	13,925	
Two-county Share of 5-county Mining, Mid-coal		74%
Uranium Employment	16,354	
Mining Employment	30,279	
Two-county Share of 5-county Mining, Uranium and Coal		82%
Total 2-county Employment with Mid-level Coal	61,600	
Total 2-county Employment, including coal and direct and indirect uranium (assuming 90% of uranium employment is in these 2 counties)	93,283	
Uranium's (Direct and Indirect) Proportion of Total 2-county Employment		34%

Table IX-15

Indian and Non-Indian Employment

	Indian	Non-Indian
1980	1,345	5,381
1985	2,772	11,089
1990	3,364	14,537
1995	5,000	17,163

depicted in Table IX-9, the Moderate projection shows indirect money generated by uranium activity would grow from approximately $285 million in 1980 to $806 million (in constant dollars) in 2000.

Thus, business activity is projected to increase rapidly. A large share of this activity would occur at the major trade centers of Farmington, Gallup, and Grants. This is because each central place provides goods and services for its own residents and residents of its trade area. The more populous and complex the center, the larger is its hinterland. People from a wide area, including residents of low order centers such as Thoreau, will travel to a larger place for medical services, cultural amenities, and consumer goods which can be provided only in a higher order center in the absence of direct subsidy.

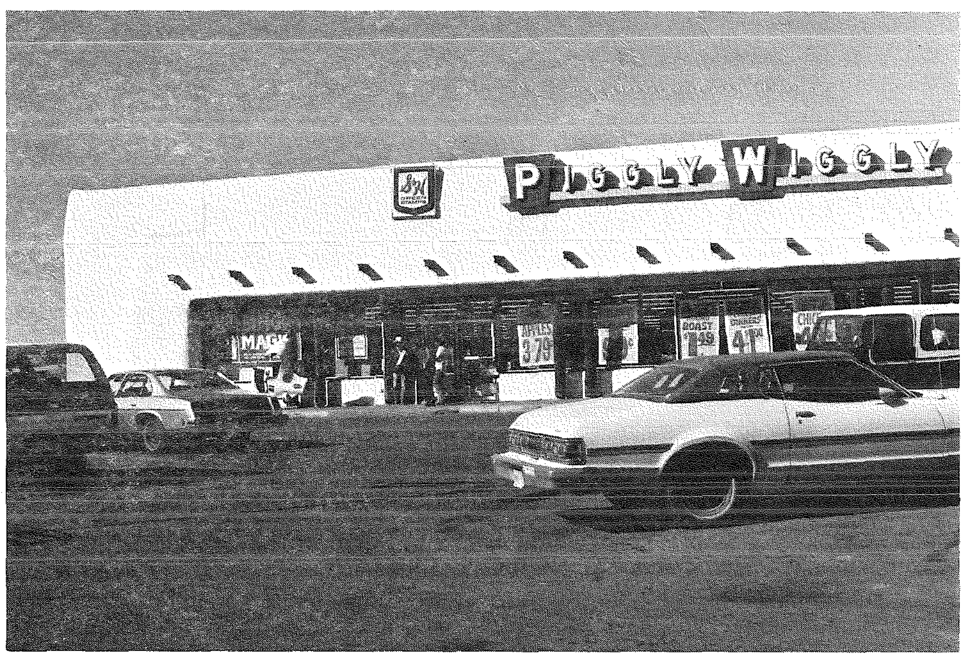


Figure IX-4.--Supermarket scene in Farmington

Table IX-16

Dollar Volume Indirectly Generated by Uranium Mining
and Related Activity
With Moderate Uranium Development
(Millions of dollars)[1]

Sector	1980	1985	1990	1995	2000
Agriculture	$ 6.8	$ 11.3	$ 15.1	$ 18.7	$ 19.3
Mining	10.4	17.1	22.3	26.3	25.9
Construction	11.2	21.2	27.5	31.9	30.7
Manufacturing	36.2	61.2	82.6	104.9	111.3
Transportation	14.2	25.7	34.7	44.4	47.4
Communications & Utilities	35.1	66.7	87.3	104.8	104.6
Trade	69.6	111.4	149.3	184.7	191.4
F.I.R.E.[2]	59.2	94.1	130.2	162.5	169.6
Services	42.4	62.3	83.9	102.6	105.6
Government	N/A	N/A	N/A	N/A	N/A
TOTAL	285.4	474.0	632.9	780.8	805.8

1/ All figures in constant dollars.
2/ Finance, Insurance and Real Estate
NA = Not Applicable.
Source: Adcock, 1979, No. 46.

A computer analysis indicates that an interesting phenomenon could occur sometime before 2000 under all three growth scenarios. Grants could take Crownpoint and Thoreau away from Gallup, a long-standing trade center for Navajos. The increasing attractions of Grants and its situation as an intervening service opportunity on the way to Albuquerque should be enough to turn trade from the rapidly growing Crownpoint-Thoreau population corridor away from Gallup (to the west) and toward Grants (and Albuquerque) to the east (Gibson, 1979, No. 47).

The areas to the east of the Farmington and Grants service sectors would, of course, "belong" to Albuquerque. The area south of the Farmington orbit and west of the Grants sector would "belong" to Gallup, according to the computer analysis of the regional economic structure

(Gibson, 1979, No. 47). These areas are shown in Map IX-1 (Gibson, 1979, No. 52).

Household Sector

Personal Income. The rise in personal income would match the population and employment growth. Table IX-17 shows that uranium activity in the assumed Moderate range would directly and indirectly generate a rise in total personal income in the basin from approximately $270 million in 1980 to $770 million in 2000. The growth in wages would be about 185 percent in 1979 dollars.

Housing. Another rapidly growing segment would be the housing market. Table IX-18 illustrates how the demand for housing units would increase between 1980 and 2000 under the Moderate scenario.

Table IX-19 breaks the growth down by community. The projections for two towns were particularly perplexing. On the Navajo reservation at Crownpoint and Shiprock, several constraints could curtail housing development, such as:

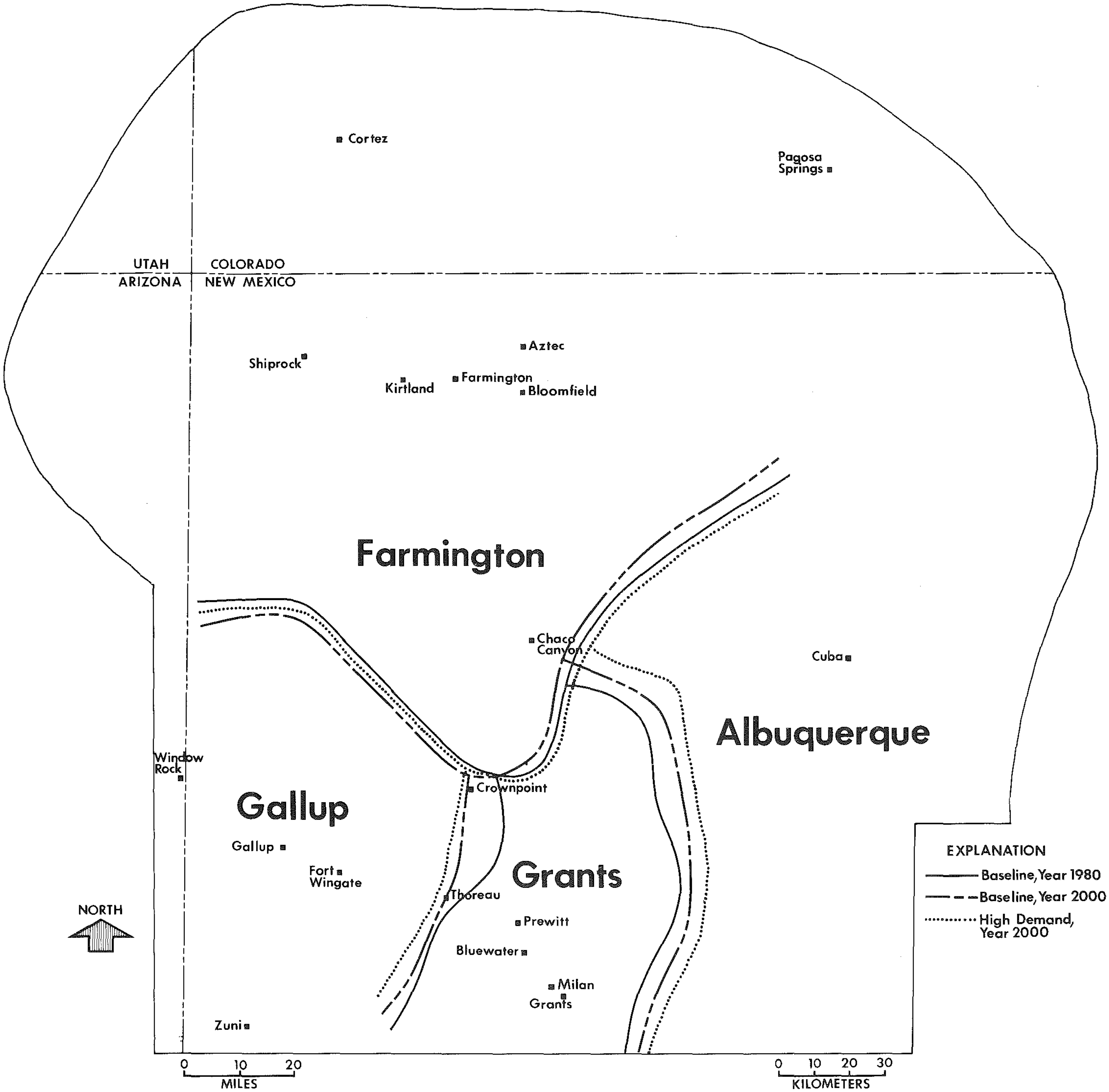
(1) special land status problems with multiple jurisdictional considerations. State, tribal, federal, private companies, chapters, and individual allottees will have a determining role in whether land is to be developed for housing;

(2) strong opinions expressed by the local chapter houses and individual allottees against committing Navajo-controlled land for housing development for outsiders, especially non-Navajos.

(3) The current lack of funding for housing development by federal agencies (BIA, USPHS-IH) and the Navajo tribe (NHA), although planning for growth is presently being conducted.

It is likely that curtailed population growth in agency communities such as Crownpoint and Shiprock would lead to a commuting worker population from nearby non-agency communities (Thoreau, Prewitt, Coolidge) which would grow larger than predicted. Infrastructure development possibilities are greater in "off-reservation" communities where more private land is available, water resources may be less restricted, and access to urban communities with more amenities is more readily accessible.

Some of the in-migrating Navajos might be absorbed on land belonging to clan relatives, but presumably the in-migrants would have to provide their own temporary or permanent dwellings. Federal land under the trust responsibility of the BIA in various smaller Eastern Navajo communities (Smith Lake, Mariano Lake, Pinedale, etc.) might be made available for occupancy, contingent upon adequate water supplies and approval by the local chapter house. Similarly, the Navajo tribe might make available



SHIFTS IN TRADE AREA BOUNDARIES FOR THREE MAJOR REGIONAL CENTERS: FARMINGTON, GALLUP AND GRANTS

Map IX-1

Table IX-17

PERSONAL INCOME GENERATED BY URANIUM ACTIVITY
MODERATE SCENARIO - 1980 to 2000[1/]
($ Millions)

	1980	1985	1990	2000
URANIUM MINING				
Private Sector:				
Direct Wages	94.3	182.3	250.8	379.7
Indirect Wages	36.5	70.6	97.1	147.0
Interest, Rents, Dividends	12.3	23.9	32.9	49.8
Public Sector:	6.6	14.4	19.7	29.9
Net Transfer Payment	0.0	0.0	0.0	0.0
Total	149.7	291.2	400.5	606.5
URANIUM MILLING				
Private Sector:				
Direct Wages	19.3	37.6	52.0	79.6
Indirect Wages	12.1	23.5	32.5	49.7
Interest, Rents, Dividends	3.0	5.8	8.0	12.2
Public Sector:	1.8	3.6	4.9	7.4
Net Transfer Payment	0.0	0.0	0.0	0.0
Total	36.2	70.4	97.4	149.0
URANIUM MINE CONSTRUCTION				
Private Sector:				
Direct Wages	16.0	47.1	51.4	---
Indirect Wages	6.5	19.3	21.0	---
Interest, Rents, Dividends	2.2	6.4	7.0	---
Public Sector:	1.6	4.8	5.2	---
Net Transfer Payment	(1.4)	(4.3)	(4.7)	---
Total	24.8	73.3	80.0	---
URANIUM MILL CONSTRUCTION				
Private Sector:				
Direct Wages	20.5	-0-	-0-	---
Indirect Wages	7.0	-0-	-0-	---
Interest, Rents, Dividends	2.6	-0-	-0-	---
Public Sector:	2.0	-0-	-0-	---
Net Transfer Payment	(1.8)	-0-	-0-	---
Total	30.3	-0-	-0-	---
EXPLORATION				
Private Sector:				
Direct Wages	14.5	7.2	11.1	7.8
Indirect Wages	10.0	5.0	7.6	5.4
Interest, Rents, Dividends	2.4	1.2	1.8	1.3
Public Sector:	1.7	0.9	1.3	0.9
Net Transfer Payment	0.0	0.0	0.0	0.0
Total	28.6	14.2	21.9	15.4
TOTAL				
Private Sector:				
Direct Wages	164.6	274.2	365.3	467.1
Indirect Wages	72.1	118.4	158.2	202.1
Interest, Rents, Dividends	22.5	37.3	49.7	63.3
Public Sector:	13.7	23.7	31.1	38.2
Net Transfer Payment	(3.2)	(4.3)	(4.7)	0.0
Total	269.7	449.3	599.6	770.7

Source: Adcock, 1979, No.46.

1/ All figures in current dollars.

Table IX-18

Summary of Housing Needs
With Moderate Uranium Development

County	Increase in 2000 over Moderate Scenario of 1980
San Juan	59%
McKinley	94%
Western Valencia	181%
Western Sandoval	104%

Source: Gibson, 1979, No. 39.

additional home sites on its lands scattered through Eastern Navajo country. The availability of water, electricity, and roads is an important consideration for such developments (Griffith, 1979, No. 51).

Navajo Economy

It is difficult to predict the extent to which regional impacts would affect the Navajo reservation alone, with Moderate uranium development. This would require a firm knowledge of the number of mines on Indian land (royalties) and the number of Navajos who would work in them (wages). It also would require construction of an economic model showing the reservation in-flow, intersectional transfer, and out-flow of cash. However, certain statements can be made.

For the extended family, uranium development would provide jobs and income that would be used to support many people. Navajos want jobs at home enabling them to stay on the reservation. It remains to be seen whether these jobs would make the subsistence sector of the Navajo economy more dependent on the money economy, at the cost of the extended family, or whether increased wages would enhance it by preventing out-migration and strengthening internal financial ties. Adjustment would probably depend on the past history of specific families.

Unless drastic changes occurred in the area, "bust" would bring a return to the subsistence-welfare lifestyle, which would be more difficult than before if middle class wages had caused the loss of survival mechanisms and the elevation of tastes so far as material goods were concerned.

The Moderate pace of development, in contrast to the High, might allow for a gradual build-up of Navajo expertise, through training and experience, and avoid the massive importing of outsiders to take up the majority of uranium company jobs.

Table IX-19

Demand for Housing - Moderate Scenario

	1980 Housing Units	1990 Housing Units	2000 Housing Units	% Change No Further Development 1990	2000
San Juan County					
Shiprock	1,175	1,691	2,208	18%	33%
Kirtland	937	1,394	1,810	22%	37%
Farmington	9,220	11,805	14,190	4%	6%
Aztec	1,996	2,722	3,393	11%	18%
Bloomfield	828	1,224	1,601	23%	35%
Remainder of County	4,586	5,719	6,687	2%	3%
TOTAL	18,742	24,555	19,889	7%	11%
McKinley County					
Gallup	5,433	7,366	8,769	14%	15%
Ft. Wingate	229	797	1,064	196%	243%
Thoreau	146	1,021	1,487	501%	659%
Crownpoint	664	2,564	3,564	229%	297%
Prewitt	96	990	1,474	800%	1052%
Remainder of County	7,117	8,820	10,238	5%	6%
TOTAL	13,685	21,558	16,596	33%	41%
Western Valencia County					
Bluewater	96	1,352	2,007	932%	1147%
Milan	1,079	3,327	4,068	120%	119%
Grants	3,168	6,789	8,139	53%	50%
Remainder Western Portion of County	2,283	3,652	4,414	14%	13%
TOTAL	6,626	15,120	18,628	63%	64%
Western Sandoval County					
Cuba	334	688	1,006	36%	63%
Remainder Western Portion of County	669	946	1,040	2%	3%
TOTAL	1,003	1,634	2,046	14%	25%

Source: Gibson, 1979, No. 39.

Moderate development also might allow time for the development of a Navajo commercial-retail sector and Navajo-owned mining related business services.

This level of development should also allow for tribal planning of mineral resource development that would balance revenue factors with local community concerns. If this is not done, local dissent might create political instability that could make Navajo resources less desirable to development companies.

PRIVATE INFRASTRUCTURE WITH HIGH URANIUM DEVELOPMENT

As with other facets of the environment, the impacts mentioned in the section on Moderate development would increase proportionately for High uranium development. Since this scenario is highly unlikely barring a major shift in policy, a complete analysis of all sectors has not been conducted. However, several groups of figures are of sufficient interest to warrant presentation here.

Industrial Sector

Employment. The anticipated employment is shown in Table IX-20. As indicated, the uranium industry work force would more than double, and total direct and indirect employment would increase 136 percent from 1980 to 2000.

Commercial Sector

Similarly, business activity would grow phenomenally as shown in Table IX-21. The total dollar volume from uranium income alone would increase 141 percent from 1980 to 2000.

Household Sector

Finally, personal income and housing starts would rise dramatically. These are shown in Tables IX-22 and IX-23. The 10-year increase for personal income is 109 percent while the 20-year increase to 2000 is 145 percent. This indicates that the major growth would be in the first decade (1980 to 1990). Delays caused by litigation, regulatory procedure, and market conditions have made this inconceivable. The earliest that major growth would take place now appears to be during the decade after 1985.

Navajo Economy

The High level of development would not bring that much more wage income to Navajos, since the added jobs would probably be filled by Anglo in-migrants. Although more royalty money would be earned by allottee families, this level of development would undoubtedly produce intolerable pressures on the Navajo government in terms of developing a political consensus and professional expertise necessary to control the development. The revenue from this level of development could raise the possibility of cutbacks in federal funding.

MITIGATION OF PRIVATE INFRASTRUCTURE PROBLEMS

General

The preceding discussion shows that huge amounts of money potentially could enter the private sector as a result of uranium development. These funds could be used to mitigate the adverse impacts of mining and milling. Whether the money would actually serve that purpose would depend upon the people. It could just as easily create hardships such as drunkenness, waste, and crime. Local and individual planning could help funnel the income into constructive channels. Help from outside, whether from government or private sources, can be useful but cannot substitute for local planning.

Industrial Sector

Many of the problems perceived by the Navajos seem to result from company exploration activities, said to result in fence cutting, unreclaimed mud pits, new dirt roads, and so on. The companies could do much to ease

Table IX-20

Jobs Created And/Or Supported By
Uranium Mining And Related Activity In The
San Juan Basin
High Scenario --1980-2000

	1980	1985	1990	2000
MINING				
Direct Jobs	5,706	13,240	18,970	24,740
Private, Indirect Jobs	5,605	10,372	14,939	19,676
Government Jobs	894	1,865	2,679	3,509
Total Jobs	12,205	25,477	36,588	47,925
Annual New Jobs	12,205	3,757	1,561	(18)
MILLING				
Direct Jobs	1,492	2,748	3,938	5,135
Private, Indirect Jobs	1,647	3,081	4,486	6,032
Government Jobs	248	461	666	882
Total Jobs	3,387	6,290	9,090	12,049
Annual New Jobs	3,387	805	399	9
MINE CONSTRUCTION				
Direct Jobs	3,515	5,725	2,857	---
Private, Indirect Jobs	1,854	3,019	1,507	---
Government Jobs	424	691	345	---
Total Jobs	5,793	9,435	4,709	---
Annual New Jobs	5,793	654	(1,228)	---
MILL CONSTRUCTION				
Direct Jobs	1,377	1,263	1,148	---
Private, Indirect Jobs	687	630	573	---
Government Jobs	163	150	136	---
Total Jobs	2,227	2,043	1,857	---
Annual New Jobs	2,227	(370)	742	---
EXPLORATION				
Direct Jobs	914	1,087	645	280
Private, Indirect Jobs	1,113	1,323	786	343
Government Jobs	160	190	113	49
Total Jobs	2,187	2,600	1,544	865
Annual New Jobs	2,187	(304)	(276)	195
TOTAL -- ALL ACTIVITIES				
Direct Jobs	13,004	24,063	27,558	30,334
Private, Indirect Jobs	10,906	18,245	22,291	26,051
Government Jobs	1,889	3,357	3,939	4,454
Total Jobs	25,799	45,845	53,788	60,839

Source: Adcock, 1979, No. 46.

Table IX-21

Dollar Volume Indirectly Generated by Uranium Mining
and Related Activity
High Scenario
($ Millions) 1/

Sector	1980	1985	1990	1995	2000
Agriculture	$ 11.2	$ 19.1	$ 23.3	$ 27.2	$ 27.4
Mining	17.7	29.6	33.4	40.3	36.7
Construction	20.8	35.7	39.7	48.7	43.9
Manufacturing	59.0	102.1	129.9	148.9	157.7
Transportation	24.1	42.2	54.8	62.2	67.5
Communications & Utilities	63.6	110.7	130.0	155.4	150.2
Trade	112.8	190.3	230.6	270.3	269.9
F.I.R.E.	96.7	164.7	203.0	235.2	239.8
Services	66.4	109.1	128.3	152.7	146.9
Government	N/A	N/A	N/A	N/A	N/A
TOTAL	472.2	803.5	973.0	1,140.9	1,140.0

1/ Figures in current dollars

NA = Not Applicable
Source: Larry Adcock and Associates, 1979, No. 46

these impacts through improved communication. By personally informing individual Navajos when they intend to move on and off of permitted or allotted parcels and promptly assessing and paying damages, company personnel might well dissipate the animosity prevalent in the area. This effort should be coordinated with the Navajo tribe, the USGS, and the BIA.

Labor. The danger of accidents is of concern to workers. The Mine Safety and Health Administration (MSHA) supervises the accident prevention programs of the mining companies and ensures compliance with the law. Safety training programs are required, as are insistence upon safe mining techniques such as roof bolting and proper spacing of support pillars. Mining

Table IX-22

PERSONAL INCOME GENERATED BY URANIUM ACTIVITY
HIGH SCENARIO - 1980 to 2000
($ Millions)

	1980	1985	1990	2000
URANIUM MINING				
Private Sector:				
Direct Wages	154.2	285.4	411.0	541.4
Indirect Wages	59.7	110.5	159.1	209.6
Interest, Rents, Dividends	20.1	37.5	54.0	71.0
Public Sector:	10.8	22.6	32.4	42.4
Net Transfer Payment	0.0	0.0	0.0	0.0
Total	244.9	455.9	656.5	864.4
URANIUM MILLING				
Private Sector:				
Direct Wages	31.6	59.2	86.1	115.8
Indirect Wages	19.8	37.0	53.8	72.4
Interest, Rents, Dividends	4.9	9.1	13.3	17.8
Public Sector:	3.0	5.6	8.1	10.7
Net Transfer Payment	0.0	0.0	0.0	0.0
Total	59.2	110.8	161.2	216.7
URANIUM MINE CONSTRUCTION				
Private Sector:				
Direct Wages	50.5	82.2	41.0	-
Indirect Wages	20.6	33.6	16.8	-
Interest, Rents, Dividends	6.8	11.1	5.5	-
Public Sector:	5.1	8.4	4.2	-
Net Transfer Payment	(4.6)	(7.4)	(3.7)	-
Total	78.5	127.8	63.8	-
URANIUM MILL CONSTRUCTION				
Private Sector:				
Direct Wages	20.5	18.8	17.0	-
Indirect Wages	7.0	6.4	5.9	-
Interest, Rents, Dividends	2.6	2.4	2.2	-
Public Sector:	2.0	1.8	1.6	-
Net Transfer Payments	(1.8)	(1.6)	(1.5)	-
Total	30.3	27.8	25.3	-
EXPLORATION				
Private Sector:				
Direct Wages	16.6	19.7	11.7	5.1
Indirect Wages	11.4	13.5	8.0	3.5
Interest, Rents, Dividends	2.7	3.2	1.9	0.8
Public Sector:	1.9	2.3	1.4	0.6
Net Transfer Payment	0.0	0.0	0.0	0.0
Total	32.6	38.7	23.0	10.1
TOTAL				
Private Sector:				
Direct Wages	273.4	465.2	566.8	662.3
Indirect Wages	118.5	201.1	243.6	285.5
Interest, Rents, Dividends	37.1	63.3	76.9	89.6
Public Sector:	22.8	40.7	47.7	53.7
Net Transfer Payment	(6.4)	(9.0)	(5.2)	0.0
Total	445.5	761.3	929.8	1091.1

Note figures in current dollars
Source: Adcock, 1979, No. 46.

Table IX-23

Demand for Housing - High Development Scenario

	1980 Housing Units	1990 Housing Units	2000 Housing Units	% Change No Further Development 1990	2000
San Juan County					
Shiprock	1,224	2,510	3,282	75%	98%
Kirtland	1,046	2,546	3,983	123%	126%
Farmington	9,409	13,623	15,800	21%	19%
Aztec	2,076	3,688	4,338	50%	50%
Bloomfield	895	2,151	2,529	112%	114%
Remainder of County	4,626	6,145	7,108	10%	10%
TOTAL	19,276	30,663	36,040	33%	34%
McKinley County					
Gallup	5,698	8,399	9,746	30%	28%
Ft. Wingate	367	1,395	1,735	419%	460%
Thoreau	269	1,844	2,415	985%	1132%
Crownpoint	880	4,649	5,779	497%	544%
Prewitt	223	1,880	2,357	1609%	1741%
Remainder of County	7,188	9,194	10,642	9%	10%
TOTAL	14,625	27,361	32,674	69%	74%
Western Valencia County					
Bluewater	255	2,277	2,781	1638%	1627%
Milan	1,374	4,190	4,765	177%	156%
Grants	3,571	7,738	8,912	75%	65%
Remainder Western Portion of County	2,354	3,822	4,576	20%	17%
TOTAL	7,554	18,027	21,034	95%	86%
Western Sandoval County					
Cuba	412	1,392	1,778	175%	187%
Remainder Western Portion of County	675	986	1,107	7%	9%
TOTAL	1,087	2,378	2,885	66%	77%

Source: Gibson, 1979, No. 39.

equipment design has improved in accordance with MSHA recommendations, resulting in the use of such safeguards as warning horns on backing wheeled equipment and protective cabs on certain mining and milling equipment.

Commercial Sector

The income from uranium development would provide great possibilities for business investment. This could benefit all segments of society--Anglo, Hispanic, and Indian--and lessen two difficulties in the region--unemployment and the often long trips to shopping areas. Stores located closer to the rural citizen might become feasible. This could be especially beneficial for the Navajo reservation. With skillful planning Crownpoint might develop a larger commercial sector.

Household Sector

Housing. The housing shortage expected to result from increased uranium development could be relieved by a number of available programs.

Their effectiveness, however, would be largely dependent on the entrepreneurship exercised by local housing developers. The motivation of these developers and the quality of the resulting housing development would be directly dependent on the effectiveness of land use planning and enforcement programs.

Since mobile homes could be expected to constitute the largest portion of the housing, at least initially, two HUD programs under the National Housing Act of 1955 are particularly relevant. Section 207 provides for the financing of mobile home parks under guaranteed loans. These are available to anyone meeting FHA's requirements for mortgages. Individual families can apply for similar loans under Title 1, Section 2 of the act.

Under the same act, cooperative housing can be developed under Section 213 which provides for guaranteed and insured loans enabling nonprofit cooperatives to acquire housing for operation as management type cooperatives. A somewhat similar program under the same section of the act provides for financing cooperatives which sell the developed housing to individual owners.

Another program which provides assistance for rural areas is the Farmers Home Administration Rural Housing Loans Program under the Housing Act of 1949. This provides direct guaranteed and insured loans for the construction, repair, or purchase of housing and also provides for the necessary and adequate sewage disposal facilities for the applicant and his family. The loans must have low interest rates, must be for families of low or moderate incomes, and must be modest in size, design, and cost. The program has the additional advantage of being applicable to certain types of leaseholds. This program could be particularly applicable when directly associated with the Farmers Home Administration's Program for Water and Sewage Facilities.

Navajo Economy

As suggested earlier, Navajo tribal planners should come to grips with developing uranium at an acceptable pace; allowing for community concern, and reinvestment of uranium royalties to help develop the other sectors of the Navajo economy. Maximum Navajo hiring should be sought through concrete affirmative action plans and available manpower skill training.

More research should be performed by the tribe on the effects of uranium development on other sectors of the tribal economy and to determine whether gains could be continued after the uranium is gone. More attention should be given to the reinvestment of revenues for uranium extraction.

One of the keys to increasing the amount of money flowing through the Navajo economy is to increase skill levels in occupations required by the uranium exploration, mining, milling, and construction activities. Programs conducted by the Grants branch of New Mexico State University and a skill center at Crownpoint are intended to deal with this problem.

Computer modeling resulted in a conclusion that significantly higher proportions of total personal income could become available to the Indian populated areas if: 1) skill levels are increased for uranium-related occupations so that Indian preference employment opportunities could be taken advantage of; 2) development occurs not only in border towns but also in surrounding areas such as Crownpoint, Thoreau, and Prewitt; 3) more Indian-owned or controlled businesses, particularly population-serving businesses, are established (Adcock, 1979, No. 46).

CHAPTER X

IMPACTS ON CULTURAL RESOURCES

Chapter X

IMPACTS ON CULTURAL RESOURCES

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Chapter X

Summary

The San Juan Basin is one of the most important cultural resource areas in the United States. Its ruins, prehistoric campsites, artifacts, and other traces of the past constitute the material heritage of basin inhabitants in prehistoric and historic times. Preservation of the integrity of these resources is of scientific and social importance.

If existing laws and regulations are enforced, uranium activities themselves should cause only minimal destruction of cultural resources. The most serious threat in coming years is exposure of cultural sites to much higher rates of vandalism. As population grows and sites that have long been isolated become increasingly accessible, the risk of vandalism will increase in any case. Stepped-up uranium development could exacerbate the problems to the extent that it contributed to the overall growth.

Existing protective measures are inadequate for the expected magnitude of the vandalism problem, and new measures would be necessary with rising uranium activity. Failure to act would result in an indeterminate but large proportion of the basin's cultural resources being irretrievably lost.

Chapter X

Impacts on Cultural Resources

EXISTING ENVIRONMENT

Introduction

The San Juan Basin is one of the most important archeological regions in North America. Human occupation extends back at least 12,000 years, and the culture history is unusually rich and varied.

Several present-day Indian groups--Pueblo, Navajo, Apache, and Ute--have their roots and most of their cultural heritage in the basin. The well-defined ecological boundaries and relatively complete and complex archeological record make the area a rare and ideal theoretical focus for the study of cultural change and stability.

The prehistoric and historic inhabitants of the basin left physical traces of their use or occupancy. In some cases these amount to no more than a few stone flakes scattered over a dune; in others, the evidences are imposing two-story rubble mounds rising above the landscape. Among these traces of the past are shrines, irrigation works, ruins of communities that had thousands of residents, isolated tools, campsites, trash dumps and the like.

From these remnants archeologists and other specialists seek, among other things, to explain cultural diversity and social change through time. This type of study offers potential insight as to why societies differ, how and why they develop, and why they decline.

Unexcavated, these sites often mean little to untrained persons who happen upon them, and disturbance or removal of artifacts or other evidence can destroy their value for scientific examination. In short, after having survived centuries of semiarid isolation, cultural resources of the Four Corners region are extremely vulnerable to the inroads of increasing population.

The central basin has been studied for more than 80 years, but knowledge is still limited and more or less restricted to a few localities. Most data are unpublished and dispersed. In recognition of this situation, the San Juan Basin Regional Uranium Study sponsored a special program to compile the coherent information base necessary to meaningful analysis of environmental impacts in this field. Results are summarized here from the report which resulted (National Park Service, 1979, No. 50).

Man's History in the Basin

From climatic indicators, radiocarbon dating techniques, and physical evidence, specialists have pieced together a sequence of human occupation and abandonment. A brief overview follows.

Paleo-Indian: Circa 10,000 - 5,500 B.C. Man's earliest known use of the region involved the hunting of late Pleistocene fauna. It is speculated that small, mobile groups hunted now extinct forms of bison and other game and gathered wild edible plants. This mode of life is now recognized primarily by distinctive projectile points and tools.

Archaic: Circa 5,500 B.C. - A.D. 450. With extinction of the Pleistocene mega-fauna, subsistence practices shifted toward gathering wild plant foods and hunting small game. Early in the period, there was probably some overlap with the Paleo-Indian form of subsistence. Larger subsistence groupings operating in smaller territories may have been characteristic of this new life style. Hearths and grinding implements are typical surviving evidence of this strategy. Toward the end of the period, seasonal rounds were again reduced and shallow pit house villages and horticulture may have emerged. However, the characteristics of the Archaic period may have continued in some places far into the next stage.

Anasazi: Circa A.D. 450 - A.D. 1300. Late in the Archaic epoch, some parts of the population gradually turned from hunting and gathering primarily to the exploitation of domestic plants. These people became more stationary, and individual groups once more reduced their defined territory. By the Basketmaker III time period (A.D. 450), more permanent living arrangements were reflected in the emergence of pit house villages and crude grey-ware ceramics. A corresponding change in social organization also probably took place. The basic Basketmaker III settlement system and social organization was probably maintained at least until the 1200's in some areas.

Evolution of society continued to take place, however, in most subregions of the San Juan Basin. By Pueblo I times, (A.D. 750-900) trends toward surface architecture, more sophisticated farming techniques, greater social control, and elaborate trade and ceremonial networks were beginning to emerge. This trend toward complexity, with its corresponding increase in population, probably reached its height between A.D. 1000 and 1200. During the Pueblo II and Pueblo III epoch, elaborate social-economic systems developed.

The most visible, and probably the most important, of these became what is known as the "Chacoan Phenomenon." Centered at Chaco Canyon, this region-wide economic, social, and political system may have controlled the entire San Juan Basin and beyond. Road systems, extensive towns consisting of ceremonial or administrative centers, and hundreds of dwellings were built throughout the San Juan Basin (Figure X-2).

By the 1300's most of the basin appears to have been abandoned. It is believed that most of the inhabitants moved during Pueblo IV times to the Zuni and Hopi areas and to the Rio Grande. The explanations for this withdrawal are subject to speculation. Theories have centered on drought,

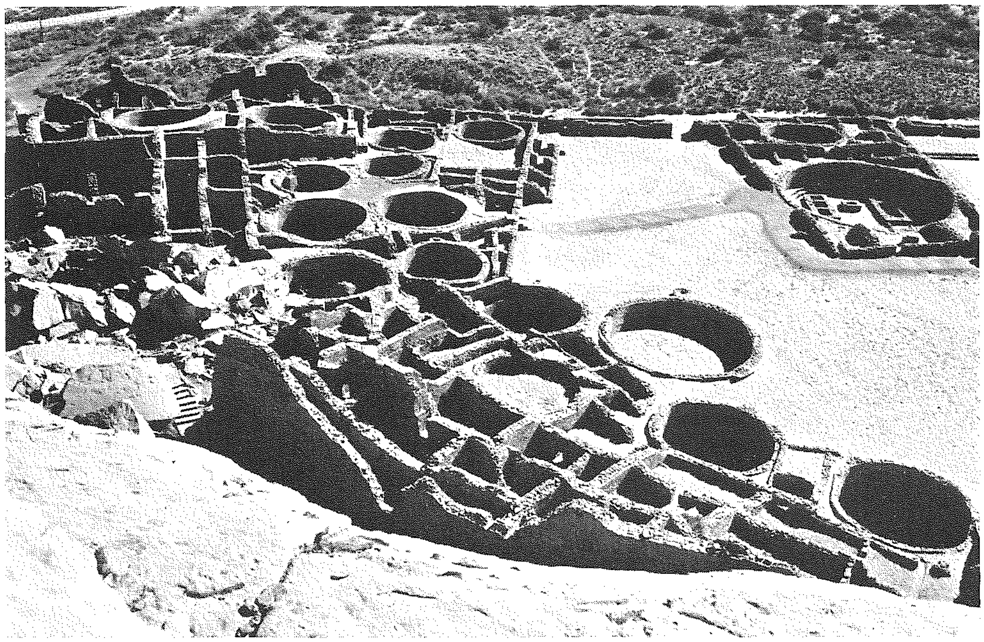


Figure X-2.--An aerial view of Pueblo Bonito, one of the impressive ruins excavated at Chaco Canyon National Monument

warfare, or some kind of social disorganization or political collapse. Satisfactory answers await further research.

Late Prehistoric, Historic: A.D. 1300 to Present. Probably sometime before A.D. 1500, the Apache-Navajo entered what was by then a practically unoccupied San Juan Basin. These new arrivals were highly adaptive and depended for their livelihood upon hunting and gathering as well as horticulture. Gradually they repopulated the area. Augmented by Pueblo people displaced by Spanish incursions, Navajo bands spread across the landscape. By the middle of the 19th century, sheep-herding and raiding had become established as additional elements in the Navajo way of life.

Forcibly removed from the San Juan Basin by the U.S. Government in 1864, the Navajos returned four years later to pursue their traditional land use patterns. The reservation system and greater interaction with the non-Navajo world wrought continued changes in the Navajo lifestyle thereafter. Today the Navajo are the largest Indian group living in the basin, and their culture is still marked by adaptive resiliency.

Pueblo culture flourished briefly in the 1400's and 1500's, then was interrupted by entry of the Spanish into the area now known as New Mexico. Often harried by hostile Indian neighbors and beset by periodic epidemics, the people of Acoma, Laguna, and Zuni steadily lost population and territory well into the 19th century. Nevertheless, these Pueblo peoples retained their territorial footholds in the basin and have maintained many traditional aspects of their culture to the present.

In the historic period, the Utes occupied the northern reaches of the basin in what is now southwestern Colorado and southeastern Utah. They rarely crossed the San Juan River to the south except to raid or trade. The historic Utes were a hunting and gathering people who became master horsemen and feared warriors after A.D. 1700.

The Jicarilla Apaches were peripheral to the San Juan Basin until 1872 when a reservation was established for them in north-central New Mexico. Originally, the Jicarilla homeland was centered in the Sangre de Cristo Mountains and the northeastern plains country of New Mexico. In historic times, like their Ute contemporaries, they were noted horsemen who relied primarily on hunting and gathering for their subsistence.

Except for a small number of missionaries, soldiers, and frontiersmen, Hispano and Anglo penetration of the basin was slight until after the Civil War. By 1900, however, trading posts, stagecoach stations, forts, towns, and ranches had become established elements in the cultural landscape.

Most of the Spanish-speaking and Anglo settlements were founded on the eastern, southern, and northern fringes of the San Juan Basin. This settlement pattern persists today (Chapter VII).

New Information Efforts

Two programs were initiated by the National Park Service to meet the needs of environmental analysis. One aimed at acquiring basic data on all recorded prehistoric and historic sites in the area, with a 60 to 80 percent recovery rate considered reasonable. Data on archeological survey intensities also were collected.

Information on approximately 15,000 archeological sites and 4,000 surveys--indicating the areas in which archeologists have made some search for cultural remains--was stored on computer tape and housed at the Kirtland Air Force Base computer facility in Albuquerque, N.M. The site total represents roughly 75 percent of the estimated recorded sites in the central San Juan Basin. A computer generated directory was produced and an interactive computer program designed to facilitate rapid retrieval. This should be a useful data source for environmental analysis and specific environmental impact statements (EIS's).

In the second program, aerial and satellite photography and other imagery was collected and interpreted. This remote sensing effort gathered data on ecological contexts of the prehistoric and historic sites. Maps of soils, geology, rainfall patterns, and environmental zones were drafted to match the site inventory base map. The remote sensing program acquired additional information on the complexity and extent of the prehistoric Chacoan road and community network mentioned earlier. An aerial photo archive was prepared as another data source for site-specific EIS's.

Information from the two programs was integrated into a coherent regional data base for environmental assessment. Ten archeologists explored this data base in a week-long National Park Service and School of

Table X-1

Descriptions of Archeological Sites for Data Base

TEMPORAL PERIOD

Paleo-Indian	Pueblo IV	Ute
Archaic	Pueblo V	Spanish
Basketmaker II	Anasazi	Anglo
Basketmaker III	Navajo-prior 1868	Unknown Lithic
Pueblo I	Navajo-after 1868	Unknown Date Ceramic
Pueblo II	Navajo-after 1958	Other
Pueblo III	Navajo	Unknown Affiliation

FUNCTIONAL TYPES

Habitation	Campsite	Resource Extraction	Ceremonial	Defensive
Pueblo	Farm Site	Quarry	Shrine	Fort
Village	Processing	Kill	Ritual Structure	Wall
Hogan Cluster	Hunting/ Gathering	Gathering	Kiva	Building
Pueblito	Animal Husbandry	Farming	Great Kiva	
Fort/Defensive Retreat	Other	Tool Making	Church	
Trading Post	Undefined	Gathering/ Process	Burial (single)	
Farm/Ranch		Mining	Burial (multiple)	
Historic House		Hunting	Other	
Public Building		Other	Undefined	
Undefined		Undefined		

Miscellaneous	Undefined Artifact Scatter	Undefined Structure
Sweat Lodge	Lithic	Coursed Stone
Petroglyphs/Pictographs	Ceramic	Concrete
Roads and Trails	Lithic & Ceramic	Cinderblock
Water Control	Hearths	Adobe
Manufacturing/Business	Modern Refuse	Wood Frame
Animal Husbandry		Wood
Alignments/Stone Piles		Jacal
Stone Enclosures		Other
Storage		
Other		

Source: National Park Service, 1979, No. 50.

American Research seminar. Results are reflected here and elaborated upon in National Park Service, 1979, No. 50.

The Known Archeological Record

Information collected about archeological sites was broken into time periods cited earlier, each marking a significant change in the way people procured food. Further subdivisions by function and space were added. The various categories are shown in Table X-1.

The nearly 15,000 sites tabulated were based on archeological surveys covering just 5.9 percent of the New Mexico portion of the San Juan Basin. It is estimated that probably 10 percent of the basin has ever been surveyed for cultural remnants. The number of sites recorded thus represents a small portion of the potentially recoverable remains.

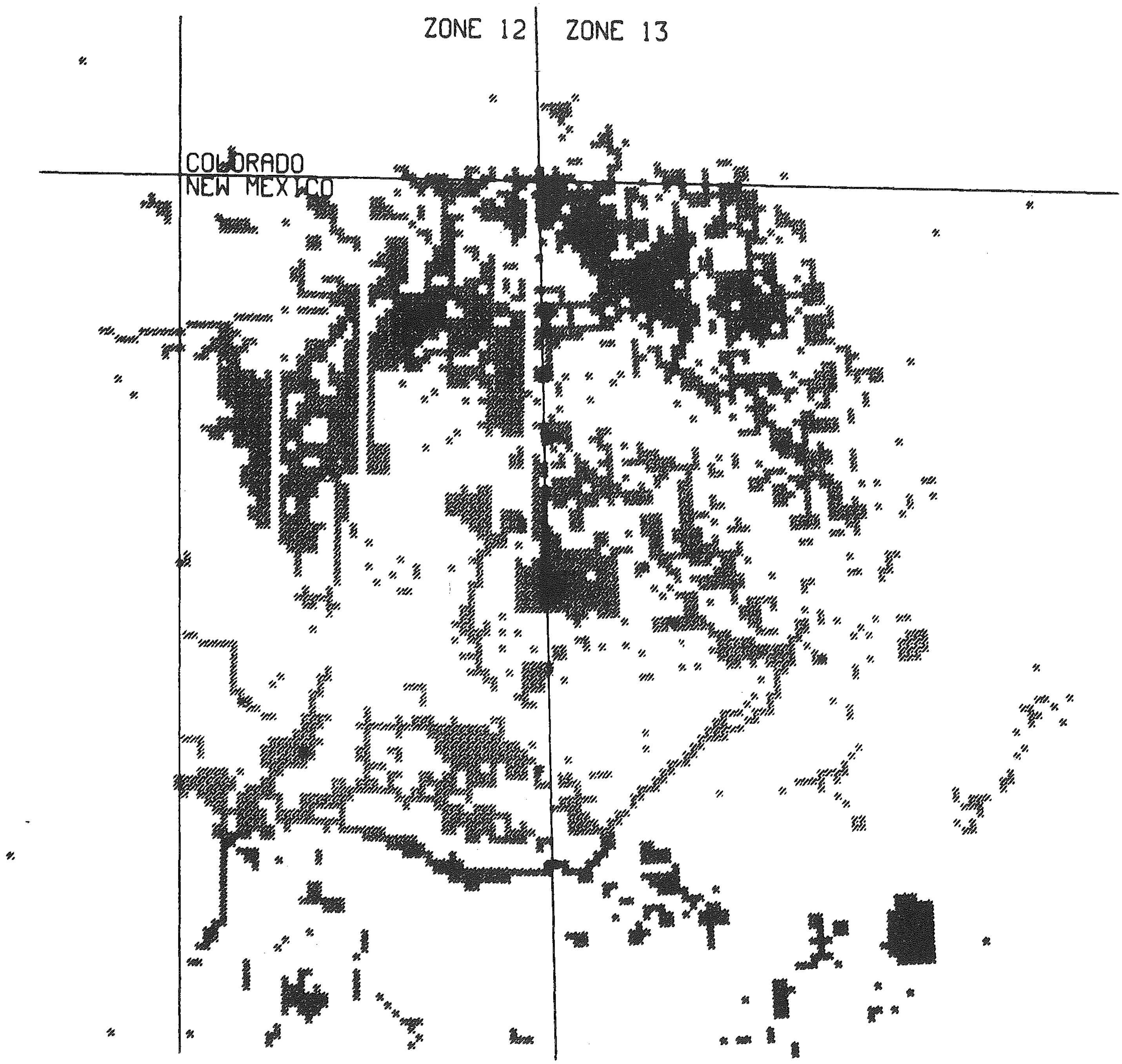
Areas in which archeologists have looked for cultural remains are shown on Map X-1. The basin was divided into grid squares of 4 square kilometers (1.54 square miles) and each grid in which any archeological work is known was shaded. Many shaded squares, however, have had less than 1 percent of their area surveyed. Maps X-1 and X-2 are taken from the National Park Service study.

The distribution of all archeological sites recorded in the data base is shown on Map X-2. The large cluster in the center is Chaco Canyon National Monument. Site locations shown on Map X-2 do not necessarily coincide in all cases with the survey areas on Map X-1. Sometimes sites are known, but the archeological survey boundaries pertaining to them are inadequate or were unavailable when the data base was compiled. In other cases the surveys cover areas too small to show up on the map.

The following maps in other chapters provide general information about the basin: Map III-1, geology; Map VI-2, topography; Map VI-3, soils; Map VI-4, vegetation. Maps in greater detail on these aspects keyed to the inventory base may be found in National Park Service, 1979, No. 50.

Summary of Cultural Resources. Whether an archeological site is "important" has generally been determined by its eligibility for nomination to the National Register of Historic Places. Criteria for such listing are: (a) Association with events that have significantly contributed to the broad patterns of history; (b) Association with the lives significant to the past; (c) Embodiment of the distinctive characteristics of a type, period, or method of construction, or sites that represent the work of a master, possess high artistic values, or represent a significant entity; (d) Likelihood of yielding information in prehistory or history. Sites listed on the National Register are shown in Table X-2. A longer list of historic sites on the State of New Mexico's list appears in National Park Service, 1979, No. 50.

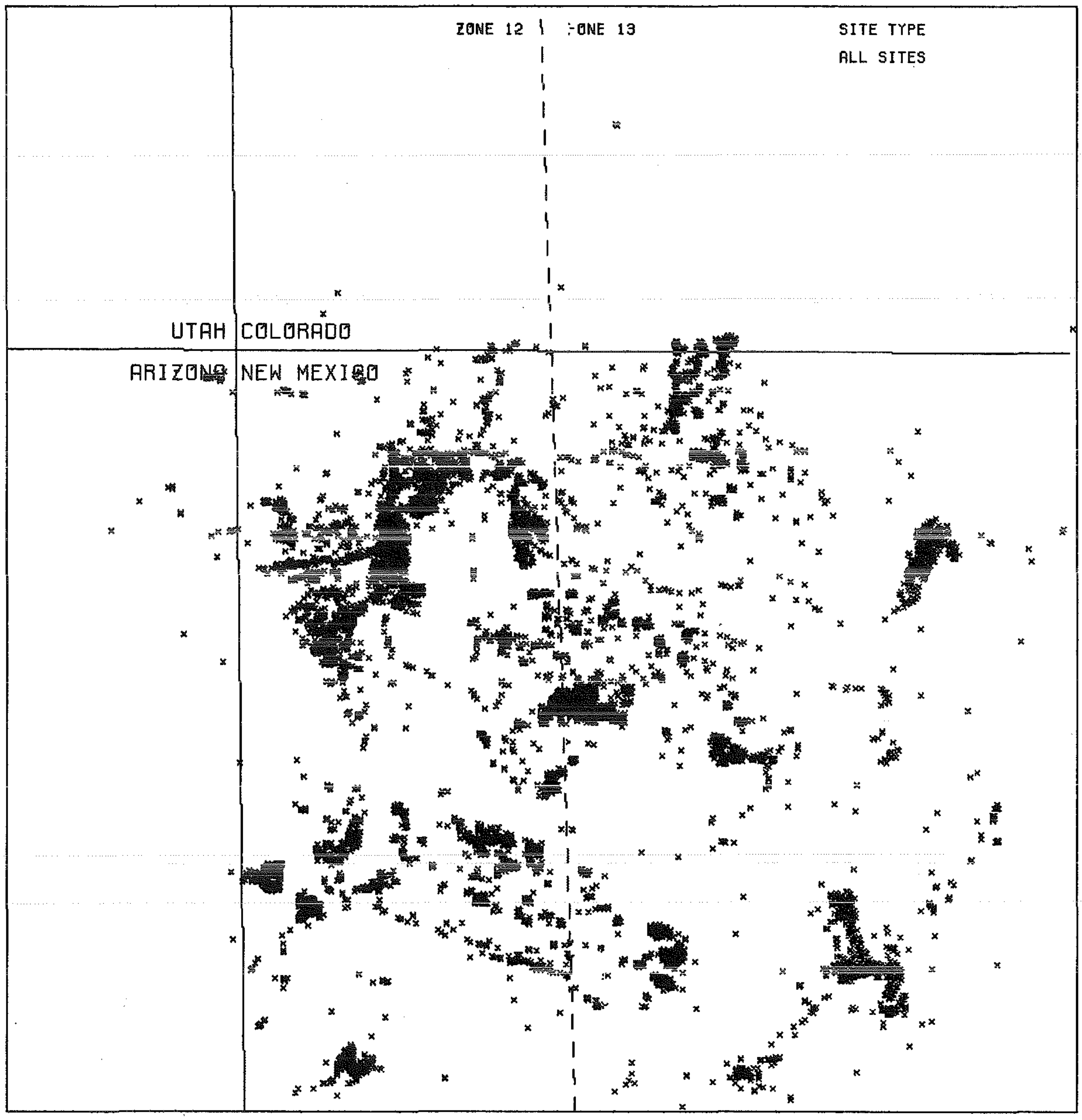
1) Sites Significant for their Heritage Values. These include places with sacred significance to Navajos; battle locations such as Washington Pass; the grave near Coyote Canyon of famed Navajo chieftain Manuelito



Areas in central San Juan Basin in which archeological surveys have been made

Map X-1

SAN JUAN BASIN SITE DISTRIBUTION



NPS-BICA COMPUTER FACILITY, 8/13/80

SCALE 1 INCH=40 KILOMETERS

Map X-2

(Hastiin Ch'ilhaajin, "Mr. Blackweeds"); early settlements, trading posts, missions, and chapter houses; and sites of regional and local importance.

There are many places in the basin that have long been held sacred by Navajos (Map X-3, Table X-3). Major places important to Navajos whether they follow tribal religion or not are such sacred mountains as Mount Taylor, Huerfano Mesa, Gobernador Knob, Shiprock, Hosta Butte, and Chuska Point. Ideal Navajo values would reserve these and certain others such as the Chaco Canyon sites as holy wilderness areas with restricted access.

All communities have nearby local places of sacred significance that are used by tribal singers, as well as spots reputed for supernatural power. These include springs, caves, trail shrines or "wishing piles", lightning-struck trees, antelope corrals, sites possessing pictographs and petroglyphs on the rocks, and other sites. In addition, various sites are cherished at the individual or family level. There may also be places held sacred by members of the Native American Church or by members of local Christian congregations. A multi-agency report to Congress by the Secretary of the Interior, pursuant to the American Indian Religious Freedom Act, recommended among other things that federal land areas of special religious significance to Indians be reserved and protected.

2) Sites with Architectural or Aesthetic Significance. Such sites, in particular, sometimes possess multiple values. The large Chacoan ruin of Kin-ya-ah near Crownpoint, for example, possesses scientific, architectural, and heritage values, the latter deriving from the ruin's status as the legendary origin of the Navajos' Towered House Clan. Navajo rock art panels, scenic spots, and early fort sites or military buildings are examples of this category.

3) Sites with Research Significance. Almost all archeological sites are potentially significant. From a practical standpoint, the level of significance is relative and changes with circumstances.

The relative significance of sites varies with changes in the physical resource base itself and with changes in the theoretical resource base. These may be viewed as models of significance. The resource model shifts with changes in the land surface; the research model shifts as questions are asked and answered, with the value of certain information depending on the state of knowledge at a given time.

In a resource model, the nature of significance of archeological sites changes according to the extent of physical effects on the site population. Destruction of a site tends to raise the value of that site type, as representative of an ecological zone, time period, or other defining characteristic. Another site type, meanwhile, experiences a corresponding decline in relative value. To the extent that the condition of the land surface can be foreseen for future dates, site significance for the resource model can be predicted. Regional resource impacts and, therefore, regional resource significance can often be assessed on the basis of site population. An example of how site distribution affects the regional resource perspective on significance is depicted in Figure X-3.

Table X-2

Cultural Sites of National Significance

Cultural resources within the New Mexico part of the San Juan Basin which are of recognized national historic significance are as follows:

A. National Park Service areas.

   1. Chaco Canyon National Monument
   2. Aztec Ruins National Monument

B. National Trails System

   1. Dominguez-Escalante Trail (currently being considered for inclusions in National Trails System)

C. Sites currently listed on National Register of Historic Places (National Historic Landmarks designated with asterisk)

   1. *Acoma Pueblo (Valencia County)
   2. Archeological Site OCA-CGP-56 (S.W. of Fruitland, San Juan County)
   3. Aztec Ruins National Monument (San Juan County)
   4. Miguel E. Baca House (on N.M. 47, Valencia County)
   5. *Big Bead Mesa (W. of Casa Salazar in Cibola National Forest, Sandoval County)
   6. Chaco Canyon National Monument (McKinley County)
   7. Crow Canyon Archeological Site (E. of Farmington, San Juan and Rio Arriba Counties)
   8. Fort Wingate Historic District (E. of Gallup, McKinley County)
   9. Dittert Site (S. of Grants, Valencia County)
   10. Frances Canyon Ruin (17 miles N.E. of Blanco, Rio Arriba County)
   11. Gallegos Wash Archeological District (S.E. of Farmington, San Juan County)
   12. Halona Pueblo (at Zuni, McKinley County)
   13. Hawikuh (12 miles S.W. of Zuni, Valencia County)
   14. Laguna Pueblo
   15. *Manuelito Complex (S. of Manuelito, Valencia County)
   16. Salmon Ruin (E. of Farmington, San Juan County)
   17. *San Estevan del Rey Mission Church (at Acoma, Valencia County)
   18. *San Jose de la Laguna Mission and Convent (at Laguna, Valencia County)
   19. Site No. OCA-CGP-54-1 (S.W. of Fruitland, San Juan County)

Source: National Park Service, 1979, No. 50.

In the research model, the "research question" defines the nature of impacts. If the question is the arrangement of sites across the face of the basin, destruction of those sites would not be adverse if the locations had been adequately mapped. If the question is the spatial relations of artifacts on a living floor, merely walking across that floor could constitute a severe adverse effect. The distinction between "resource" and "research" significance dwindles with advance toward the present because the interrelationships between time, ecology, economics, and social patterns are better understood.

Known Sites and their Potential Research Values

The potential value of archeological remains in the basin, for research purposes, depends on the extent to which specific sites can fill in unknown facts about past human activity there.

Some of the questions and concerns which scholars hope someday to satisfy by studying selected sites of varying ages, including some yet to be discovered, are treated briefly here. Combined with this discussion of theoretical values is a summary of site inventory findings for various time periods. Further information and detailed archeological concerns are available in National Park Service, 1979, No. 50, from which this is taken.

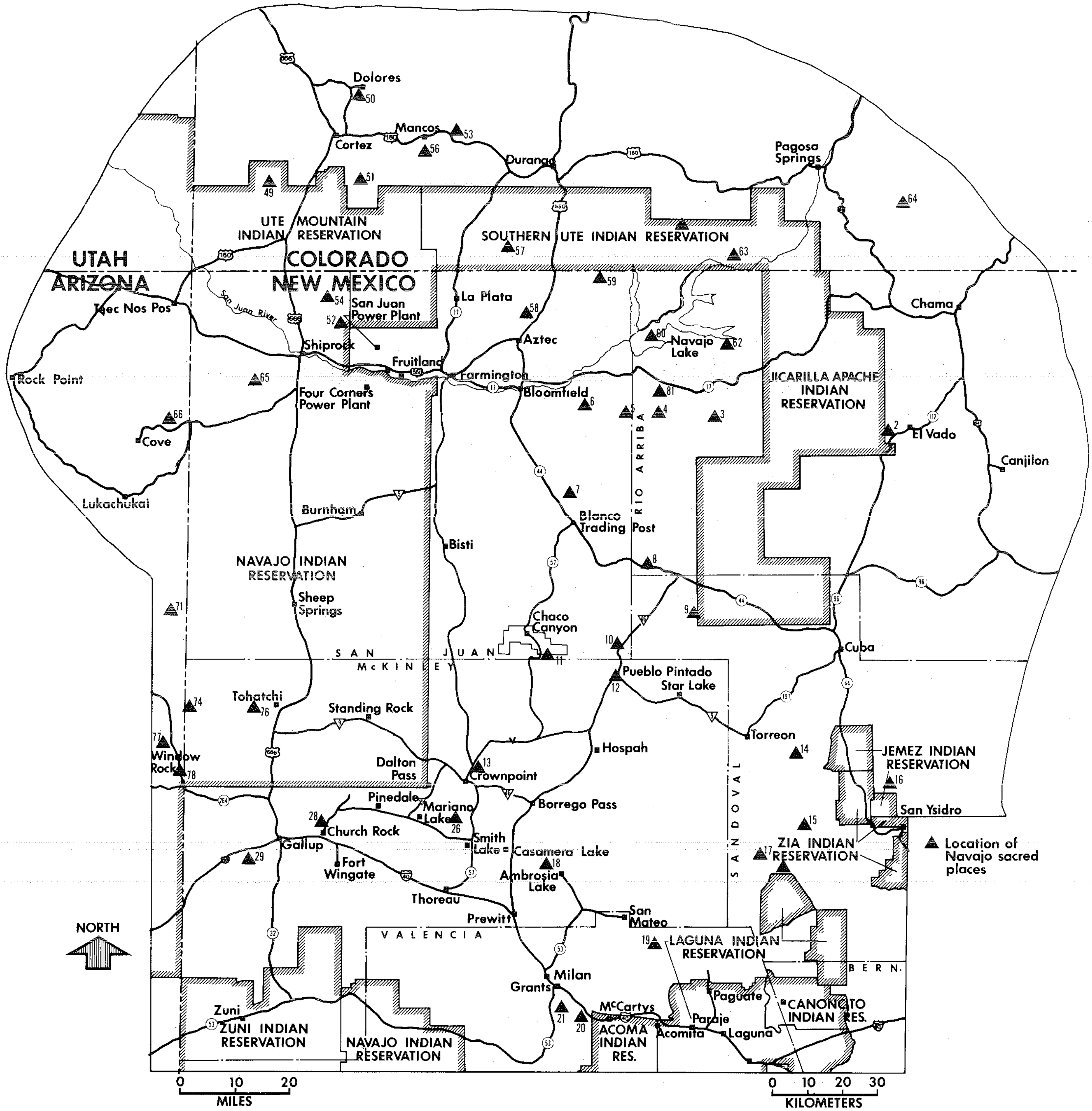
Paleo-Indian Sites. Little can be said at this point about the Paleo-Indian period (earlier than 5,000 B.C.) in the basin. Only 14 sites with Paleo-Indian remains were identified in the data base. Of these, nine show evidence of more than one time period. This leaves five actual sites, only two of which are large enough to yield potentially valuable information.

Paleo-Indian sites are so rare that even isolated artifacts are considered extraordinary finds. Therefore, all remains must be considered highly significant, regardless of their condition or location.

Archaic Period Sites. There are 840 sites in the basin inventory which have been classified as Archaic (approximately 5,500 B.C. to A.D. 450). Generally this means that at least one projectile point thought to be of Archaic age was found at a site. An additional 534 sites are classified as "unknown time period lithic" sites; many of these probably date from the Archaic period. Very few Archaic sites have been excavated and even fewer dated by other than broad diagnostic projectile point criteria.

While 840 sites may appear to be a substantial number, these sites represent a span of prehistory which can range up to almost 7,000 years. Assuming an even distribution of sites through time, which most archeologists would probably be unlikely to do, there might, therefore, be information on 100 sites for each thousand years of Archaic prehistory. This is too small a sample to warrant even broad assumptions concerning the type of sites to expect for the period.

Many prime questions are yet to be answered concerning human life in Archaic times. Too few Archaic sites are known, for example, to permit detailed observations about their placement in relation to environmental



NAVAJO SACRED PLACES

Map X-3

Table X-3

NAVAJO SACRED PLACES
(Key to Map X-3)

No.	ENGLISH NAME	NAVAJO NAME
1.	Blanca Peak, also Sierra Blanca	Sisnaaiiñi, Horizontal Black Belt
2.	Buford Lake, also Stinking Lake	Tóindoots'os, Slim Water Between Ridges
2a.	Taos Pueblo	Toghwol
3.	Governador or Gobernador Knob	Ch'oel'i'i, Fir Mountain
4.	Navajo Trail	Diné na'atiin, Navajo Trail Going Upward
5.	Salt Point	Ashiih náa'ah, Salt Going Down Point
6.	Mesa Quartado	Dził nitaas, Big Mountain
7.	Huerfano Mountain, also El Huerfano	Dził na'aadziłii, Encircled Mountain (by people)
8.	Escrito Spring	Tó doo hok'aadi, Rock Cave in the Water
9.	Wide Belt Mesa	Sísnateel, Wide Belt
10.	Wijiji	Kin dootłlizh, Blue House
11.	Mesa Fahada, also Mesa Faohada, Mesa Fajada	Tsé digili', Tsé'dighin, both interpreted to mean Holy Rock
12.	Pueblo Pintada	Kin teel, Wide House
13.	Khinya	Kin yáa a'hí, Towered House
14.	Red Mountain	Dził łichii', Red Mountain
15.	Cabezon Peak	Tsé nadzin, Black Rock Coming Down
16.	Pajarito Peak	Tl'ish jik'áhi', Grinding Snakes
17.	Cerro Caliso; also Big Bead	Yoo'tso, Big Bead
18.	Old Crater	Náá'ágháni, Their Eyes That Kill
19.	Mt. Taylor	Sootdził, Unetymological
20.	San Mateo Lava Flow	Yeii tso bidiłniniigheezh, Where Big God's Blood Congealed
21.	Ojo de Gallo	Tó sido, Warm Water
21a.	Guadalupe Canyon	Tséghi hayázhí, Little Box Canyon
22.	Cerro Berra	K'aaló gii dził, Butterfly Mountain; also Dolidził, Bluebird Mountain
23.	The Geyser	Tó alchin, Wild Water
24.	San Mateo Peak	Tsé naahá bith, Overhanging Rock Ledge
25.	Mogollon Baldy	Noodahas'ál, Yucca Slope
26.	Hasta Butte	'Ak'iina'st'ani, Mountain Sitting on Top of Another Mountain
27.	Star Mountain	Sóntsola, Stars Strung Out
28.	Navajo Church Rock	Tsé ii áhí, Standing Rock
29.	Twin Buttes	Tsé in desgizh, Gapped Rock
30.	(No English Name Known)	Galngi'doił, Unetymological
31.	Salt Lake	'Ashiih, Salt
32.	Mesa Santa Rita	Nahoobá, Horizontal Gray Streak
33.	Mesa Redonda	Dziłbiídzooldzisii, Mountain With Pockets or Recesses
34.	Woodruff Butte	Tooji'hwiidzoh, Line Marked Down to Water
35.	Sunset Mountain, also Sunset Knoll	Jadi hi'ibikoo, Antelope Coming Up
36.	Bill Williams Mountain	Tsin beel'ahi, Tree Grove Slope
37.	Sheep Hill	Dibé shijée'í, Where Sheep Lie Down
38.	Sunset Crater	Dził bílátaa łitso, Yellow Topped Mountain
39.	San Francisco Mountains	Dook'o'skid, Never Thaws on Top
40.	Moqui Buttes	Chézhin ch'ídeelyá, Lava Extends Horizontally Outward
41.	Awatovi, 'Awat'ovi, Place of the Bow (Hopi)	Táalahoogan, Wind Struck Houses
42.	Red Butte	Tsé zhin e'áhí, Black Rock Standing Up
43.	Salt Cave	'Ashiih, Salt
44.	Black Mountain	Dziłzhin, Mountain Which Appears Black
45.	Bolukai Mesa, also Salahkoi Mesa	Báalok'aaí, Reeds Under the Rim
46.	Navajo Mountain	Naatsis 'áán
47.	El Capitan	'Aghaa'ła, Much Wool
47a.	Desert View Point	Yáh éh áhi, Standing Tower
48.	Bear's Ears	Shashjaa, Bear's Ears
49.	Ute Mountain; also Sleeping Ute Mtn.	Dzílnaazhini, Black Mountain Sloping Down
50.	Dolores	Hódiliid, Burned Area
51.	Mesa Verde	Gadeizah, Hogback or Serrated Ridges
52.	Chimney Rock	Tsé e'ahi, Standing Rock
53.	Mancos Canyon	Tó ints'ósí koo, Slim Water Canyon
54.	Salt Creek	Tódokonzh bikoo, Salt Water Canyon
54a.	Rainbow Mountain	Náats'iilid dzíił, Rainbow Mountain
55.	La Plata Mountains	Dibéntsaa, Big Mountain Sheep
56.	Manefee Peak	Induschii joth to'ii, Shooting Pine
57.	Soda Spring	Tódokonzh'adii, Alkalin Water Coming Out
58.	Aztec Ruin	Kin niteel, Wide House
59.	Mesa Mountains	'Ageé nachíi, Cedar Bark
60.	River Junction	Tó'aheedli, River Junction
61.	San Rafael Canyon	Taanez'a, Poles (fence) Strung Out
62.	Big Water	Tó tso, Big Water
63.	Cerro Sandaval	Dził bi'aniiłgail, White Faced Mountain
64.	Rio Blanco	Tsé gihi', Between the Rocks
64a.	San Juan Mountains	Dził łigaii, White Faced Mountains
65.	Shiprock Pinnacle	Tsé bit'a'l, Winged Rock
66.	Roof Butte	Dził dáneeztínii, Mountain Went Out On Top
67.	Mark on Rock Peak	Tsé dá'ahoodze, Mark on Rock
68.	Black Rock (De Chelly)	Tsé zhini, Traprock
69.	White House Ruin	Kin níi na'igaih, White House in Between
70.	Wide Rock	Tsé n teel, Wide Rock
71.	White Cone	Séihiits'osi bikáa, Slendor Male Sand (pile)
72.	Big Lake	Bee'akid hatsoo, Big Lake
73.	Fluted Rock, also Dził Tusyan Butte	Dził da si ání, Mountain Sitting on Itself
74.	Red Lake Volcanic Plugs	Be'ek'id halchíi, Red Lake
75.	Buell Park	Tsé zhin hodóo klizh, Black Rock in Blue Area
76.	Chuska Peak	Ch'óoshgail, White Colored Spruce Trees
77.	Black Rock (Ft Defiance)	Tsé zhini, Black Rock
78.	Window Rock	Tséghàhodzani, Perforated Rock
79.	Black Point	Chézhindesá, Black Point
80.	Dove Spring	Hasbidi tó, Dove Water
81.	Juniper Ridge	Godiłnalkiid, Base of Juniper
82.	Shonto	Shaa'tó, Sunnyside Water
83.	Bitahochii	Bitahochíi, Red Streaks Going Up

zones. Archaic sites have generally been found near dune fields and in areas in which a sand cover has been blown off. The fact that Archaic sites are found in sandy areas raises a question as to whether this is due to erosion and deposition, or whether there was some link to the specific environmental zone.

Another question is whether an apparent paucity of sites in the southwest part of the basin indicates that the evidence is buried or that Archaic peoples avoided that area. A major concern is development of criteria by which to relate time periods to climatic and subsistence changes.

Other typical concerns include: development of independent evidence of paleo-climatic shifts; documentation of major shifts in subsistence strategy; study of seasonal implications in subsistence pursuits and mobility and of the possibility that the basin was not continuously occupied during the period; study of relationships between storage facilities and subsistence behavior.

Significant Archaic sites should shed light on these or other factors. "Extremely significant" sites might hold the potential of providing new, datable information on the Archaic period, including seasonal, paleo-climatic, or dietary aspects; or lie outside of dune areas or in the possibly unsettled southwest part of the basin.

Anasazi Period Sites. Nearly 8,500 sites identified with the Anasazi period (approximately A.D. 450 to A.D. 1300) were included in the data base. For this period, archeologists consider of critical importance any evidence that could disclose new information on horticulturalist-forager relationships.

Other research concerns, on the early Basketmaker III-Pueblo I period (A.D. 450 to A.D. 850 approximately), include precise location of possible agricultural areas and specific inquiries into the relationships of the expanding horticulturalists and their non-agricultural contemporaries. Sites deemed "extremely significant" would be expected not only to provide such information but also to hold the potential for providing chronometric information, other than ceramic, in order to refine the chronological information base, or to supply information about those environmental zones in which known Basketmaker III-Pueblo I sites are comparatively rare.

The data base contains 2,274 sites identified with the early Anasazi phases, Basketmaker III and Pueblo I. While these span just 400 years, archeologists suspect a dramatic change during this period in the way many inhabitants made their living. Such evidence as ceramics and village remnants suggests sedentary constraints. However, fewer than 13 percent of recorded sites have been excavated or tested and fewer than 1 percent dated by tree-ring, radiocarbon and/or archeomagnetic methods. One theory, based partly on discoveries of stockaded villages in the Gobernador and Navajo Reservoir areas and elsewhere, suggests there was conflict between expanding horticulturalists and resisting foragers.

The data base compiled almost 6,200 archeological sites representing the subsequent Pueblo II-Pueblo III period (approximately A.D. 850 to A.D.

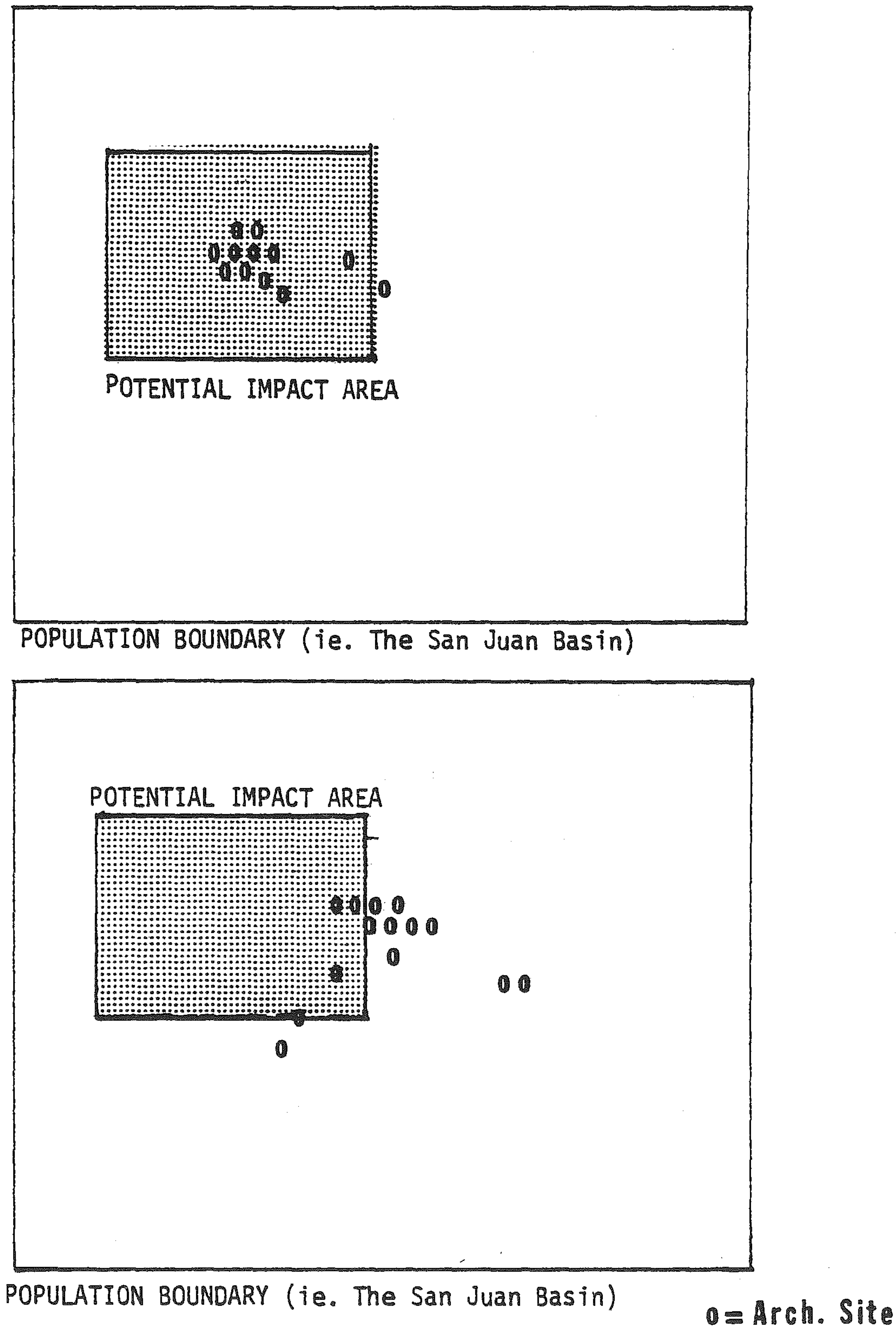
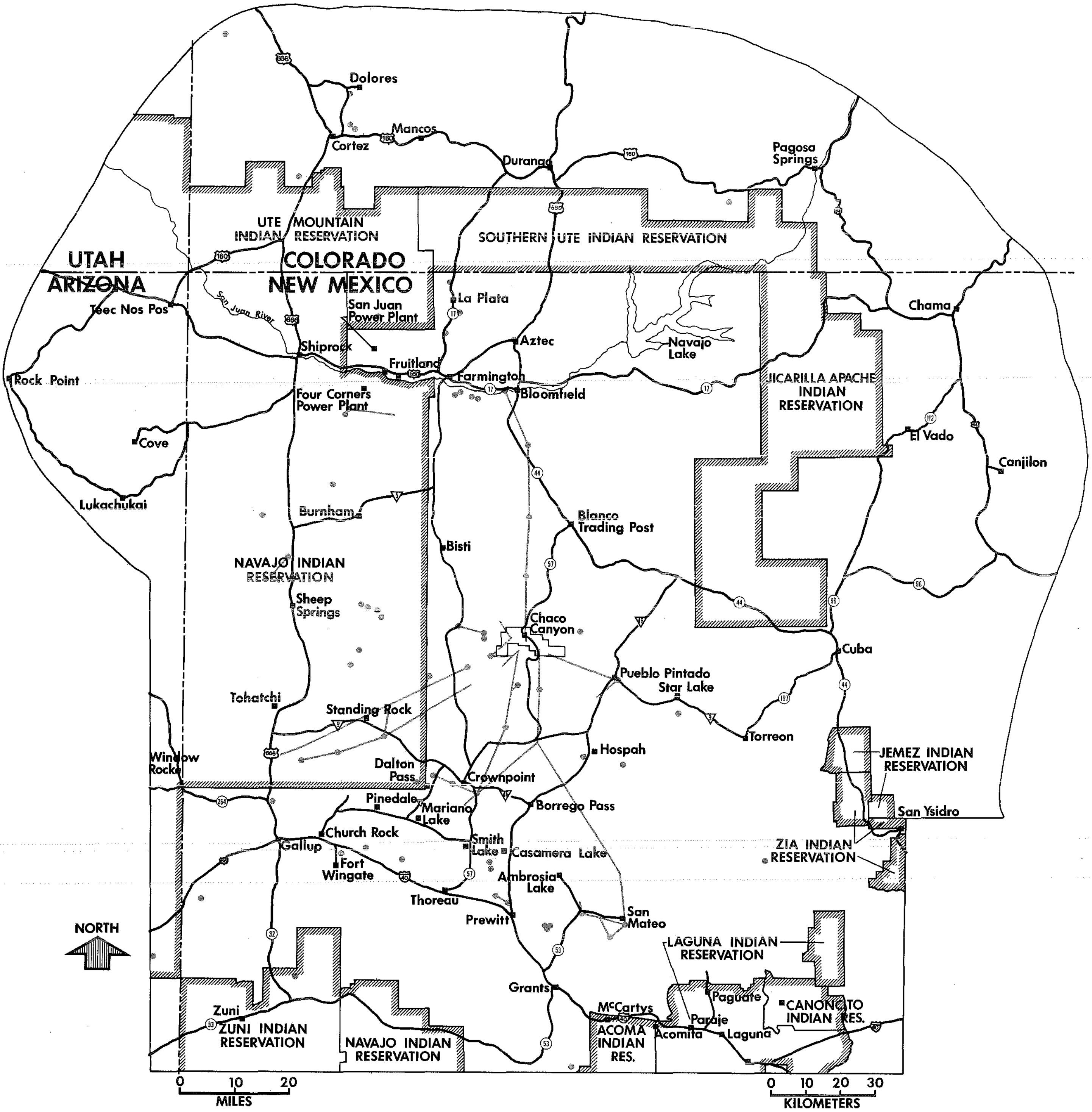


Figure X-3.--Uranium development impacts on archeological sites. (Lines depict theoretical limits of uranium exploration in two areas: one containing a few hypothetical archeological sites, the other containing more sites. Impact on site population would be greater in the first example because the sites comprise 100 percent of that type site known in region, while in the second instance other sites lie outside the hypothetical impact zone.)



KNOWN CHACOAN ROADS AND OUTLIER TOWN SITES

Map X-4

1300). It was in this era that the Anasazi achieved their greatest social, economic, and architectural success ("Man's History in the Basin" section).

Sites recorded include 3,200 Pueblo II sites, 2,322 Pueblo III sites, and 667 sites distinguished only as Pueblo II-Pueblo III. Seventy-six Chacoan town sites have been identified. A network of prehistoric roads appears to have linked the towns (Map X-4). Based on the incomplete studies to date, some scholars speculate that the Chacoan society may have controlled not only potential agricultural lands, but also the Chuska range of mountains with their potentials of game, water, and wild plant food, and probably the Zuni Mountains and Chacra Mesa, as well. Indirectly it may have controlled the Pajarito Plateau and parts of the Rio Grande Valley.

Because of the obvious agricultural emphasis and the apparent dispersal of goods within the San Juan Basin and possibly outside the basin, specialists consider as critical the need to identify the sites' relationship to environmental or resource zones.

Archeologists who reviewed the data base suggested, concerning the significant Pueblo II-Pueblo III period, that in view of the marginal and unstable environment, mechanisms used to maintain agriculture (once it was developed) must be defined. Needing study are (a) attempts at intensification of horticulture, (b) structured exchange and trade among horticulturalists and between horticulturalists and foragers, and (c) the social mechanisms used to diversify susceptibility to risk.

If the "Chacoan Phenomenon" is to be understood, elements of the Chacoan system must be identified within very narrow frames of time. Pueblo II-Pueblo III sites are poorly dated. Whether all outlying towns were occupied at the same time is unknown. How they differed from one another, how they functioned in the overall system, what their relation to Chaco Canyon was, and what their internal structure was--these questions cannot be answered until accurate chronological controls have been established and until functional types of sites are identified and correlated with specific environmental factors.

Other archeological research areas considered important to understanding of the period include: labor investment in agricultural intensification, in communication and storage, and in construction and maintenance of public architecture; craft specialization; task specialization; stratification within and between communities; trade and/or movement of goods within the basin and between the basin and other regions; and access to resources not available within the region, such as game.

"Extremely significant" sites would include those with the potential to provide archeometric dates; all "Chacoan towns;" all sites identified as being complete or undisturbed by either human or environmental factors; and sites in those environmental zones in which non-Chacoan sites occur.

Late Prehistoric, Historic Sites. The exodus from the San Juan Basin during the 14th century is reflected by a scarcity of sites located thus far for the period. Only 79 archeological sites in the data base date from the years of transition from Pueblo III to Pueblo IV. Even fewer, 44, are

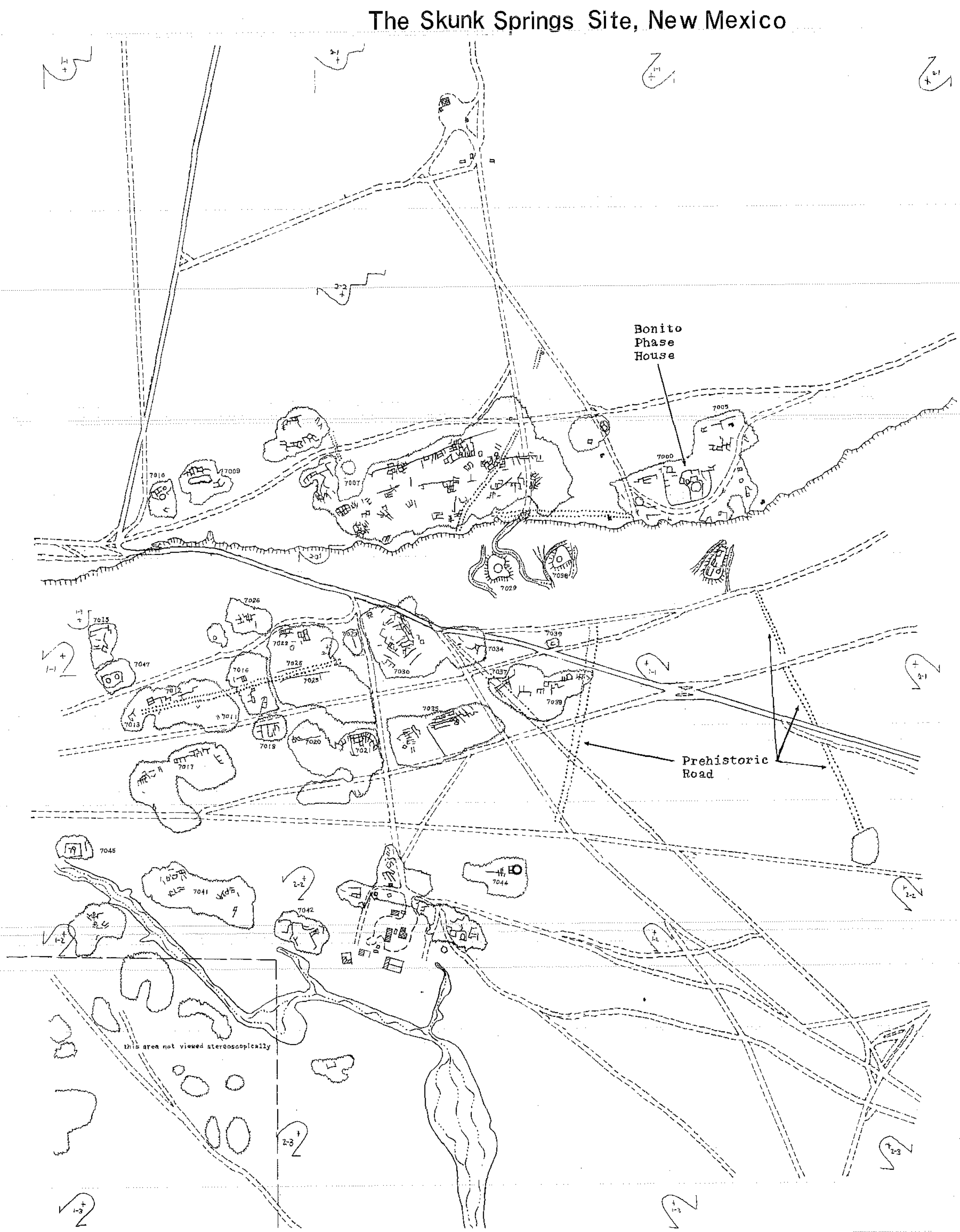


Figure X-4.--Plan of Skunk Springs, a large Chacoan outlier community near Newcomb, N.M. Produced by the National Park Service remote sensing division, it shows the Bonito Phase "Great House" surrounded by associated roomblocks. Two prehistoric roads appear just south of the "Great House." Other roads are modern dirt roads and vehicle tracts. (National Park Service, 1979, No. 50)

Figure X-5.--Acoma Pueblo, known as "Sky City" due to its mesa-top setting

traced to the Pueblo IV period proper (A.D. 1300-A.D. 1400). All but a few are in the southeastern part of the basin or in Zuni borderlands. The arrival of Europeans in the 16th century cut short a cultural resurgence among the Pueblo groups, and disease and warfare greatly reduced the Puebloan population by 1700, leaving them in the areas their reservations occupy today.

Few sites have been found from the early Navajo days in the basin prior to 1868, when the tribe signed a peace treaty with the U.S. Government. Most such sites are in the northeast parts of the basin and near Mount Taylor to the south.

Also rare are early evidences of Utes and Jicarilla Apaches. The basin contains a number of sites important to the heritage of the modern Pueblo people, the most numerous being associated with the pueblos of Acoma and Laguna on the southeast edge of the basin.

Late Pueblo sites that would be considered significant would provide tighter chronological control and information on: 1) the causes of the cultural instability and migrations; 2) how the Puebloans responded to their changing environment; 3) Puebloan interaction with Europeans and acculturative processes; 4) inter-Pueblo cooperation as an adaptation to environmental stresses; 5) population shifts and their relation to social and environmental pressures; 6) and the linkage of 20th century Puebloan groups with their ancestral homelands.

Important questions about Navajo origins exist. Early history (16th and 17th centuries) is known mostly through historical documentation, and few sites have been found. Social and economic patterns of the 15th and

16th century peoples in the basin are unknown, and any site from this period is considered extremely significant. Social and economic patterns in the 17th, 18th, and 19th centuries are also poorly understood.

Among archeological subjects considered critical to interpretation of the protohistoric and historic periods in the basin are origins of Navajo-Apachean occupation, amalgamation of Pueblo cultural elements into Navajo culture, war and peace, epidemic history, the effects of conquest, effects of foreign rule, settlement patterns and mobility, identification of socio-political units, activity areas, sex roles, effects of vehicular transport, development of art styles, intercultural relations, and comparison with prehistoric remains. Of particular importance in the San Juan Basin is comparison of historic period occupation with the Chaco phenomenon on the same terrain.

Significant sites would include those that might provide information on these subjects, all "early" (pre-1868) evidence of human occupation or activity which has the potential for yielding archeometric dates, all pre-1900 archeological sites, and all modern Navajo or other historic sites complementing or verifying ethnographic and historic accounts.

Site Density

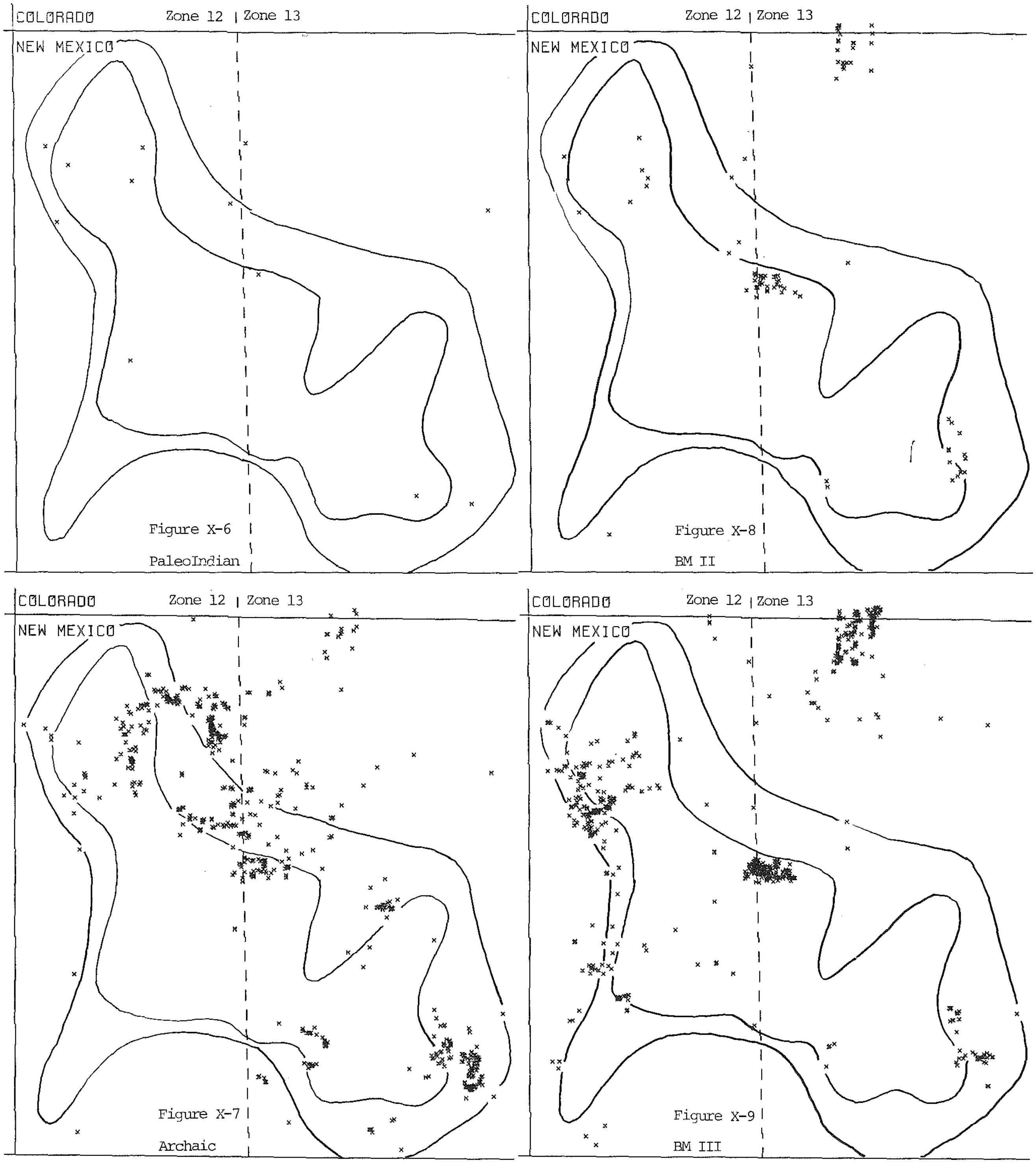
To predict the density of archeological sites in the basin, the information available from the site data base and environmental maps derived from remote sensing was combined with that from field checks and maps showing surface geology, precipitation, soils, and vegetation. Of approximately 140 cover-type zones defined in the basin, 21 had been surveyed sufficiently for archeological sites to warrant projections. The data base revealed 3,343 sites on these 201,666 acres. These selected zones typified approximately 20 percent of the total area of the New Mexico part of the San Juan Basin in their various covers and types.

The site concentrations predicted for the basin ranged from more than .1 site per hectare (2.47 acres) downward. While lack of information precluded estimating site densities for all areas, the planned uranium development area clearly is an area of extremely high expected archeological site density. Map X-5 (in pocket) illustrates expected densities for various areas. More detailed information for specific types of cover is possessed by the National Park Service and may prove useful in future environmental studies and planning in the basin. (For estimated number of sites in basin, see "Forecast of Uranium Development Impacts.")

IMPACT OF URANIUM DEVELOPMENT

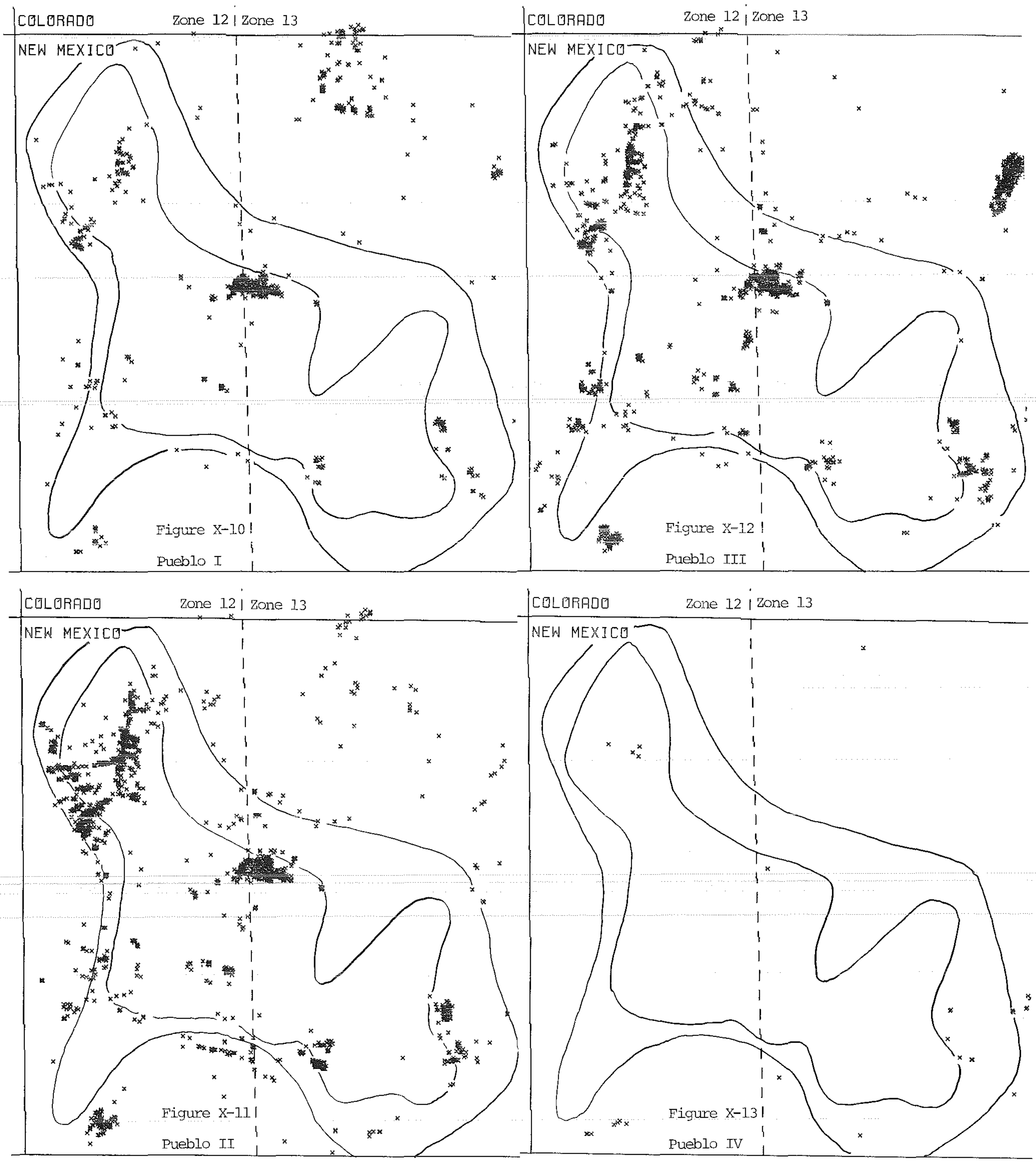
Introduction

Potential uranium development impact areas and their relation to known cultural resources are illustrated in Figures X-6 through X-21. In these figures, the known distributions of archeological sites in the San Juan Basin from different time periods are plotted against the outlines of expected primary and secondary impact zones (Chapter II). The outer line in each figure shows the expected limit of uranium exploration up to 2000.



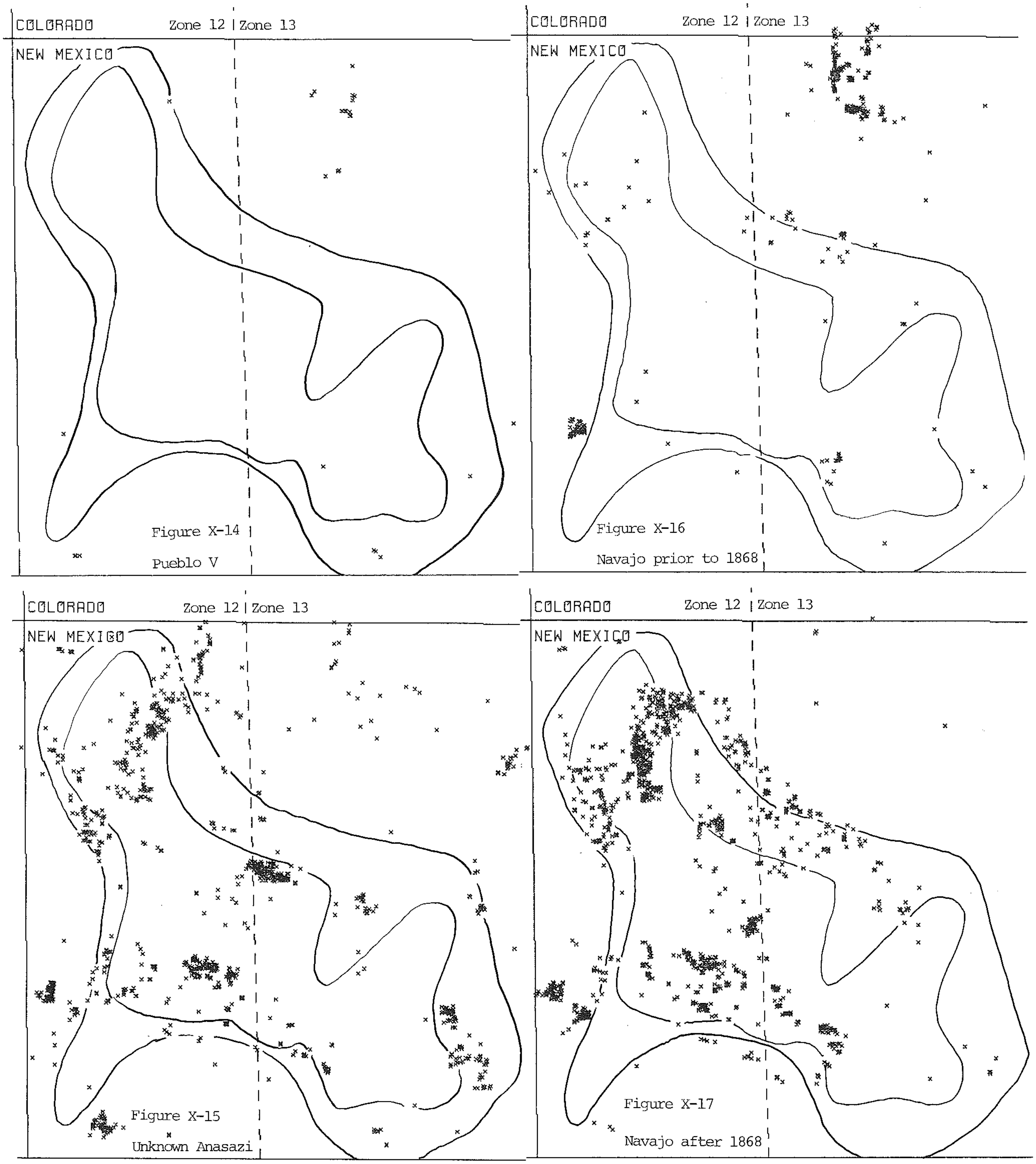
Potential Uranium Development Impact Areas
and Their Relation To Known Cultural Resources

Figures X-6 through X-9



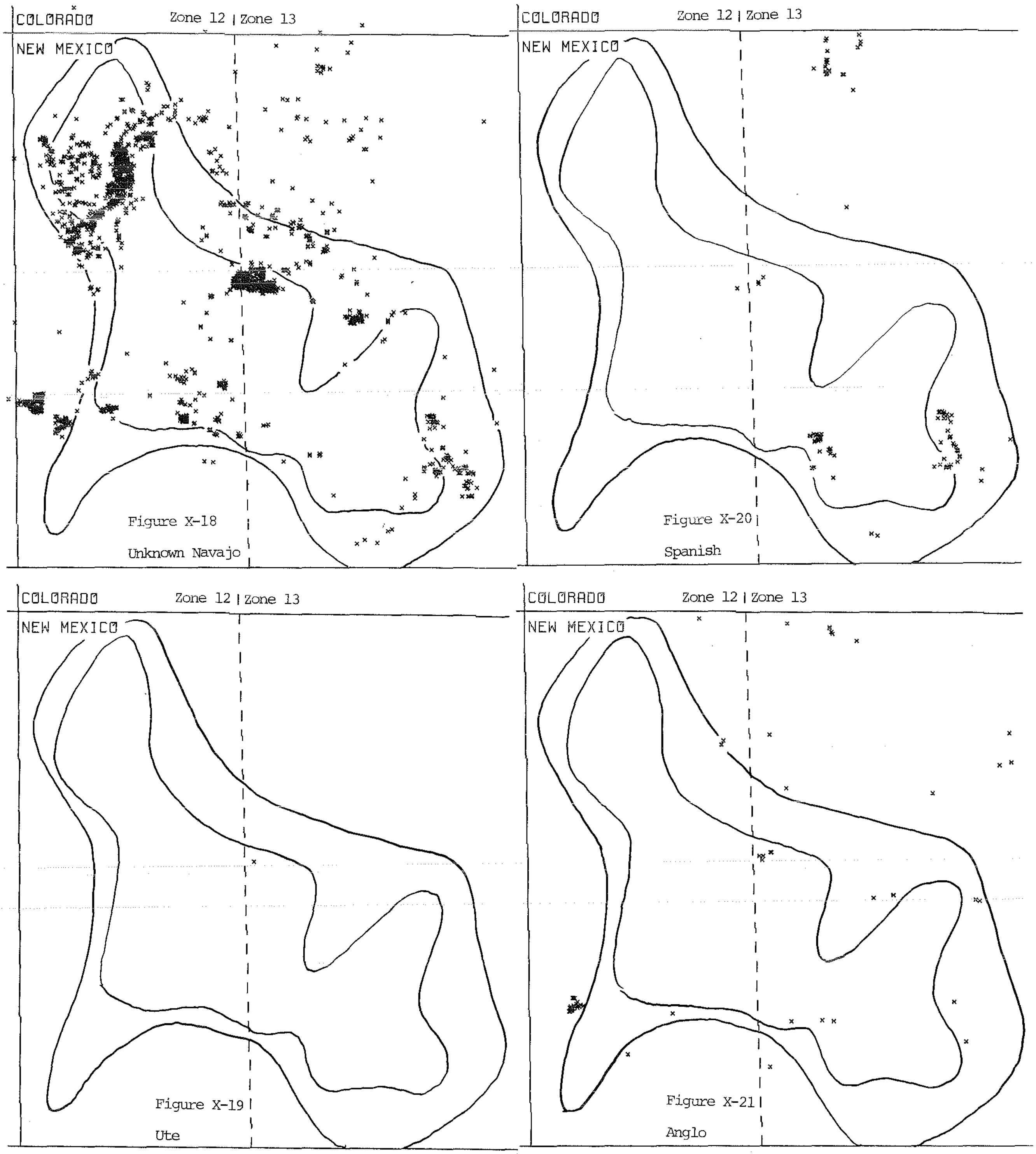
Potential Uranium Development Impact Areas
and their Relation To Known Cultural Resources

Figures X-10 through X-13



Potential Uranium Development Impact Areas
and Their Relation To Known Cultural Resources

Figures X-14 through X-17



Potential Uranium Development Impact Areas
and Their Relation To Known Cultural Resources

Figures X-18 through X-21

The inner line shows the expected area of active uranium exploitation in 1995, when uranium mining could peak. Reference to Table X-1 may be helpful in viewing the figures. It should be reiterated that the site data shown in these figures have been derived from an archeological survey coverage of less than 6 percent of the basin's land area.

In each case, the known distribution of prehistoric remains generally corresponds to expected uranium development areas. This is because the areas of known potential energy resources have been most intensively surveyed and the uranium development areas, in a broad sense, pivot around the center of the "Chacoan Phenomenon"--Chaco Canyon.

Based on the number of known sites representing each time period, the Anasazi remains appear to be the most threatened by possible uranium development. The data base distribution maps (which are subject to sampling error) indicate that many of the unknown Archaic and more recent Navajo sites border the uranium area. Early Navajo sites lie mostly outside the expected uranium development area.

Uranium Activity Impacts

In uranium development, direct impacts on cultural resources can result from these aspects: exploration, ore body definition, or development drilling, and mining. (For description of the technology used in locating, mining, and milling uranium in the San Juan Basin region, see Chapter III.)

Exploration. As discussed below, damage from exploration can range from negligible to total. Outputs of exploration activity which can result in these varying impacts include roads, vehicle tracks and ruts, erosion from drill rig transport and operation, and the force and weight of a vehicle contacting a structural feature such as a ruin wall or stone shrine.

Before an exploratory drill rig can be positioned for work, the drill site sometimes, though not invariably, is bladed level. Mud pits are excavated, and a trash pit dug. The earth displacement involved can damage or destroy any archeological sites in the work area, depending on the surface disturbance required at individual locations. While blading is normally shallow, most archeological sites in the basin occur on or immediately under the surface. The mud pits can range up to 20 feet long, 10 feet wide, and 7 feet deep. Their excavation can seriously damage buried remnants such as pithouses, kivas, or stratified middens or refuse heaps. The smaller trash pits can produce a similar, but slighter, impact.

Actual drilling generally causes little impact because any archeological site in the immediate proximity is likely to have been damaged by the site preparation. This also is true of the liquid sludge flow from the drilling process.

Negative impact to aesthetically important sites is minimal with exploratory drilling, which usually does not last more than 48 hours.

Ore Body Definition. Activities in ore body definition produce essentially the same types of impacts as those described for exploration.

However, because of the density of drilling over a wide area (for example, every 200 feet in a grid covering one to four square miles) the intensity of impacts is greatly increased and may completely erase cultural resources in the work area. Earth displacement will be the primary cause of damage. On the other hand, archeological surveys associated with intensive drilling result in greater knowledge of local prehistory and history.

Mining. Mining activities, while affecting less land, are more effective in obliterating sites. Though blading and preparation of the mine site will partly or completely destroy cultural resources in the area, mine site clearing should have less overall impact than exploration or ore body definition on the cultural resources. This is because mine sites are relatively few in number and small in size (Chapter II). It should also be recognized, as indicated under "Sites with Research Significance," that some types of sites are more expendable than others by virtue of being more plentiful. Scarcity makes for value.

Individually, land changes associated with major paved roads and wide rights-of-way would have greater impact than those associated with unimproved roads. However, earth displacement connected with the building of many unimproved roads would most likely have the greatest total impact on cultural resources, since the greater the area affected, the more likely it is that cultural resources would be impacted.

Impacts could be expected from earth displacement for borrow pits and from movement of equipment. The degree of impact would vary with weight, number, and types of vehicles, the degree to which cultural resources are exposed on the surface, and the fragility of the cultural resources. Surface lithic scatters of the Archaic period can be destroyed by single vehicles. Damage will usually be less to a small Pueblo II masonry ruin.

Once the site was prepared, sinking the shaft would have few impacts on resources, since any in the path of the shaft would have been destroyed during clearing. Blasting, however, could weaken and damage nearby structures. Streams created by water from mines might alter archeological sites at a considerable distance from mining activities by producing new channels and cutting deeper arroyo banks. Upon abandonment of a mine site, subsidence could damage resources--especially standing remnants--above the mine area. Milling would have approximately the same impacts as shaft mining.

Indirect Impacts

The impacts of actual mining activities could be small compared to the impacts of human population pressure. Road grading and uranium mine site preparation are generally preceded by archeological investigations and recommendations (at least on state and federal property). There are no currently effective controls against "people pressure." Projected population growth and expansion of housing, utilities, roads, and public facilities, discussed elsewhere, will lead to increased public awareness of the location of archeological remains and to impacts from looting and off-road vehicular traffic.

Table X-4

Projection of Cultural Sites
Directly Impacted by Uranium Development

	Exploration		Mining Activity			Milling Activity			
	Number of Sites	Number of Acres	Number of Mines	Number of Sites	Number of Acres	Number of Mills	Number of Sites	Number of Acres	Total Sites Affected
Moderate Development:									
1990	168	7,670	48	74	3,360	11	70	3,190	312
2000	248	11,315	72	110	5,040	15	95	4,350	453
High Development:									
1990	273	12,480	80	123	5,600	16	102	4,640	498
2000	362	16,515	105	161	7,350	22	139	6,380	662

Source: National Park Service, 1979, No. 50.

Forecast of Uranium Development Impacts

The greatest impacts on cultural resources related to projected uranium development, as noted previously, would come from the growth in population and "people pressure." For all municipal areas except Farmington-Kirtland to the north, approximately 66,500 sites are estimated to lie in potentially high impact growth areas. Those two towns were omitted due to an intermingling of expansion areas, making it difficult to separate sites affected. Because of the uncertainties involved, projections of possible site damage from growth are difficult. Information for site-specific purposes is available in the National Park Service study.

The number of sites that can be expected to be affected directly by projected uranium development is shown in Table X-4.

The estimated total number of sites in the New Mexico part of the San Juan Basin, based on expected density projections, is in the vicinity of 280,000. This figure could change as more becomes known about human life in the basin's past.

MITIGATION OF IMPACTS

Significant archeological sites that lie within the path of proposed uranium development activities are not always lost. Federal, state, and tribal regulations often call for either protection from adverse effects or mitigation of damage.

Protection is often accomplished through simple avoidance. If an action must take place close enough to threaten a site, temporary fencing might be erected or archeologists might accompany the work crews. If avoid-

ance is impossible, a mitigation program is initiated whereby all archeological information is recovered from the site, or in the case of large areas from a reasonable portion of the sites to be impacted. Mitigation actions are recommended by a participating archeologist and are subject to review and approval by the federal agency involved, the State Historic Preservation Officer, the Advisory Council for Historic Preservation and the Keeper of the National Register of Historic Places.

The degree and effectiveness of existing preservation mechanisms and efforts to mitigate adverse impacts on cultural resources is variable and to an extent dependent upon land ownership and control. The Bureau of Land Management, the Bureau of Indian Affairs, the National Park Service, and the U.S. Forest Service all have active management programs to ensure that land-modifying actions comply with applicable federal, state, and tribal historic preservation legislation. However, it must be recognized that each of these federal programs is designed to meet an agency's specific responsibilities.

The long term physical preservation of a site is more likely if it is located within a National Park Service area. The State of New Mexico is currently expanding its preservation program, and additional controls are expected for state lands. The Navajo and Zuni Tribes have existing cultural resource management programs which are rapidly expanding to meet the threat of destruction of their cultural heritage.

Sites on privately owned lands have no legal protection unless a land--modification activity is under federal control or sponsorship. Thus, the physical existence of these sites is totally dependent upon the concern of the land owner and the independent efforts of private development.

Two major problem areas with all current mitigation programs are imbalance in mitigative measures from project to project and lack of control over individual depredation after compliance responsibilities have been met. All uranium development sponsors working on federally controlled lands or through federally licensed or funded programs are required to inventory the cultural resources of these lands. In small projects where sites cannot be avoided, all archeological material often is excavated or sampled by archeologists. This often constitutes 100 percent recovery of information. On large projects where avoidance cannot be achieved, sample sites are selected on the basis of resource and research goals. The sample can be as low as 10 to 20 percent of the known sites. The remaining 70 to 80 percent of the resource is in effect "written off."

In effect, land managers and archeologists thus face a moral dilemma. Sites which could yield information and/or artifacts useful to many goals listed earlier are being turned under. Realistically, archeologists are not able to excavate them all because of high costs.

It has been demonstrated, however, that there is such a thing as a redundancy of information; that a small sample of sites can and does provide as much information as a large sample. The problem, then, does not lie in sampling but in current methods of choosing the samples.

RECOMMENDATIONS

Some options by which the direct and indirect impacts of uranium development on cultural resources in the San Juan Basin could be further reduced are presented here.

Centralized Data Bank. If the cultural resources of the San Juan Basin are to be effectively protected and managed in the coming years, a greater reliance will have to be placed on computerized data-base systems. Planners, researchers, and managers must have access to large amounts of current archeological data if they are to make informed decisions.

Computer systems provide the only efficient way to store and retrieve the huge amounts of data that have been gathered. There should be at least one central data bank and several specialized systems. The SJBRUS archeological data base, developed for the project by the National Park Service, is the one currently existing computerized, central archeological data bank. This information should form the base for a continuing, updated joint agency effort to monitor the location and identification of cultural resources in the basin.

Coordination. The establishment of a central coordinator for basin archeological research might help achieve purposes outlined in these pages. This coordinator would essentially be a management consultant. Powers of the office would derive from cooperative agreements among governmental agencies, tribes, energy companies, municipalities, and other involved entities. As envisioned, the coordinator would serve as a central clearinghouse for archeological purposes.

Management of the Chacoan System. A plan to protect and preserve the Chacoan system should be implemented as soon as possible. This would probably require the active cooperation of a number of federal, state, and tribal agencies. The plan should provide two basic elements as a minimum:

(1) A representative sample of Chacoan sites should be set aside for long-term preservation and fully protected from vandalism, land-modifying actions, and destructive forms of archeological research (e.g., excavation, extensive collection).

(2) Archeological research on other Chacoan ruins should be closely coordinated and regulated. Projected research activities should be subject to careful peer review and comment.

It should be stressed that proper management of the Chacoan prehistoric system will necessitate a better understanding of the resources. We know very little about this complex ruin system at present.

Meetings between Industry and Archeologists. It would be extremely useful if a forum could be developed, perhaps bi-annually, where uranium industry representatives could meet with representatives of the archeological community to discuss mutual problems in the realm of historic preservation. Greater cooperation and understanding between energy developers and archeologists could result.

Increased Emphasis on Reducing Vandalism. A major long-term effort should be made to inhibit "pot-hunting" in the basin. This might include:

(1) Increased emphasis on the enforcement of relevant federal, state, and tribal antiquities legislation; (2) Enlistment of public support for historic preservation through the public media and government publications; and (3) Protection of key cultural resources by means of restricted access, fencing, controlled visitation, posting, etc.

Remote Sensing. Remote sensing could be used periodically to monitor impacts of uranium development on cultural resources. Remote sensing provides a cost effective method of assessing impacts on huge tracts of land. Satellite imagery could be used in general assessments; larger scale imagery could be used for specific tracts of land to supply more detailed and specific assessments. Remote sensing is also a beneficial and non-destructive research tool in archeology, and its increased use in the basin is to be recommended wherever appropriate.

Ethnohistory. The uranium industry and other sponsors of land-modifying actions should make increasing use of ethnologists or ethnohistorians to identify sites of religious or cultural importance to Native Americans. Project sponsors should consult with local leaders as to any sites that require special consideration.

High Archeological Report Standards. Professional archeologists operating in the basin during the next 20 years should maintain high investigative and reporting standards. Archeologists must actively work toward the acquisition of comparable data and the timely and widespread dissemination of research results.

PART 4

CONTROLLING URANIUM-INDUCED CHANGE

CHAPTER XI

JURISDICTIONAL AND LAND OWNERSHIP CONSTRAINTS

Chapter XI

JURISDICTIONAL AND LAND OWNERSHIP CONSTRAINTS

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Chapter XI

A Note to Readers

Chapter XI falls into a special category in this report because of the legal complexities with which it deals. This is especially true of the checkerboard area. Therefore, the draft copy was reviewed as to federal law applicable to the San Juan Basin and to yellowcake production by the Office of the Field Solicitor, Bureau of Indian Affairs. Language on these aspects has been revised to meet the suggestions from that office.

The law cited as applicable to the basin, as well as the legal principles which are applicable to the basin, apply only to the New Mexico portion of the overall San Juan Basin region as set out in Chapter I.

This basin and the state of New Mexico have a unique legal history. Hence, the law discussed may not be applicable in whole or in part to other regions, states, or Indian tribes in the United States. Conversely, other law affecting federal-state-tribal-private relationships applicable in the non-basin part of a county may not be applicable within the study area.

While the chapter cites correct legal opinions, in the study team's judgment, it should be looked upon as simply an overview of the problem. It reflects the federal perspective and federal law; differences in legal opinions exist on some issues, including questions concerning federal, state, and Indian jurisdiction. Solutions to individual legal problems should be as ascertained by competent legal counsel.

Chapter XI

Jurisdictional and Land Ownership Constraints

INTRODUCTION

"From a government jurisdiction standpoint," says a recent academic study of the Four Corners area, "the region may be the most complex in the country." At the heart of this complexity cited by Resources for the Future (1977) are the confused land ownership patterns.

The most complex part of the four states, without question, is the checkerboard area which sprawls across the path of expanding uranium development. This hodgepodge of federal, Indian, state, and private lands forms a jurisdictional no-man's land between the Navajo reservation and the rest of New Mexico to the east and south (Map XI-1).

Through more than six decades of New Mexico statehood, the area has posed difficult problems in the realms of law enforcement, taxation, highway construction, education, public assistance, and other aspects of governmental responsibility.

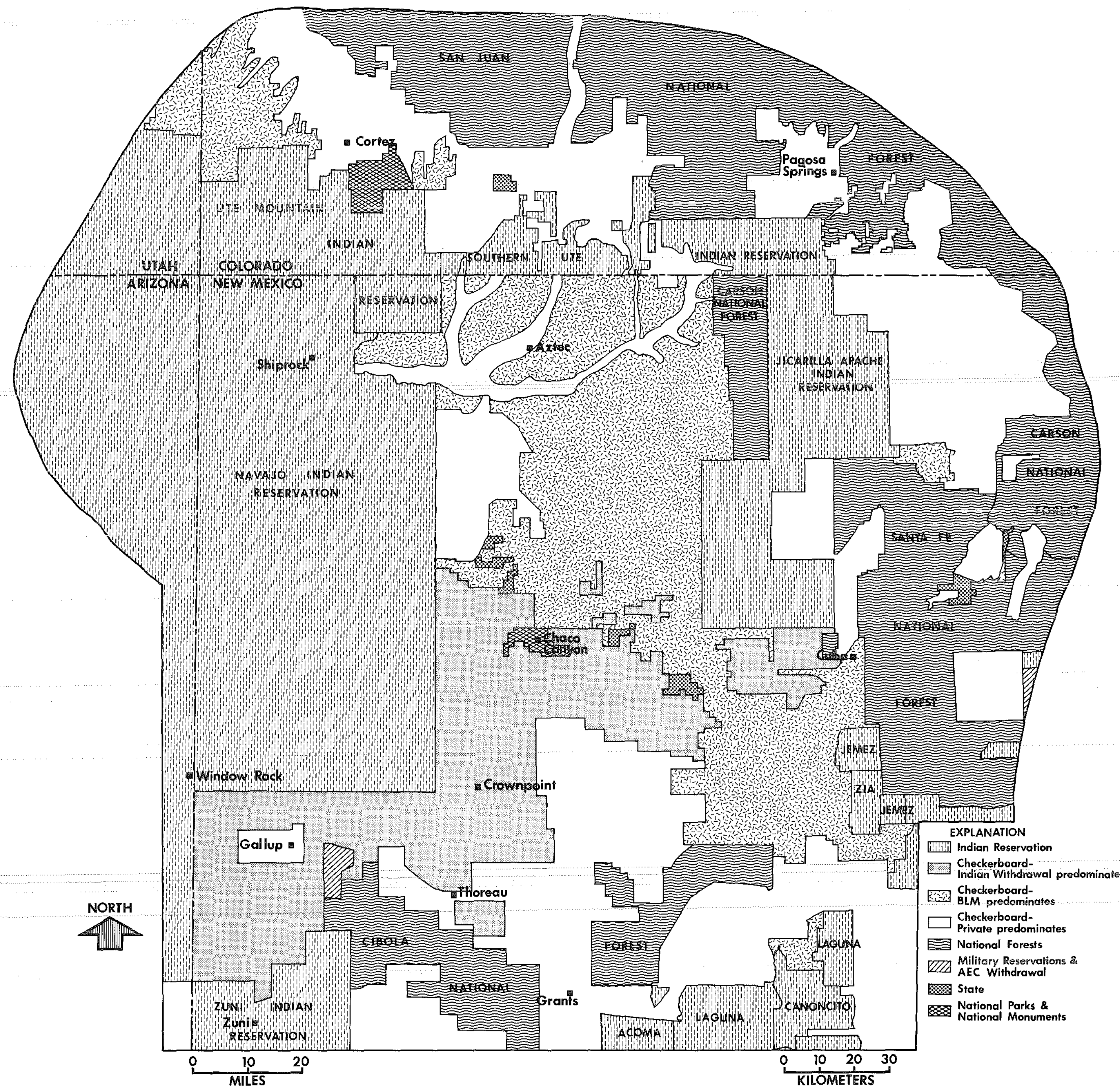
Indians own almost half of the region, the federal government another 30 percent (Table XI-1). This circumstance alone has dictated many of the terms for settlement and political and economic development during the 20th century. In addition, surface and subsurface mineral rights and ownerships are scrambled within townships, creating a web of overlapping and undefined jurisdictions and property rights. For example, while Indian and federal lands account for more than three-quarters of regional surface ownership, they account for only one-half of subsurface ownership. This set of conditions reaches its peak in New Mexico's checkerboard area.

All in all, the land status of the San Juan Basin in New Mexico affects all meaningful human activities and often proves decisive in the location of towns, mineral development, and water rights, jurisdictional, judicial, and regulatory matters.

LAND CATEGORIES

Land categories in the San Juan Basin are so interwoven by location and surface-subsurface complexities that they often are inextricable. From the legal or jurisdictional standpoint, however, there are five basic categories of ownership:

1) Federal Lands. These are nearly all administered by the Bureau of Land Management and U.S. Forest Service, with a smaller acreage under the National Park Service. There are lands owned



LAND STATUS MAP

Map XI-1

Table XI-1

Ownership in San Juan Basin Region

Ownership Category	Acreage*	Percentage Of Total Acreage
Private	3,735,323	21%
State	460,560	3%
Federal	5,220,814	30%
Indian	8,198,494	46%
Total	17,624,191	100%

*Totals may not add due to rounding.

Source: Maynard, 1978, No. 29.

by other federal agencies such as the Department of Defense, Department of Energy, Bureau of Indian Affairs, and U.S. Public Health Service, but they are too small to play a significant role.

2) Indian Lands. These include reservations, allotments, and Pueblo land grants.

3) Private Lands.

4) Spanish Land Grants other than Pueblo Grants.

5) State Lands.

In Table XI-2, federal lands are broken into their three major administrative categories, while private lands are combined with Spanish land grants.

Federal Lands

Federally owned land or estates in land acquired from another sovereign nation are termed "public lands." "Public domain" is a historical term for "public lands." In this category are the majority of the lands administered by the BLM and Forest Service and of the subsurface estate of lands patented under the Stock-Raising Homestead Act of 1916. The source of public land in the basin is ungranted land acquired from Mexico by the signing of the Treaty of Guadalupe Hidalgo in 1848.

Public lands may be reserved for specific purposes, e.g., forest reserves created by the Organic Act of 1897, 16 USC §475; or they may be withdrawn from certain types of uses or entry, e.g., lands withdrawn from entry under the Mining Law of 1872. Public lands are distinguished from acquired federal lands which the United States Government obtained in its capacity as a property owner or money lender, by purchase, condemnation, foreclosure, or other means.

Table XI-2

Land Status - San Juan Basin Regional Uranium Study

Acreage Recapitulation
Estimated*

State (region)	County	Indian Acreage	Indian %	B.L.M. Acreage	B.L.M. %	Forest Service Acreage	Forest Service %	National Park Acreage	National Park %	State Acreage	State %	Private Acreage	Private %	Total Acreage	Summary - Federal Acreage	Summary - Federal Percent
UT	San Juan [1]	265,960	86	23,680	7	0	0	440	1	5,760	2	11,360	4	307,200	24,120	8
AZ	Apache [1]	1,164,160	100	0	0	0	0	0	0	0	0	0	0	1,164,160	0	0
CO	Montezuma	434,624	33	179,460	13	243,309	18	51,632	4	11,890	1	412,973	31	1,333,888	474,401	36
	La Plata	203,013	19	29,344	3	393,567	36	0	0	16,380	1	447,068	41	1,089,372	422,911	39
	Archuleta	128,655	15	11,984	1	401,078	47	0	0	3,560	1	305,749	36	851,026	413,062	49
	Totals	766,292	23	220,788	7	1,037,954	32	51,632	1	31,830	1	1,165,790	36	3,274,286	1,310,374	40
NM	San Juan	2,272,448	64	855,093	24	0	0	11,880	1	126,080	4	264,739	7	3,530,240	866,973	25
	McKinley	2,330,065	66	266,262	7	211,345	6	21,318	1	166,210	5	514,755	15	3,509,955	498,925	14
	Rio Arriba [1]	646,948	23	474,355	17	940,420	33	0	0	26,040,	1	746,837	26	2,834,600	1,414,775	50
	Sandoval [1]	339,168	20	489,432	29	250,000	15	0	0	61,120	3	570,280	33	1,710,000	739,432	43
	Valencia [1]	320,625	29	43,040	4	318,375	29	960	1	36,480	3	371,770	34	1,091,250	362,375	33
	Bernalillo [1]	101,828	50	3,840	2	0	0	0	0	7,040	4	89,792	44	202,500	3,840	2
	Totals	6,011,082	47	2,132,022	16	1,720,140	13	34,158	1	422,970	3	2,558,173	20	12,878,545	3,886,320	30
San Juan Basin Regional Totals		8,198,494	46	2,376,490	13	2,758,094	16	86,230	1	460,560	3	3,735,323	21	17,624,191	5,220,814	30

Indian plus Federal = 76% of Total Area   New Mexico = 73% of Total Area

[1] Partial counties in study area.

*The acreage compilations are predicted upon comparing published acreage reports and records inspection, adjusted for time differences in reports, and known unrecorded ownership changes. The source material was researched in County Assessor records, BLM publications "Public Land Facts, FY 1977, BIA publication "Annual Report of Indian Land, June 30, 1975", Navajo Area Office, Real Property Management 1977 Annual Report, and Forest Service, Durango, Colorado, for Colorado forest service acreage. The statistical records were kept for various purposes and in some instances had not been updated since 1972, thus the data was compiled in different years from 1972 to 1977 which necessitated adjustments and interpolation. The partial counties and much of the respective ownerships were scaled and the included acreages were calculated.

<u>Source</u>: Maynard, 1978, No. 29.

The major sources of acquired federal land in the basin are: "reacquired railroad lands" resulting from government exchanges of its alternate sections for those granted to the railroads in order for both the railroad land offices and the federal government to have separate manageable tracts of land, and "submarginal lands" which the Department of Agriculture obtained as a consequence of agricultural bankruptcy in the 1930's.

The surface estate on acquired federal land managed by the BLM and Forest Service is generally administered in the same manner as public land. The subsurface estates of these two land types are administered differently. Disposition of the locatable mineral rights is governed by the Mining Law of 1872 on public lands and by various leasing statutes on acquired federal lands. Leasable minerals such as coal, oil, and gas are covered by various other statutes. National Park Service lands are withdrawn public lands and are not subject to mineral entry in this region.

Indian Lands

Generally, Indian lands are trust or restricted trust lands; that is, lands or interests in land to which the United States holds legal title in trust for a given tribe or individual Indian, or lands owned by the various Pueblos on which the federal government has imposed a restriction against alienation. The trust or restricted status of Indian lands prevents many forms of taxation, alienation, or encumbrance from being imposed upon the tribe or individual Indian without the consent of the United States. Indian title to and occupancy of lands in the San Juan Basin have been derived from several different sources: treaties, executive orders, acts of Congress, allotments, homesteads and purchases, exchanges and conveyances.

Indian reservations are lands reserved by treaty, act of Congress, or executive order for the beneficial use of Indians. Legal title is held by the United States Government with beneficial title (right of use and occupancy) held by the Indians. The lands owned by the Pueblos in fee simple are restricted lands. The sources of these holdings were either lands granted by the Crown of Spain or other lands purchased in the Spanish and Mexican periods from grant holders. The use of the land and any interest therein (i.e., leaseholds, profits, and licenses) by non-Indians are subject to the approval of the Secretary of the Interior. The land is held by the tribe as a corporate body, and individual interests are not inheritable except in accordance with tribal law.

Although the power to establish beneficial Indian title is reserved to Congress, the Department of the Interior is not powerless to make changes in lands available to Indians. The chief mechanism is "withdrawals in aid of legislation." These are lands withdrawn from the public domain by order of the Department of the Interior for the use and benefit of Indians pending an act of Congress to permanently transfer beneficial title to the Indians. Some of these lands have been withdrawn since the end of the executive order period, i.e., 1919, without any congressional action. An example of withdrawn lands are the 230,000 plus acres described by Public Land Order 2198.

Allotments and Indian homestead lands must be considered within the context of the historical forces creating the "checkerboard area." The "checkerboarding" originated in the 1866 grant of alternate sections in a 40-mile right-of-way to the Atlantic and Pacific Railroad Company, forerunner of the Santa Fe Railway.

Navajos in the checkerboarded tracts saw little reason to lease or buy land they had used historically. The railroads, in turn, began conveying the lands to the Anglo ranchers who dispossessed the Navajos. The Commissioner of Indian Affairs and Department of the Interior responded to the growing problem (which continues today) and by executive order (E.O. 709 of 9/9/1907, E.O. 744 of 1/28/1908) extended the reservation eastward. These executive orders withdrew the land from non-Navajo entry and required that individual Navajos were to secure title to the public domain sections of the checkerboarded areas by application under §4 of the Dawes Act of 1887. This law originally provided for public domain allotments to Indians without a reservation.

Unlike many other tribes, the Navajo tribe not only may own land in fee simple but also may determine its use without federal restriction. The Act of April 19, 1950 (64 Stat. 46, 25 USC 635) provides that "Notwithstanding any other provision of law, land owned in fee simple by the Navajo Tribe may be leased, sold, or otherwise disposed of by the sole authority of the Navajo Tribal Council, in any manner that similar land in the State in which such land is situated may be leased, sold, or otherwise disposed of by private landowners, and such disposition shall create no liability on the part of the United States."

Even though the Navajo tribal fee simple lands, some 415,851 acres, are not subject to the federal supervision that attaches to other Indian trust or restricted lands, they would be managed by the Navajo tribal council in a fashion similar to that for their other lands and therefore have been included in this discussion as though they were trust or restricted Indian lands.

Private Lands

Private lands are those lands owned in fee simple absolute by a private person or corporation. In contrast to the other land types discussed here, private lands may be freely sold, exchanged, leased, mortgaged, etc., without the permission of a government. Private "lands" include surface and subsurface estates. In the San Juan Basin there are many instances in which the surface is "private" and the subsurface "public," or vice versa.

Private landowners are subject to applicable federal statutes and regulations and to the general civil and criminal laws of the state, county, and/or municipality in which they reside. Other than on Indian lands, users of non-private surface or subsurface estates are subject to the same laws. It should be noted that the state and local civil laws jurisdiction over private lands within the exterior boundaries of an Indian reservation is limited.

Spanish Land Grants

Spanish land grants, with the exception of Pueblo grants and grants acquired by Pueblos, have the same characteristics as the lands described under "Private Lands." Spanish land grants are those lands conveyed to individuals, communities, and Pueblos by Spanish and Mexican governments and confirmed by the United States in the Treaty of Guadalupe Hidalgo of 1848.

The major acts which enforced the Treaty of Guadalupe Hidalgo were the act to establish the offices of the Surveyor General of New Mexico, Kansas and Nebraska, enacted on July 22, 1854, and the act to establish a court of Private Claims in several states including New Mexico, enacted on March 3, 1891.

The 1854 act recognized the validity of the Spanish and Mexican land grants when proven. The United States disavowed any interest in such grants, because it did not have any vested interest in them.

The primary purpose of the 1891 act was to verify those land titles which were imperfect because of a lack of governmental action by Spain or Mexico at the time of the Treaty of Guadalupe Hidalgo (1848). Land titles which were perfect at the time of the treaty could be confirmed by the court at the owner's option. The Court of Private Land Claims only released any claim the United States had in the land. It did not decide the title of the grants as to any private person. Indian rights and interests in the grants or other lands were not adjudicated, determined, nor extinguished.

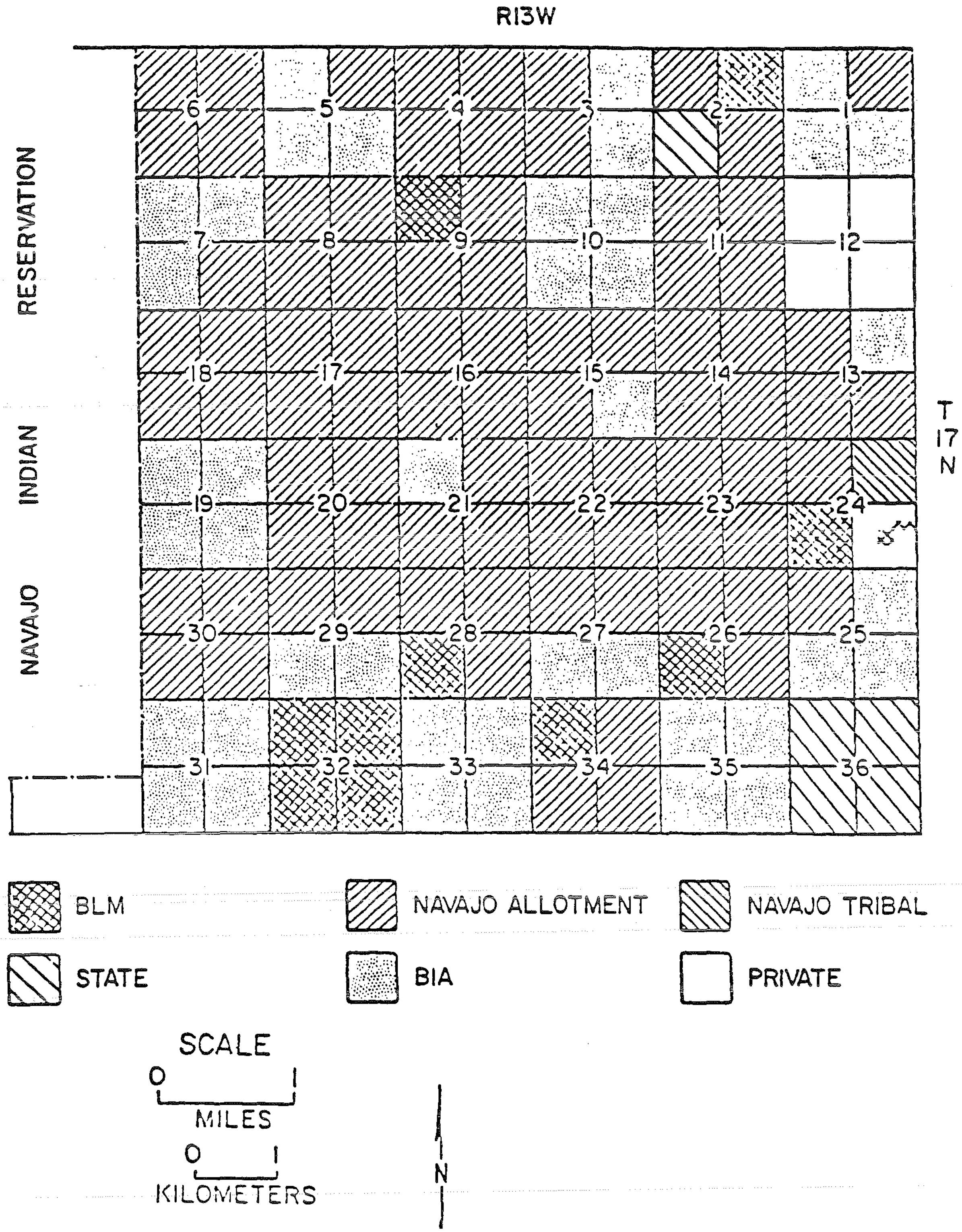
Both acts stipulated that common lands of the land granted were not public domain and therefore not open to entry under the homestead or mining laws. Spanish non-Indian grant lands are still typically held in common by the families named in the grant and their heirs. Conveyance requires community approval (NM Stat. Ann. 49-1-1 through 49-10-6).

State Lands

State lands are those lands granted to the state by the federal government for the benefit of public institutions, the majority of which are schools and universities. The Ferguson Act, 30 Stat. 484 (1898), granted two sections in every township to states and territories. The Enabling Act of June 20, 1910, provided for two additional sections of state land in every township. Land ownership in the township west of Crownpoint is shown in Figure XI-2.

SUBSURFACE OWNERSHIP AND MINERAL RIGHTS

Even after the question of surface ownership is resolved, the complexity of subsurface and minerals ownership remains. Often the surface and minerals are owned or leased by two different parties. Much of the following summary is excerpted from Bliss (1979, No. 42) and Maynard (1978, No. 29), where greater detail may be found.



Source: Tennessee Valley Authority, 1978.

Figure XI-2.--Land ownership in a typical township in the checkerboard area

Federal Lands

The General Mining Law of 1872 covers acquisition of the rights to mine uranium on public lands and various subsurface estates with minerals reserved. Uranium is a "locatable" mineral under this act, which describes procedures for discovery of a mineral deposit, staking of a claim, and patenting of the claims.

In practice, claims are staked and then exploration work begins. If a deposit of a "valuable mineral" is discovered, the land and mineral deposit may be patented to the person making the discovery. After discovery, the mineral operator has the right to remove and market the minerals. No royalties or rents need to be paid to the federal government.

In order to maintain a claim, the locator must mark the boundaries, do "discovery work" as detailed by state law, and expend at least $100 annually in labor or improvements--"assessment work"--with a total of $500 before applying for a patent. Under the Federal Land Policy Management Act of 1976 (FLPMA), claims must be recorded by the BLM.

Mineral claims constitute an interest in real property that may be sold, traded and inherited. It is estimated that several hundred thousand claims have been filed in the study area, including over-filing (one claim filed on top of another) in the highly mineralized areas. Validity of the many claims is unknown; any effort to validate all claims would take years under the BLM and U.S. Geological Survey procedures.

A program to determine the extent of the mineral claims that are an encumbrance against the U. S. mineral ownership will begin before long with expiration of a grace period provided in the FLPMA for filing the outstanding claims with the BLM. Procedures can then be implemented to inventory the recorded claims, and any unrecorded claims would not be a valid right.

On National Forest land, the 1872 law also applies; however, the Forest Service enforces additional regulations in the Code of Federal Regulations (CFR) which provide for surface protection (36 CFR 252). On acquired and some withdrawn lands, the 1872 Mining Act does not apply. With few exceptions in the region, mining companies must lease uranium rights on BLM acquired lands much as described below for Indian lands. Withdrawn lands in the basin have been withdrawn from mineral development.

Indian Lands

Mineral rights on Indian tribal trust lands are leased under the Mineral Leasing Act of May 11, 1938, 25 USC §396 a-g, and the regulations under 25 CFR 171. Tribal lands are controlled under 25 CFR 177 affecting Surface Exploration, Mining, and Reclamation of Lands. The unallotted lands within any Indian reservation or land owned by any tribe, Pueblo group or band of Indians under federal jurisdiction, with the approval of the Secretary of the Interior may be leased for mining purposes by authority of the tribal council or other authorized spokesman.

Three ingredients are necessary for tribal mineral development or alienation of the mineral estate: (a) a lease or permit, (b) approval by the tribal council, and (c) approval of the Secretary. All tribes in the study area are represented by a tribal council empowered to act in behalf of the tribe. Approval by the Secretary may be by an authorized representative.

The prospective mining entity must also conform to the requirements of 25 CFR 177, as it affects surface mining activities of every kind and description. The cited regulations are presently being amended by the Department of the Interior. (See 45 Fed. Reg. 53164 (1980).) New regulations should be promulgated early in 1981.

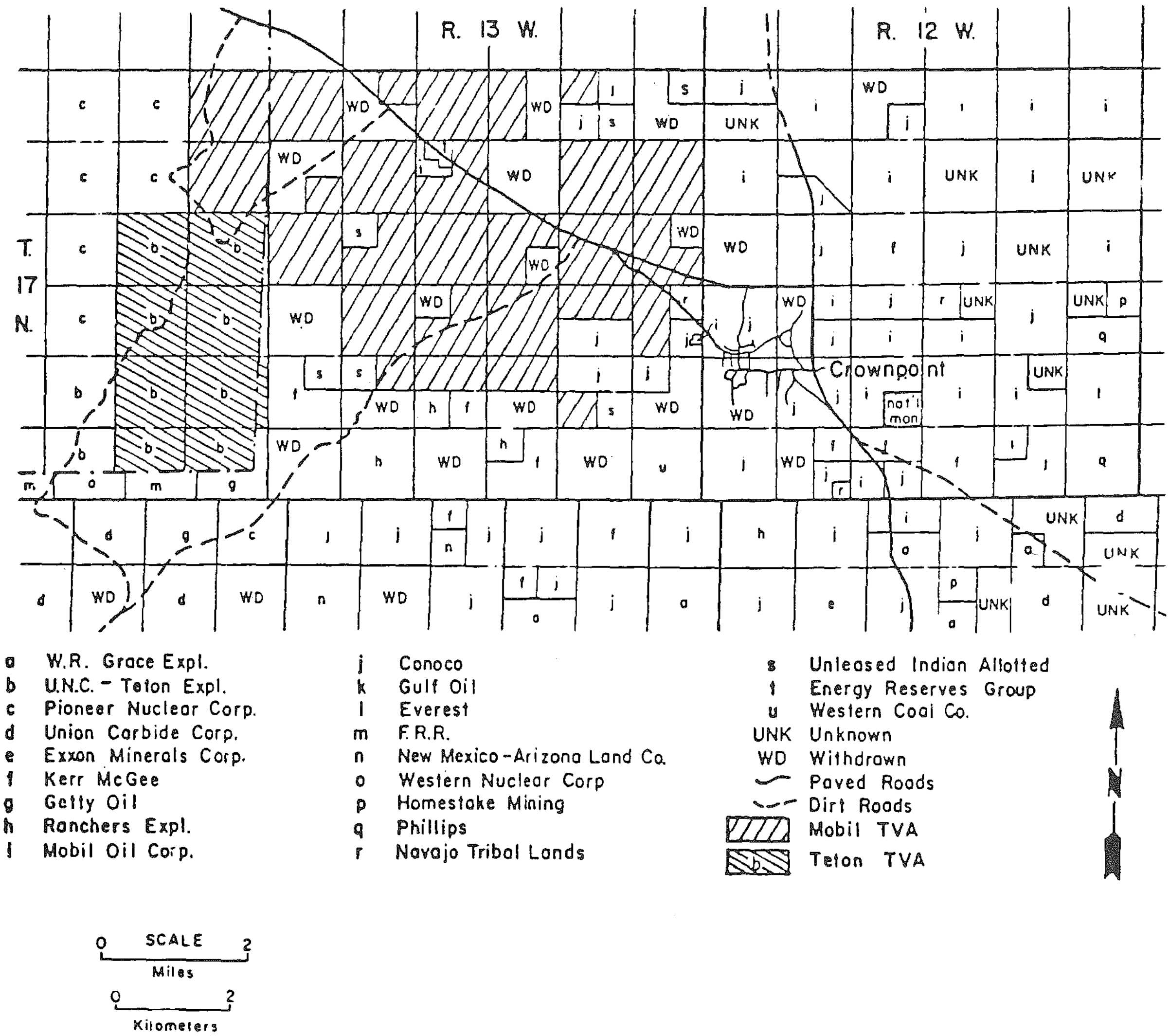
The leases are valid for terms not to exceed 10 years and so long thereafter as minerals are produced in paying quantities. There has been industry criticism of the shortness of the 10-year primary term. It is often insufficient time to bring an ore body to production and also be granted all necessary governmental approvals. Exclusive mineral prospecting permits with options to lease do extend the 10-year period.

There has been Indian criticism of the indefiniteness of this latter term as too long and inflexible in the face of changing economic conditions. Therefore, it is essential to provide terms which protect against inflation and future market changes. The mineral lease form currently in use by the BIA allows for royalty changes after five years, at the end of the primary term, and every 10 years thereafter.

The allotted or individual lands may be leased for mining purposes under the Act of March 3, 1909 (35 Stat. 783, 25 USC 396) and regulations in 25 CFR 172 and 25 CFR 177. The basic requirements applicable to tribal lands also apply to allotted land: (a) a lease or permit are the contractual form to acquire minerals; (b) the individual Indian or his heirs must execute; and (c) the Secretary must approve. While the legislation is not as explicit for allotted lands, the regulations supplement and extend additional requirements comparable to the tribal provisions. (Also see requirements of 25 CFR 177.)

Allotted lands present administrative complications following the death of the original allottee or any of the subsequent heirs. Complications in allotted land ownership, sometimes involving many heirs and possible fee co-owners, make the process of leasing or permitting the relatively small tracts much more time consuming and costly than under the single ownership represented by the larger tribal holdings. The complexities in leasing small parcels are indicated in Figure XI-3, where a multitude of leases cover three townships.

Similar laws and regulations exist for surface leases and permits which may be necessary for the proposed developments associated with uranium milling, commercial operations, residential, and related uses.



Source: Tennessee Valley Authority, 1978.

Figure XI-3.--Typical lease status in the checkerboard area

Private Lands

Separate mineral estates may be owned in fee simple in the same manner as land is owned. The mineral estate is usually included in the land title, but often it is separated from the surface estate by grant or reservation and can be conveyed independently.

The concentration of private lands in the basin extends generally westerly from Albuquerque to within a few miles of Gallup. The width is substantial north of Grants (Map XI-1). Much of the surface is privately owned with U.S. reserved minerals comprising a high percentage of the alternate sections. This is the primary location of present uranium mining and milling activity and has a high prospective value for future uranium production (Maps I-5 and I-6).

Spanish Land Grants to Non-Indians

Generally speaking, under Spanish law all mines were the property of the Crown. For ordinary land grants, as distinct from land grants for the extraction of minerals, only an interest in the non-mineral estate was conveyed. Some clarification of this principle is needed, however, in light of the Ordinance of the 22nd of May 1783, enacted by Spain.

This ordinance enabled any person to discover minerals and establish a mine on both grant lands and non-grant lands. The mine owner did not dispossess the grant owner of his land. The mine owner was, however, given the mine in property and possession which he could sell, rent, exchange, donate or pass by will. Therefore, the mine was considered a gift made by the king subject to conditions. A portion of the net proceeds had to be paid to the Crown.

Under the circumstances described above, the grant holder could mine on his own grant or establish the mine and alienate the grant and the mine together or separately. The minerals discussed in Spanish law or the succeeding Mexican law were gold, silver, copper, iron, and quick-silver (cinbar). Precious stones are mentioned.

Under the Treaty of Guadalupe Hidalgo, the United States took mineral rights which were recognized as Crown property by Spain and as Republic property by Mexico. All other minerals, such as stone, sand, gravel, and clay were considered part of the grant. The acts of 1854 and 1891 (cited under "Spanish Land Grants,") confirmed in the United States the metals described above. The other minerals mentioned above also were confirmed to the grant holder or owner. (For a brief detailed history of the Spanish and Mexican mining law, see the majority and dissent opinions in Castillero v. United States 2 Black (U.S.) 17, 17L. Ed. 360 (1862). Also see Law of Mines, Blachard and Weeks, 1877.)

Since uranium was not recognized or discovered in New Mexico as a mineral in 1848, 1854, or 1891, there is a serious legal question whether this mineral passed to the United States or passed with the grant to the grant owner under the Mexican treaty or the confirmatory acts. This issue must be left to judicial determination.

State Lands

New Mexico law provides that there may be no exploration for or production of uranium on state lands until a lease is obtained from the commissioner of public lands (NMSA 7-8-26; 7-9-17). Leasing is accomplished by competitive bidding, with the commissioner deciding at his discretion which parcels are to be offered (NMSA 7-9-34).

Individual leases are limited to a contiguous area of no more than 16 legal subdivisions, or about 640 acres (NMSA 7-9-31). The successful bidder pays annual rents and royalties on production. Currently there are two producing uranium mines on state land, with several others expected to operate by 1980.

JURISDICTIONAL CONSTRAINTS

The jurisdictions of federal, state, regional, county, municipal, special district, and tribal governments in the San Juan Basin region occasionally overlap. At the federal level, governmental entities with authority based upon the land include the BLM, Forest Service, National Park Service, and BIA. The BIA is responsible for executing the United States trust responsibility on Indian lands and to Indian tribes. The Environmental Protection Agency, Nuclear Regulatory Commission, Geological Survey, and MSHA are among those who exercise regulatory authority. (See Chart XI-1 in pocket.) Agencies of the State of New Mexico involved in the area include the state land office, state highway department, state engineer, state mine inspector, state construction board, state environmental improvement division, six county governments and several municipalities.

The Indian tribes, who own 47 percent of the New Mexico part of the region, exercise exclusive jurisdiction over their land subject to the trust responsibility of the Secretary of the Interior. This can be decisive; the Navajos, for example, rejected a proposal to build a coal gasification plant on their reservation.

The geographical role of county agencies and the extent of Indian land holdings are shown in Table XI-3 based on the Maynard land status findings. San Juan and McKinley counties lie wholly in the study area.

Table XI-3

County and Indian Land Roles

County	Percent of Region	Percent of N.M. Portion	Percent Owned by Indian
San Juan	20.0	27.4	64.4
McKinley	19.6	27.3	66.4
Rio Arriba	16.1	22.0	22.8
Sandoval	9.7	13.3	19.8
Valencia	6.2	8.5	29.4
Bernalillo	1.1	1.6	50.3
	72.7%	100.1%*	

*Totals may not add due to rounding.

Source: Maynard, 1978, No. 29.

More specifically, the governmental jurisdictions may be considered as belonging to three categories as described in Bliss (1979, No. 42): federal, Indian, and state or local.

Federal Jurisdiction on Federal Lands

The federal government's power over federal land, e.g., public lands or acquired lands managed by either the Secretary of the Interior (BLM) or the Secretary of Agriculture (Forest Service) is based on the property clause of the U.S. Constitution (Art. IV, Sec. 3, Cl. 2). The property clause states:

> The Congress shall have power to dispose of and make all needful rules and regulations respecting the territory or other property belonging to the United States.

Until recently the courts have interpreted the clause to mean that the United States, as proprietor of federal lands, is subject to state laws in much the same manner as any private landowner. However, in Kleppe v. New Mexico, 426 U.S. 529 (1976), the Supreme Court cited with approval the language of an earlier case, Canfield v. United States, 167 U.S. 518 (1897) which declared that the federal government "...has a power over its own property analogous to the police power of the several States, and the extent to which it may go in the exercise of such power is measured by the exigencies of the particular case." The Court in Kleppe went on to hold that "...the power over public lands thus entrusted to Congress is without limitation."

Generally, it may be stated that the state may control the activities of private parties using federal lands. State criminal codes, including traffic laws, apply to such parties. Civil disputes between such parties are determined in state, rather than federal, courts. The federal government, however, retains the power to legislate within any area in which it has an interest, and such legislation would apply in that area, despite any state statute.

Thus, the BLM, National Park Service, Water and Power Resources Service (formerly the Bureau of Reclamation), and Forest Service regulate particular uses of the federal lands within their respective jurisdictions.

Governmental Jurisdiction on Indian Lands

There are three sovereigns exerting authority over Indian lands: the tribe, the state, and the federal government. Each may exert jurisdiction (general governmental power) over certain activities and classes of people.

Areas of concurrent jurisdiction and points of conflict involve all three. There are substantial questions as to what constitutes an impermissible state or federal intrusion on tribal sovereignty and the extent of tribal authority beyond the exterior boundaries of a reservation. Questions exist as to the applicability of the term "Indian Country" as defined by 18 U.S.C. § 1151 to other than criminal matters. It is not clear whether the state exercise of a federally delegated power is exertion of

federal or state power. For example, air or water quality plans passed pursuant to federal environmental protection laws but enforced by state agencies may arguably be viewed as an exercise of either federal or state jurisdiction. The law bearing on these questions is complex and sometimes contradictory.

A discussion of the power of the tribe begins with the concept that tribes have those inherent powers of self government of any sovereign nation. Such inherent powers include the ability to regulate the actions of persons within the territory of the sovereign. Indian sovereignty has been limited by treaties, statutes, and judicial decisions, but several fundamental principles remain.

As established by the case of Worcester v. Georgia, 31 U.S. 515 (1832), these principles are: 1) the Constitution gives the federal government plenary power over Indian relations; 2) although Indian tribes are dependent on and subject to federal authority, they retain their internal powers of self-government; 3) Indian territory is outside the authority of the state in which it is located, and state law does not apply to Indian territory.

The first two principles have been continuously upheld by the courts since 1832. The third principle has evolved to mean that where both the state and the tribe have an interest or a basis upon which to exert governmental power, such as an activity on tribal land involving non-Indians, the state must yield to the tribe in virtually all situations.

Summary of Civil Jurisdiction in Indian Country

The pattern of civil jurisdiction in Indian Country is summarized in Table XI-4. The table seeks to provide direction as to which court or administrative agency is the proper forum for resolution of civil matters such as tort cases, zoning matters, licensing, and other activities of Indians and non-Indians on Indian land.

Specifically with regard to taxation, the power to tax mineral extraction on Indian reservations is shared by the tribal and state governments. In Merrion v. Jicarilla Tribe, 617 F. 2d 537 (1980), the Court of Appeals for the Tenth Circuit held that the tribe has the inherent power to levy a severance tax on non-Indian lessees who produce oil and gas from within the reservation despite the assertion by the lessees that the State of New Mexico may be able to impose upon them an identical tax. State taxation is not permissible under all conditions, however. The U.S. Supreme Court has held that an assertion of state civil and regulatory jurisdiction over non-Indians within the exterior boundaries of an Indian reservation must not infringe the right of the tribe to make its own rules and regulations, nor may such state action interfere with or frustrate any federal policy regarding Indians. (See Williams v. Lee, 358 U.S. 217 (1959) and Warren Trading Post v. Arizona Tax Comm'n., 380 U.S. 685 (1965)).

An argument may be made that any state tax on an activity such as uranium mining within an Indian reservation could be termed an infringement. The Department of the Interior has taken the position that production from

Table XI-4

Civil Jurisdiction in Indian Country

	Reservation	Off Reservation[1] Indian Trust Lands	On Reservation - Non-Trust and Fee Lands
Government			
State			
Land	No	No	Yes[5/6]
Persons			
Indian	No	No	No
Non-Indian	No	Yes[2]	Yes[2]
Federal			
Land	Yes[3]	Yes[4]	No[6]
Persons			
Indian	Yes	Yes	Yes
Non-Indian	Yes	Yes	Yes
Tribe			
Land	Yes[3]	No[4]	No
Persons			
Indian	Yes	Yes[2]	Yes[2]
Non-Indian	Yes	No[2]	No

1/ Indian trust lands include allotted lands, homestead lands and tribal trust lands upon which exists a restriction against alienation.

2/ Concurrent federal-tribal-state jurisdiction depending on the nature of the action.

3/ Generally requires Indian-federal concurrence.

4/ The federal government has a trust responsibility to the individual Indian for the duration of the trust period. The tribal government has no legislative authority over the land.

5/ States do not generally regulate the disposition of private lands, but may regulate the use of private lands.

6/ The federal government cannot control disposition of private lands unless the use of such lands runs contrary to a federal policy such as the introduction of liquor into the Indian Country. In some instances, federal regulation has been delegated to the tribes. See U. S. v. Mazurie, 419 U.S. 544 (1975).

Source: Maynard, 1978, No. 29.

oil and gas leases entered into under the 1938 Mineral Leasing Act may not be taxed by the states (Op. Sol. I.D., M-36896, November 7, 1977). An unanswered question is the extent to which tribal taxation preempts or excludes state taxation.

With regard to the issue of zoning, the supreme court of New Mexico has held that city planning and subdivision controls may not be imposed on Indian reservations and trust lands. (Sangre de Cristo Development Corporation, Inc. v. City of Santa Fe, 503 P2d 323 (1972). See also 25 CFR § 1.4.)

Summary of Criminal Jurisdiction in Indian Country

The rules governing criminal jurisdiction are complex and depend, in part, on the nature of the offense and the race of offender and victim. The beginning point is the definition of "Indian Country" at 18 U.S.C. § 1151. The following scheme applies in Indian Country:

1. If the offender is an Indian and the crime is one of the 14 felonies listed in the Major Crimes Act, 18 U.S.C. § 1153, the federal government has jurisdiction.

2. If the offender is an Indian and the crime is not listed as mentioned, the tribal courts have jurisdiction.

3. Regardless of the race of the offender, if the crime is a federal offense, such as destruction of federal property valued above $100, the federal government has jurisdiction. (See U.S.C. § 1152.)

4. If the offender is a non-Indian and the victim is non-Indian, the state has jurisdiction.

5. If the offender is a non-Indian and a victimless crime, such as a motor vehicle offense, is involved, the state has jurisdiction.

6. If the offender is a non-Indian and the crime involves an Indian victim or Indian property, the federal government may prosecute pursuant to the Assimilative Crimes Act, 18 U.S.C. §13. This act gives the federal government authority to prosecute offenses defined by state law and incorporated by reference into the federal criminal code.

The BIA employs police officers who patrol the Indian reservations and trust lands, and there are tribal police officers in most areas as well as state police officers. Where the jurisdiction is federal, as outlined above, the crime is investigated by the Federal Bureau of Investigation and is prosecuted by the U.S. Attorney.

Governmental Jurisdiction on Private and State Lands

The state has the broad power to enact and enforce legislation for the general welfare of its citizens. This power, termed the "police power", limits the power of a private land owner to use his land without restraint.

The powers to zone and control land subdivision are shared by New Mexico counties and municipalities. The New Mexico zoning enabling statute (NMSA 14-20-1) provides that a county or municipality is a zoning authority and may in the interest of the general welfare regulate: 1) height and size of buildings, 2) lot size and building setbacks, 3) density of population, 4) land use, and 5) building type and construction. There are no statutory exceptions for mining; therefore, theoretically, local zoning authorities could control the location and type of mining development on private land. This is politically unlikely, and this section will discuss zoning and subdivision controls as they affect residential and commercial development.

Municipalities have zoning powers within their boundaries and, under the proper circumstances, for one to three miles beyond their boundaries. The "extraterritorial" zoning power may be shared by the municipality and county.

The zoning power is a police power and is valid only if the state has police power jurisdiction over a particular type of land. Like any state law, it is subject to the federal preemption power. The Federal Land Policy and Management Act of 1976 ("BLM Organic Act") gives the BLM land use planning powers that could preempt state law on the same subject. Thus, the zoning power may be exercised only on private lands. (Note: for police power purposes Spanish land grants and tribal fee lands are "private lands.")

EXAMPLE OF JURISDICTIONAL COMPLEXITY

In the real world, jurisdictional problems are sometimes met in the following manner, summarized from Bliss, 1979, No. 42.

Figure XI-4 is a hypothetical schematic illustration of typical mixtures of land types found in certain areas of the San Juan Basin. It is assumed, unless otherwise noted, that the surface and mineral ownership are the same. The Crownpoint region is a checkerboarded area that contains all of these land types, with variations, within 25 miles of Crownpoint. Uranium ore bodies are typically small, covering a few acres. For purposes here, just four ore bodies are shown.

Ore Body 1. The rights to mine Ore Body 1 (on Indian reservation and off-reservation Indian allotted lands) could be acquired through a BIA sponsored lease sale or by direct negotiation with the tribe and the Indian allottee. Development of the mine would be jointly regulated by the BIA and the USGS in consultation with the Indian mineral owner at certain points of the development. This federal approval might trigger the requirement to write an environmental impact statement (EIS). Rights to use the surface for a mill, roads, or transmission lines would have to be separately acquired from the Indian owners, subject to BIA supervision.

The tribe could tax production, require preferential Indian employment, and exercise environmental controls over the reservation portion of Ore Body 1. The tribe might be able to exercise similar powers over the allotted portion of Ore Body 1, but this has not been attempted. The

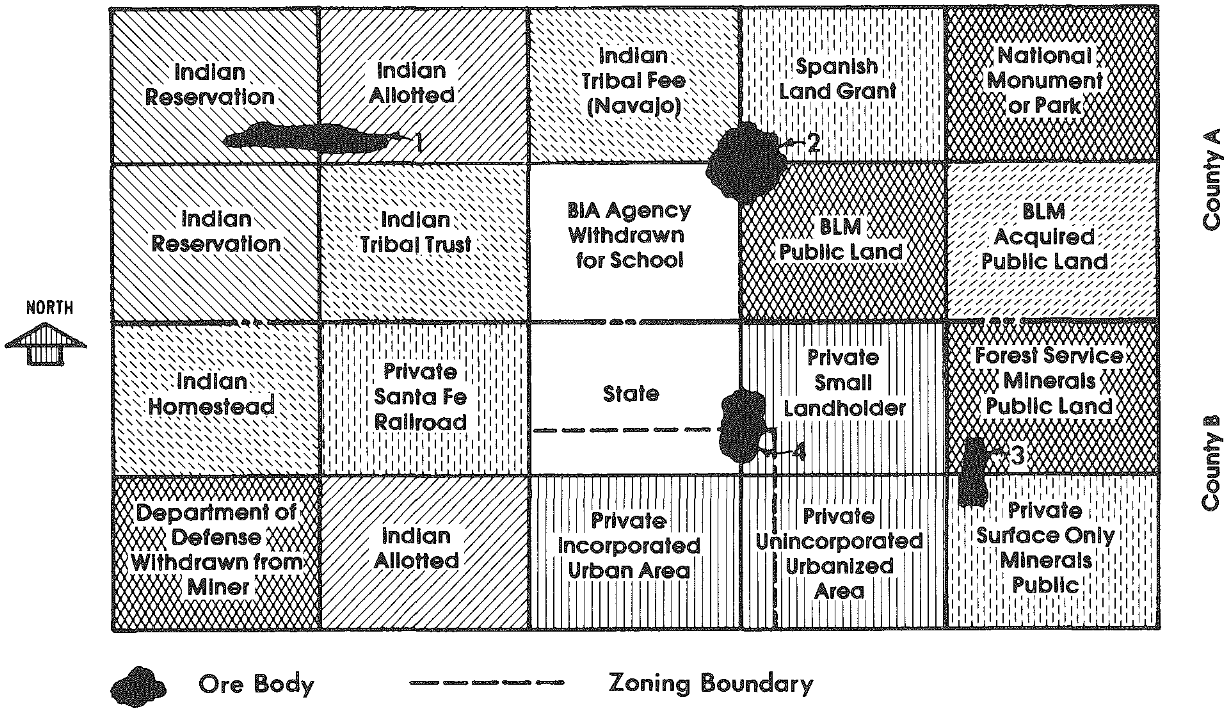


Figure XI-4.--Map of hypothetical checkerboard land status

authority of the State of New Mexico to tax production on Ore Body 1 is questionable. Although the State claims power to enforce environmental laws on reservation and allotted lands, general principles of federal Indian law indicate that the State has no jurisdiction in this instance.

Residential developments for miners of Ore Body 1 would depend on their race. Indians could be accommodated on the reservation subject to the tribal code's homesite provisions. Non-Indians could lease either tribal or allotted land with the permission of the Indian owners and in compliance with a complex BIA surface lease process. It is more likely that they would live in the nearest urban area.

Ore Body 2. Ore Body 2 is located on four types of land: tribal fee, Spanish land grant, public land, and agency withdrawn land. The rights to mine the tribal fee land must be approved by the tribal council, in this instance the Navajo. The BIA is not involved in the conveyance of interests in land held by the tribe. Neither the USGS nor the BIA is involved in regulating any portion of mineral development on this type of land.

The rights to mine the portion on the non-Indian Spanish land grant must be obtained from the governing corporation or board of trustees, subject to the approval of the New Mexico judiciary. These rights to mine are subject to the approval of the residents of the grant. The portion on BLM public land must be acquired by a "mine claim" under the Mining Law of 1872. The document granting the agency withdrawal would govern the disposition of the minerals under that land. The minerals might still be "public"

and subject to claim in the same manner as on BLM public lands. At the other extreme, it may take an act of Congress to release the minerals for development.

All of Ore Body 2 is subject to the general environmental regulations of the State and to any specific environmental protection clauses inserted by the individual mineral owners, i.e., the tribe and governing body of the Spanish land grant. There are no specific environmental protection measures built into acquisition of minerals under the Mining Law of 1872. Additional rights to use the surface would have to be acquired separately on the tribal fee and Spanish land grant land. The right of access is granted by the 1872 Mining Law, but the construction of a road or transmission lines requires a permit from the BLM. The issuance of such a permit could come within the mandate of NEPA and require the writing of an EIS.

A mill or residential development in conjunction with Ore Body 2 could be located on tribal fee or Spanish land grant with approval of the respective governing bodies, but not on agency withdrawn or BLM land. A mill site on BLM land could be claimed under the 1872 law, but, since allowable acreage is limited in that law, it might be inadequate to meet future needs. A mill site could also be obtained by a land exchange with the BLM.

Ore Body 3. Ore Body 3 is completely within the public domain and subject to being claimed under the Mining Law of 1872, although the surface is owned separately by the Forest Service and a private landowner. The title of the latter is based on a patent issued under the Stock-Raising Homestead Act of 1916. Development of this ore body would be subject to the general environmental controls of the State and the specific surface protection regulations of the Forest Service. The Forest Service approvals could be of a scope to require the writing of an EIS.

The private surface owner would have to be compensated for damages to crops and improvements, although he would not necessarily receive income from the mining operation. The private owner could sell his surface interest for a mill or residential development, but neither of those uses is compatible with Forest Service regulations.

Ore Body 4. Ore Body 4 is located on State land and that of a private landowner who also holds the mineral rights. Rights to mine the portion on State land must be acquired by competitive bid at a State lease sale. The rights to mine the private portion must be acquired by negotiation with the private landowner who could receive royalties, sell outright, or make other types of agreements. Development would be governed by the general environmental laws of the State. Additional surface rights could be bought or leased from the private owner, or leased or exchanged with the State.

Ore Body 4 is within the extra-territorial zoning powers of an incorporated town that has the power to control (zone) surface land uses three to five miles beyond its boundaries. This power could limit the location of a mill or residential development.

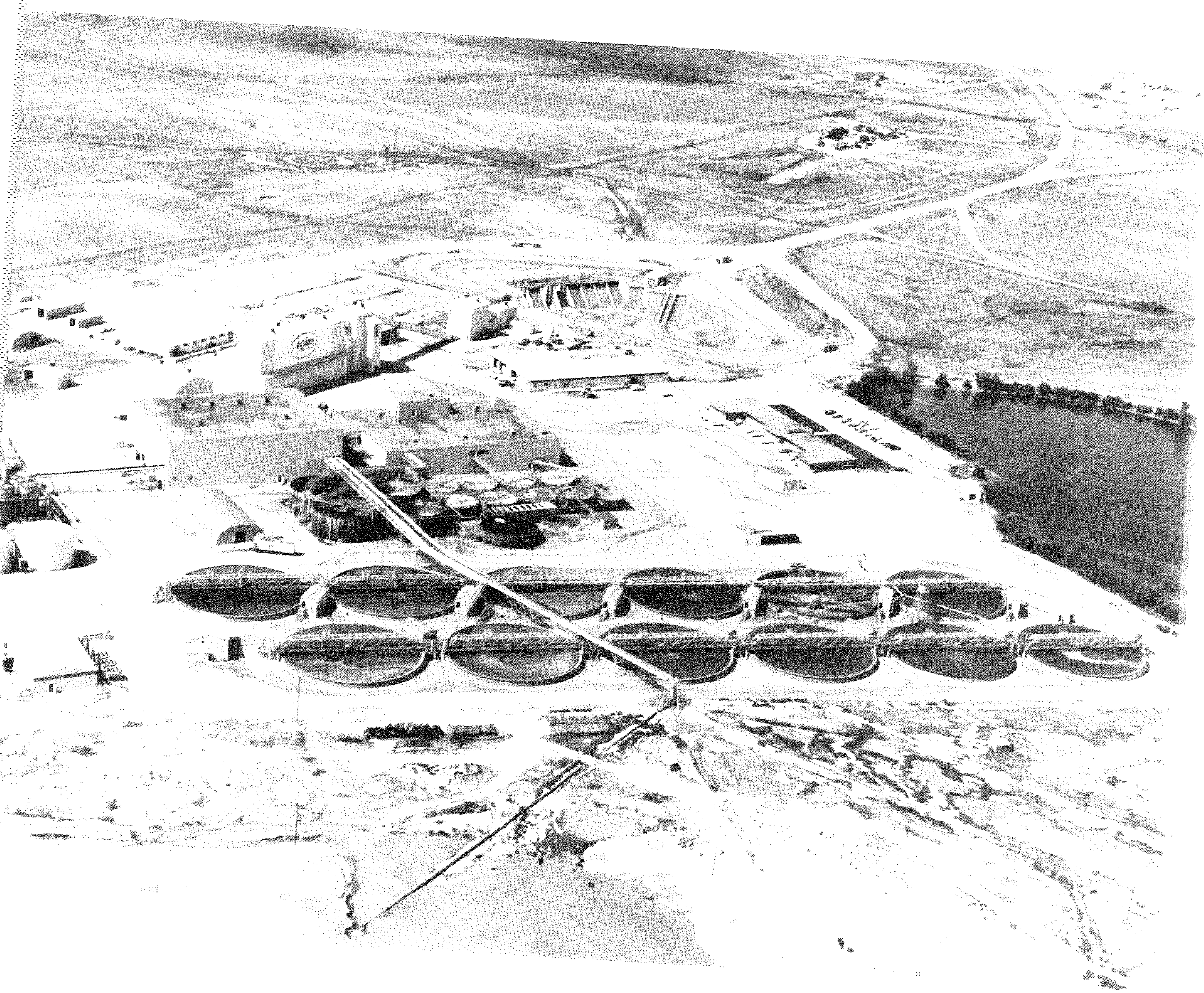
General. Social and environmental governmental agencies must react to any development resulting from mining company officials' actions. Often

residential development or mills valuable as tax property are located where private land and land for urban development are available. Taxable mines and mills may be located in one county, with residential development straining a local infrastructure located in another. Figure XI-4 indicates this problem by showing Ore Bodies 1 and 2 in County A and the residential development likely to occur in County B.

The general immunity of Indian trust land and Indians from State control means that a town such as Crownpoint cannot become a municipality under State law and thus is ineligible for various types of financial support. The limited authority of the Navajo tribe over the intensively Navajo occupied area to the south and east of the reservation boundaries may hamper its ability to control land use or environmental impacts outside the exterior boundaries of the reservation.

CHAPTER XII

LEGAL CONSTRAINTS



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Chapter XII

A Note to Readers

Chapter XII presents an overview of selected environmental laws and regulations affecting uranium mining and milling in the New Mexico portion of the San Juan Basin. The discussion of each statute or issue is necessarily brief. Therefore, some statutes have been summarized and specific sections have not been fully developed. Furthermore, space and time limitations have precluded discussion of specific regulations developed in execution of the various statutes.

Discussion reflects the federal perspective. It should be noted that several regulatory commissions of the State of New Mexico mentioned in these pages have been legislatively terminated. On the assumption that the state is continuing the policies of these commissions, references to them by name have been retained for reader convenience.

The study team believes the discussion of the statutes is accurate, subject to the qualifications above. However, a reader with a specific legal problem should consult an attorney and the appropriate governmental agency for guidance.

Chapter XII

Legal Constraints

INTRODUCTION

A substantial body of law and regulations affecting many aspects of uranium mining and milling has developed, much of it during the 1970's. Legal constraints are designed to protect the environment and human health and safety. The industry, along with regulatory agencies, can do much to instill public confidence simply by compliance with the policies and requirements prescribed to date.

Rules governing the front end of the nuclear fuel cycle--uranium mining and milling--are condensed into chart form in Chart XI-1 (pocket), for ready reference. Some of the major legislative constraints are outlined in this chapter.

ENVIRONMENTAL LAW

National Environmental Policy Act of 1969 (NEPA)

Prior to enactment of NEPA, environmental protection was largely voluntary in many fields. As a result, planning specifically aimed at reducing environmental costs was limited. NEPA introduced a look-ahead stance, requiring--for the first time in many areas--a thorough study of 1) all impacts of a proposed project on the environment, and 2) possible alternatives to the action proposed.

Under NEPA any major federal action that might produce a significant impact on the environment must be analyzed as part of the overall decision-making process, first internally by federal officials involved. If a decision is then made that the proposal could, in fact, significantly affect the environment, an environmental impact statement (EIS) is required. This undergoes public review and is revised as necessary into a final document.

Among EIS's prepared to analyze the impacts of uranium mining in the San Juan Basin region are the Navajo-Exxon EIS for an area southwest of Shiprock, the Dalton Pass EIS for a mine west of Crownpoint, the Crownpoint EIS for a uranium mine northwest of the town, and an EIS covering uranium on the Ute Mountain Ute reservation. Environmental assessments have been prepared for a number of uranium leases and permits.

A number of Navajos and the organization Friends of the Earth have filed suit against several federal agencies contending, among other things,

that EIS's rather than the less stringent environmental assessments should have been prepared prior to leasing or permitting. The issue is pending.

A new requirement for "scoping" meetings, included in Council for Environmental Quality regulations that became effective in mid-1979, means that all future uranium EIS's will undergo this preliminary process permitting the public and interested parties to help plan in advance the scope of the environmental analysis.

The State of New Mexico has no process as thorough and comprehensive as that required by NEPA, but it requires an environmental assessment prior to licensing of uranium mills.

The UMTRCA also requires, in Section 204 (e) (1), a written environmental impact analysis when a state issues a license for any activity which results in the production of by-product material and which has a significant impact on the human environment. This analysis must include the following information: 1) assessment of impact on the public health; 2) assessment of impact on waterways and ground water; 3) consideration of alternatives to the activity, including alternative sites and engineering methods; and 4) consideration of longterm impacts, including decommissioning, decontamination, and reclamation impacts, and management of by-product material.

These assessments and analyses review environmental impacts on state and private lands much as an EIS does for Indian and federal land. It should be noted that New Mexico's process for licensing uranium milling requires that separate licenses or permits be obtained for air quality, water quality, and radiation (Garber, 1979).

Clean Air Act of 1970 as Amended 1977 (PL 95-95)

The Clean Air Act of 1970 established two sets of national ambient air quality standards. One set was designed to protect the public's health; the other, a secondary standard, was aimed at protecting the public welfare and included such aspects as property, vegetation, and aesthetics. The secondary standard is normally the lower, or less stringent, of the two (Table IV-6). Since a pollutant customarily reaches that concentration first, the secondary standard tends to govern.

While standards have been set for most harmful airborne pollutants, criteria have not been established for certain elusive particles or gases. Chief among these are radionuclides and radiation. At present, radiation is regulated by the NRC as a health problem rather than as an air quality problem. Of the pollutants for which criteria have been established, none is produced in quantity by uranium mining or milling. (See Chapter IV.) Thus the Clean Air Act of 1970 is not a constraint on uranium development.

The Amendments of 1977, however, have the potential of constraining uranium and other energy development in northwest New Mexico. Under these amendments the states must prepare plans to limit the deterioration of air quality in those areas which currently meet the ambient air standards. State plans must limit emissions rather than provide for greater dispersal

of pollutants (for example, by requiring scrubbers rather than tall stacks). State plans must consider direct sources, such as factory smoke stacks and automobiles, and indirect sources, such as central business districts or shopping centers which attract automotive traffic.

If the state submits an implementation plan which fails to meet the requirements of the Clean Air Act, the EPA administrator may set and enforce a plan for the state. Because of this power, the state plans are a subject of much negotiation between the EPA and the state governments (Bliss, 1979, No. 13). Air quality regions are established, with limits set for certain air pollutants. The EPA announced in the December 27, 1979 Federal Register its intention to establish air quality standards for radioactive emissions under Section 112 of the Clean Air Act.

The Class II classification which covers the New Mexico portion of the San Juan Basin would not affect uranium development there, but other energy development could be affected. (This subject is also discussed in Chapter IV, including the section "Current Regulations.") If the classification were changed to the more stringent Class I as proposed by the National Park Service, however, all development would be severely restrained. New Mexico's plan and exceptions are set forth in 40 CFR 52.1620.

The act is complex, covering such things as state implementation, new source standards, research, and financial assistance, and this summary touches only the relevant highlights.

Federal Water Pollution Control Act as Amended by PL 92-500(1972) and PL 95-217(1977)

To control water pollution, the Federal Water Pollution Control Act (FWPCA) authorizes and requires the Environmental Protection Agency and the states to adopt regulations which establish effluent and pollutant standards on all discharges into the navigable waters of the United States. The act covers point sources and nonpoint sources of pollution. However, the 1977 amendments exempted certain point sources and nonpoint sources. Among these sources are return flows from irrigated agriculture, emergency construction, normal farming, silviculture (a branch of forestry), and ranching activities. (See 33 USC 1344(F)(1) and 33 USC 1342(1).)

The states through their own legislation implement the provisions of the federal law with approval of the EPA. The basic precepts of the act are relatively simple, but complexity arises in the definition of standards and their means of implementation.

The effluent limitations in NPDES permits imposed by the act become more restrictive as time passes. The act requires secondary treatment of all wastes by 1977, "Best Available Technology" (BAT) for waste treatment by July 1, 1984, and zero waste discharge by July 1, 1987. The EPA has the authority to exempt discharges from industries if the industries can prove that the discharged pollutants will not be harmful to the aquatic environment and will not interfere with attainment of National Water Quality Standards. Arguments over the meaning and practicality of the 1987 deadline have resulted in some rethinking of individual cases and postponement of

the scheduled dates. The basic desire for clean water remains the national goal in this regard.

While water quality standards are set by the states, the EPA has broad discretion to modify the standards. Additional effluent limitations must be established if it is determined that application of BAT by 1984 will not assure protection of the following: public water supplies; agricultural and industrial uses; fish, shellfish and wildlife, or water recreational activities (FWPCA § 302(a)).

In setting such limitations, the EPA must consider the economic and social costs of their achievement, including any economic or social dislocations and benefits. It also must determine whether proposed limitations can be implemented with available technology or alternative control strategies (FWPCA § 302(a) (Bliss, 1979, No. 13)).

In order to control the effluent discharges, Section 402 of the act establishes a National Pollutant Discharge Elimination System (NPDES) requiring permits for discharge of pollutants. These permits, issued by the EPA or by the state under EPA authority, certify that the discharge by the applicant is not in violation of any provision of the act (Bliss, 1979, No. 13).

NPDES permits will regulate non-point sources such as site runoff, spills, leaks, and drainage from sludge or waste disposal and from raw material which is associated with or ancillary to an industrial manufacturing or treatment process. The non-point sources will be regulated through Best Management Practices (BMP) Plans as a part of the NPDES permit (Brothers, 1980).

The New Mexico environmental improvement division's (EID's) attempts to force uranium companies to obtain NPDES permits for the discharge of treated mine water demonstrate the complexity of the act. Some companies are adjudicating the permits on grounds that most discharges are not into "navigable waters of the United States." The net effect of the court challenge is delay. Six permits have been stayed in the courts, and 15 are pending (Sorenson and Marston, 1979, No. 35). However, the act arguably applies to effluent discharge in all waters of the United States, including non-navigable waters and intrastate lakes, rivers, and streams which are utilized for industrial purposes by industries in interstate commerce (Bliss, 1979, No. 13). The matter is unresolved.

Moreover, the NPDES permit system, even if effective, does not regulate the impact on surface waters of non-point sources such as spoils pile runoff. In actuality, as noted in a study for this project, non-point sources of water pollution, which are not covered in any regulations, are significant in the mining industry. (Sorenson and Marston, 1979, No. 35)

The Water Quality Control Commission (NMSA 75-6-4) is the New Mexico water pollution control agency that formulates regulations to implement the Federal Water Pollution Control Act, the Water Quality Act of 1965, the Clean Waters Restoration Act of 1966, the Safe Drinking Water Act, and the New Mexico Water Quality Act (NMSA 74-6-1 <u>et seq</u>.).

The New Mexico Water Quality Control Commission has adopted as Part 3 of its regulations a comprehensive set of regulations to protect ground water quality. These regulations were recently upheld by the New Mexico supreme court.

One difficulty encountered in northwest New Mexico is that Part 2 of the New Mexico Water Quality Control Commission regulations appears not to be sufficiently developed to stand alone, or to provide backup capability for the NPDES program. Part 2 regulations were used in two separate enforcement actions in mid-1979 involving slaughter house wastes and domestic waste water, respectively. Although the Part 2 regulations are so written that they may not be used if a discharge is subject to a permit under NPDES, they may be used if written notice of a permit violation is given by the EPA and the violation is not corrected within 30 days of receipt of the notice.

Recent commission minutes reflect the view that Part 2 regulations could be used in cases where a NPDES permit has not yet been issued. However, the reader should be aware that the effluent limitations included in Part 2 are more aptly applied to domestic waste water than to industrial wastes which may contain heavy metals and toxic chemicals. Sorenson and Marston write (1979, No. 35):

> Thus a critical issue is the inadequacy of enforcement by EID. The problem is a function of ambiguities and gaps in the laws and regulations and insufficient enforcement powers. It is also a reflection of a small overworked and insufficiently funded staff.
>
> What industry's practices are without an effective state or federal regulatory mechanism is difficult to say. In all likelihood, no major effort to avoid compliance is underway, and many problems are a function of scale.
>
> The strategies proposed by the New Mexico WQCC to improve upon the existing regulatory network governing water quality is focused directly upon: 1) jurisdiction over discharges to waters not of the United States; 2) "discharges that are non-point"; 3) stayed NPDES permit regulations; 4) enforceable requirements that are more stringent than the federal requirements; and 5) a comprehensive groundwater monitoring program.

In essence, the FWPCA backed up by state law and enforcement could prevent water pollution by the uranium industry in New Mexico. While it has not prevented pollution in the past, its potential for the future is real and it should provide an effective legal constraint on the uncontrolled discharge of radioactive or other wastes into the environment.

<u>Solid Waste Disposal Act as Amended by the Resources Conservation and Recovery Act</u>

The effect of the Solid Waste and Resources Conservation acts on the uranium industry in New Mexico is yet to be determined. The acts are aimed

at finding a satisfactory way of disposing of solid wastes, particularly garbage and industrial residues. Overseen by the EPA, they prohibit open land dumps and open burning; they provide grants for research in disposal and recycling along with grants for training, pilot plants, and development of solid waste management plans; and they regulate the treatment, storage, transportation, and disposal of hazardous wastes. At present the definition of hazardous wastes does not extend to radioactive wastes. These are covered in the Uranium Mill Tailings Radiation Control Act and the Federal Water Pollution Control Act and are regulated by the NRC. The EPA and NRC have cooperated to define their jurisdictions. As outlined in greater detail in Chapter VI ("Mitigation of Topographic Problems"), UMTRCA regulations were scheduled to take effect toward the end of 1980.

Safe Drinking Water Act (PL 93-523)

The Safe Drinking Water Act was enacted to protect drinking water supplies, particularly the supplies for municipal water systems. It includes, in Part C, a program for the "Protection of Underground Sources of Drinking Water." This part requires that states establish, pursuant to EPA regulations, underground injection control programs (§1421). The state must issue permits which include provisions for monitoring injection that might endanger drinking water sources. On the reservations, presumably federal agencies or the tribes themselves would issue the permits (Bliss, 1979, No. 13).

Currently, some mine waters not used for mining and milling purposes are dumped into the arroyos and thus become subject to requirements of the NPDES permit program, where the program is applicable. In the case of mill wastes, on the other hand, the possibility of underground disposal exists. Here, the potential to contaminate a public drinking water supply is apparent and presumably the Safe Drinking Water Act and pendant state permit and monitoring programs would apply. The State of New Mexico since 1977 has had regulations to protect ground water quality covering injection wells, in situ leaching projects, and seepage from tailings ponds. If the possibility of contaminating a public water supply became apparent, a permit accompanied by adequate monitoring would be necessary.

While the need to apply this act has not yet occurred, it should eventually become a tool of the authorities to prevent pollution.

HEALTH AND SAFETY CODES

The laws and codes regulating safety are those applicable to all underground hard rock mining and will not be described in detail here. Health is another matter, however, because it concerns the danger of radiation.

The Atomic Energy Act of 1954 and Provisions for Agreement State Status

The Atomic Energy Act of 1954 is the basic statute regulating all aspects of the nuclear fuel cycle. It defines the regulatory powers granted the NRC. Of particular interest to New Mexico is the NRC's authority to regulate "source material." Source material is defined in 42 USC §2014 as uranium, thorium, or any other material determined by the NRC to be

necessary for producing nuclear fuel, and ores containing one or more of those materials (Bliss, 1979, No. 13).

Moreover, 42 USC §2201(b) gives the NRC power to restrict possession of source material to holders of an NRC license and to promulgate regulations and standards governing these licenses. §2021(b) empowers the commission to enter into agreements allowing the states to issue the licenses and transferring certain NRC authority to the states. New Mexico is an agreement state authorized to regulate specified materials for the protection of the public health and safety from radiation hazards (Bliss, 1979, No. 13).

The New Mexico Radiation Protection Act, enacted to comply with agreement state status, gives the environmental improvement board the following powers: to promulgate regulations to protect the public from radiation hazards; to prescribe license fees and conditions; to enter and inspect licensed property; to require a bond to ensure compliance with the regulations contained within a license for source material, and to establish a fund for continued care of radioactive materials after the expiration of the license.

The New Mexico Radiation Protection Act exempts a large part of the state's uranium industry from regulation. Section 8C of the Radiation Protection Act specifies:

> The Radiation Protection Act (12-9-1 to 12-9-12) shall not apply to the mining, extraction, processing, storage, or transportation of radioactive ores or uranium concentrates that are regulated by the United States Bureau of Mines or any other federal or state agency having authority unless the authority is ceded by such agency to the board. (NMSA 12-9-8)

Since the state mine inspector has jurisdiction over radioactivity in mines for purposes of miner health and safety, this provision has been found to prevent the EID from regulating radioactivity in mines in any manner, in spite of the fact that the mine inspector has no express authority and has not made any effort to control venting of radioactive air at uranium mines (Bliss, 1978, No. 13). New Mexico does have the power to control radon or its daughters vented from the mines, under terms of the Radiation Protection Act (NMSA 74-3-1 to 74-3-16). No enforcement mechanism exists (Sorenson and Marston, 1979, No. 35).

One method available to control this radiation stems from the NRC specification of allowable dosage to which people can be subjected (10 CFR 20.105). (See Chapter IV.) This regulation can be used to judge whether surface radiation in the vicinity of mines and mills is within tolerable levels. As stated in Chapter IV, it should be noted that the EPA, NRC and state are expected to modify the "maximum permissible concentration" values to include use of exposure to concentration values "as low as reasonably achievable." The EPA is developing regulations for radon emissions from mines.

The granting of a license to a mill applicant is based on two primary concerns: 1) the health and safety of the employees, and 2) the environmental impact of the operation of the mill, including the radiological hazard to the public (N.M. Environmental Improvement Agency, Uranium Mill License Application Guidelines).

The EID requires an applicant for a mill license to submit, in conjunction with its application, "an environmental report describing the environmental impact and demonstrating that the operation and facility design results in an impact which is as low as reasonably achievable and that the issuance of a license would not be inimical to the health and safety of the public." Also required is a mill radiation report on the safety of the applicant's facilities and radiation protection program, showing that the radiological hazard to the employees is as low as reasonably achievable (Bliss, 1979, No. 13.)

All licensed mills in New Mexico must have a monitoring program to determine the amount of radiation created by their operations, covering possible exposures of employees or the surrounding population to radiation. The EID monitors these records and orders control measures or the cessation of plant operations if dangerous levels of radiation are present. A license may be revoked or suspended for "violation of or failure to observe any of the terms and conditions of the act or of the license, or of any rule, regulation or order of the agency." (Radiation Regulations §3-480(B))

No burial or special treatment of mill tailings was required in New Mexico in the past. However, if radioactivity reached a sufficiently high level, the mill could be required to bury or treat the tailings. The problem was that in the Grants area there were so many operations in relatively close proximity that it was difficult to determine which operation was posing a health hazard (Bliss, 1979, No. 13). Some of the currently operating mills are located next to towns or on banks of rivers or arroyos (Sorenson and Marston, 1979, No. 35). Prior to the passage of the Uranium Mill Tailings Radiation Control Act, the EID had to show both the existence of a danger to the public health and that a particular operation was at fault.

There was recently a one-year study by the EID to determine whether radiation levels in the Grants uranium belt pose a risk to health. It should be noted that the New Mexico EID has issued new regulations covering mill tailings.

While it is undisputed that the radiation protection section of the EID has authority over all state land, it is unclear whether the state has jurisdiction over federal lands in New Mexico. New Mexico recently has taken the position that it is entitled to regulate uranium operations on Indian land. Unless Congress enacts legislation specifically giving the state the power to regulate uranium mills on Indian land, the state cannot regulate such activity. It is clear that the state cannot exercise jurisdiction over mill tailings on Indian land under the UMTRCA (42 USC 7915).

New Mexico's status as an agreement state provides it the same jurisdiction over radioactive materials that the NRC exercises in non-agreement states. There is no major question as to the requirement for an EIS on the issuance of a mill license. The state cannot be required to file an EIS. The NRC would be required to file an EIS if it were to license the mill rather than delegating this function to New Mexico. The state properly contends that the licensing of uranium mills is a state action and that the state need not compile an EIS (Bliss, 1979, No. 13). As noted early in this chapter, the UMTRCA requires agreement states to write an environmental analysis prior to licensing of uranium mills. (This requirement was summarized under "National Environmental Policy Act of 1969.")

Thus gaps exist in the provisions and enforcement of the Atomic Energy Act of 1954. The Uranium Mill Tailings Radiation Control Act described below should fill the major gap.

The Uranium Mill Tailings Radiation Control Act of 1978 as Amended

The UMTRCA for the first time explicitly brings uranium mill tailings under statutory control. The act 1) provides for cooperative agreement between the secretary of energy and state governments for remedial action to neutralize and dispose of tailings from inactive mills; and 2) amends the Atomic Energy Act of 1954 to include tailings within the definition of "by product material" and hence subject to control by current licenses issued by the NRC.

Title I, the Remedial Action Program, designates sites which contain tailings from inactive mills that must be processed. The locations of these sites, including two in New Mexico at Shiprock and Ambrosia Lake, are specified in the statute (§102). The act specifically covers "residual radioactive waste," which is defined as tailings and other associated waste which have been determined by the secretary of energy to be radioactive (§101(7)). The statute authorizes funding to buy the land on which the tailings piles are located and land for disposal sites. There are provisions for the eventual disposition of the reclaimed land (Bliss, 1979, No. 13).

Title II of the act amends the Atomic Energy Act of 1954 to provide for the control of tailings generated by mills operating under current and future licenses issued by the NRC or agreement states. The definition of by-product material is amended to cover mill tailings. Previously it covered only wastes associated with the production and use of nuclear fuel. Agreement states will issue licenses for the possession of by-product material and these licenses will contain decontamination and reclamation standards set by the NRC (§201 of the UMTRCA amending §83 of the Atomic Energy Act). The NRC does not have any licensing authority over by-products produced in any activity covered by its agreement with the State of New Mexico until three years after the date of enactment of the UMTRCA (93 Stat 799).

§202 of the UMTRCA gives the NRC power to require bonds for the care of mill tailings and require that tailings ponds be designed in a manner reducing the need for long term maintenance. Ownership of the reclaimed

tailings property would be transferred to the federal government or state at the option of the state.

Both Title I and Title II contemplate perpetual care of the stabilized tailings piles. The administrator of the EPA is authorized to set standards for protection of the public health, safety, and environment from radiological and non radiological hazards associated with uranium mill tailings. This authority covers the remedial action taken in regard to the inactive tailings and the license conditions attached to current operations.

Title III provides for the study and designation of two processing sites in New Mexico: tailings piles at the United Nuclear-Homestake mill at Milan and the Anaconda mill at Bluewater. Both mills have been in operation for some time and have massive tailings piles which would be corrected by Title I remedial action but are exempt because they are currently in operation. Title III authorizes the New Mexico attorney general and the NRC to determine what should be done about these sites and report to Congress (Bliss, 1979, No. 13).

Under the provisions of the UMTRCA, the states have no jurisdiction over processing sites on Indian and federal lands. The remedial action required with respect to uranium tailings sites on Indian lands is to be paid for in its entirety by the Department of Energy. The respective Indian tribes and the Secretary of the Interior must be consulted prior to the performance of any remedial action on Indian lands, and qualified Indian labor must be hired so far as feasible. The United States has sole responsibility to control and guard processing sites on Indian lands.

This act closed most of the gaps in previous statutes but left a few questions still unanswered. One is the degree of responsibility or liability which might exist between the mill owner, the federal government, and the state for active or future tailings that are at least partially generated for national defense. Another is the possibility for overlapping authority, particularly since radioactive wastes could readily be defined as a hazardous waste under Subtitle C of the Solid Waste Disposal Act. Despite its shortcomings, however, this act has much environmental protection potential.

Transportation of Radioactive Materials

The NRC requires a license for the transfer of yellowcake. Under 49 USC §1801 et seq., the Department of Transportation formulates regulations for safe handling, packaging, labeling, and transportation of hazardous materials. The department is required to consult the Interstate Commerce Commission before designating transportation routes. These regulations are binding on all carriers, other than pipelines, which engage in interstate commerce, and violation carries a severe criminal penalty.

All shipments of radioactive materials which are made by the NRC, DOE, or Department of Defense are exempted. The regulations, basically packaging regulations, are found in Title 49 of the Code of Federal Regulations (Bliss, 1979, No. 13).

Federal Mine Safety and Health Act of 1977

This act and accompanying regulations codify the maximum exposure limit set forth by the Mining Enforcement and Safety Administration (MESA) in 1975. The succeeding agency, Mine Safety and Health Administration (MSHA), enforces the limit of one Working Level (the radiation from any combination of radon daughters in one liter of air that will emit 1.30×10^5 million electron volts (MEV) of alpha ray energy) in the mine and four Working Level months per year of exposure for each miner. Results of the monitoring for 1976 are shown in Table XII-1.

Table XII-1
1976 Uranium Mine Exposure

Total Employment	Average Exposure	Miners having exposure in indicated intervals, percent				
		0-1 WLM	1-2 WLM	2-3 WLM	3-4 WLM	4 WLM
4,306	0.99 WLM	60.4	22.0	11-4	6.0	0.1

Source: U.S. Environmental Protection Agency, 1976.

The state mine inspector is responsible for checking radiation levels of mines in the state. The mine operator has the primary responsibility to do monitoring and keep records of radiation exposures for each individual miner. The state inspector has access to all files, in addition to inspecting the mine four times a year (NMSA 63-4-5).

OTHER PROTECTIVE STATUTES

Archeological, Historic, and Religious Sites

The Antiquity Act of 1906 (16 USC §§431-433) establishes federal control over archeological resources on federally owned or controlled lands. It establishes a permit system for scientific investigation of these resources. The Historic Sites Act of 1935 (16 USC §§461-467) establishes a national policy of preservation of archeological sites of national significance.

The Navajo tribe in 1972 passed an Antiquities Preservation Law which established the tribe's department of parks and recreation as guardian and repository of all antiquities found on Navajo land. This law forbids unauthorized excavation, destruction or sale of antiquities or paleontological objects found on tribal lands. New Mexico has extensive cultural preservation regulations (NMSA 4-27-4 through 4-27-18). These cover all land in New Mexico, including private land.

There is extensive coordination within the state between the National Park Service, the state archeologist, and the BLM archeologist. Essentially, each of these groups issues archeological clearances or performs or contracts for salvage archeology on all land under its jurisdiction. Unless a particular ruin is listed as an antiquity on a state or federal register,

there is no requirement that would stop development affecting it, although data must be preserved (Bliss, 1979, No. 13).

None of these statutes provides adequate protection against "pot hunters," as amateur and professional collectors are called.

The Historic Preservation Act of 1966 (16 USC §470) creates the National Historic Register of Historic Places and the President's Advisory Council on Historic Preservation. This group must comment on any development which adversely affects property designated on the National Register. (See Chapter X.)

The American Indian Religious Freedom Act, enacted in 1978 as PL 95-341 (42 USC 1996) provides for procedures to preserve selected sites valued by Indians for their religious connotations. The act has been mentioned in connection with the Mount Taylor area and the vicinity of a planned geothermal plant in the Jemez Mountains. Sacred sites are discussed briefly in Chapter X.

Federal Wildlife Protection Statutes

The Endangered Species Act of 1973 is codified in 16 USC §§1531 through §1543. §1533 requires the Secretary of the Interior to determine which species are "endangered" and gives him discretion to issue regulations to conserve these species. §1535 allows for cooperation with the states. It requires the Secretary to consult with states on land acquisition, conservation and management agreements.

The other wildlife protection acts provide for the establishment of wildlife sanctuaries (16 USC §715 et seq.); the study of the environmental effects on wildlife of construction of dams (16 USC §§661-666); and the preservation of game and sport fishing (16 USC §702).

Under 16 USC §665, the Secretary of the Interior is authorized to make investigations as to the effects on wildlife of polluting substances and report with recommendations to Congress. Specifically, the Secretary is authorized to make such investigations as he deems necessary to determine the effects on wildlife of domestic sewage, mine, petroleum and industrial wastes, erosion silt, and other polluting substances.

STATE AND INDIAN CONFLICTS: WATER RIGHTS AND POLLUTION CONTROL

An additional difficulty faced by the uranium industry in the checkerboard area is the conflict between state and Indian jurisdiction. While not a party in the conflict, a mining company or commercial developer can easily find itself caught in the middle. The problems with the greatest potential for constraining development are water rights and pollution control.

Indian Water Rights and the Winters Doctrine

The San Juan Basin is a water short area. Competing interests seek to develop the available water supply. The ground waters and surface waters

are, in most cases, part of the same hydrologic system. Thus, rights to the use of ground water and surface water are interrelated. Integrated control and administration of the use of both water sources is important.

The legal differences for the basis and measure of Indian reserved rights to the use of water, founded upon federal law and water rights created by state law, are explained in Bliss, 1978, No. 33, where greater detail on this subject is available.

Judicial decisions have resolved the conflict between the application of federal law or state law to reserved water rights by holding that state law is not applicable to surface water reserved for present and future uses on Indian reservations. However, the status of the law is not settled with respect to the reservation of ground water for Indian reservation uses and the right to control and administer the use of ground water.

The 1980 enactment of the New Mexico Mine Dewatering Act (NMSA 72-12A-1 through 13, 1978 Comp.) by the New Mexico legislature demonstrates the state's determination to assert its jurisdiction in this area. That act gives jurisdiction of mining activities which affect ground water to the state engineer.

Additional light was cast on the subject of Indian reserved water rights in the Cappaert case (Cappaert v. United States, 426 U.S. 128, 1975, discussed in Bliss, 1978, No. 33) and in a recent appeals court decision in the consolidated cases of Colville Confederated Tribes v. Boyd Walton, Jr. et ux., et al., and the State of Washington, No. 79-4309. In the latter case, the 9th U.S. circuit court of appeals on August 20, 1980 affirmed for the plaintiffs (460 F. Supp. 1320 (E.D. Washington, 1978)). In this case, the court reinforced the principle that state law does not apply to the Indians' reserved water rights but held that state law is applicable to water which at any given time exceeds the Indians' needs.

Whether water use involved in uranium mining is in excess of the Indians' needs may differ from case to case. Also, the tribe's interests in the control and disposal of mine discharge waters may vary. Therefore, the resolution of the conflict over administration and control of the ground water involved in uranium mining developments on Indian reservations in New Mexico remains uncertain.

The legal interests of the tribe and individual allottees affected by the development of uranium, coal, and other resources of the area may at times be opposed to each other. That issue is an intra-tribal matter and is not discussed here.

Political factors associated with the funding of water developments have colored the scene in which Indian water rights are exercised. Those factors have had an adverse effect on the exercise of Indian water rights and will continue to affect the opportunity to develop and use the available water supplies in the area of the study.

Unless an overall solution is achieved by legislation, agreement, or court decision, each situation affecting both ground water and surface

water uses in connection with mining in this area will have to be resolved on its own facts.

State Pollution Control Enforcement on Indian Land

Both the Clean Air Act and the Federal Water Pollution Control Act contain authorization for state enforcement and monitoring. Neither act, however, expressly establishes state jurisdiction over Indian lands for such enforcement and monitoring.

The New Mexico EID has claimed such jurisdiction based on the provisions of the acts, its status as an instrument of the federal government, and the assumption that pollution originating on Indian land will adversely affect state land. In the absence of an express congressional delegation of state jurisdiction, however, basic principles of federal Indian law indicate that the state has no authority to regulate activities on Indian lands, particularly in a field largely preempted by federal legislation.

Such state regulation would contravene basic principles of Indian self-government by infringing on the right of the tribes to regulate health and welfare on the reservation. State regulation of pollution control on Indian reservations is also prohibited by Title 25 of the Code of Federal Regulations, Section 1.4, which provides that state laws governing the use or development of real or personal property shall not apply to Indian trust lands.

However, the tribes could choose to adopt state standards for pollution control as tribal ordinances and enforce compliance with the standards by that means.

REGULATING AGENCIES

The various acts and regulations governing uranium development in the San Juan Basin are currently monitored and enforced by numerous agencies, as the partial list given below indicates.

Federal Government

- Department of the Interior
  - Bureau of Indian Affairs
  - Bureau of Land Management
  - U.S. Geological Survey
  - National Park Service
  - Fish and Wildlife Service
  - American Heritage and Conservation Service
- Department of Energy
- Mine Safety and Health Administration
- Occupational Health and Safety Administration
- Department of Agriculture
  - U.S. Forest Service

Nuclear Regulatory Commission

Department of Health and Human Services
    Public Health Service (Indian Health Service)

Department of Treasury
    Division of Alcohol, Tobacco, and Firearms

Environmental Protection Agency

<u>State of New Mexico</u>

- Environmental Improvement Division
- State Engineer
- State Mine Inspector
- State Land Commissioner
- State Bureau of Mines
- State Historical and Archeological Society

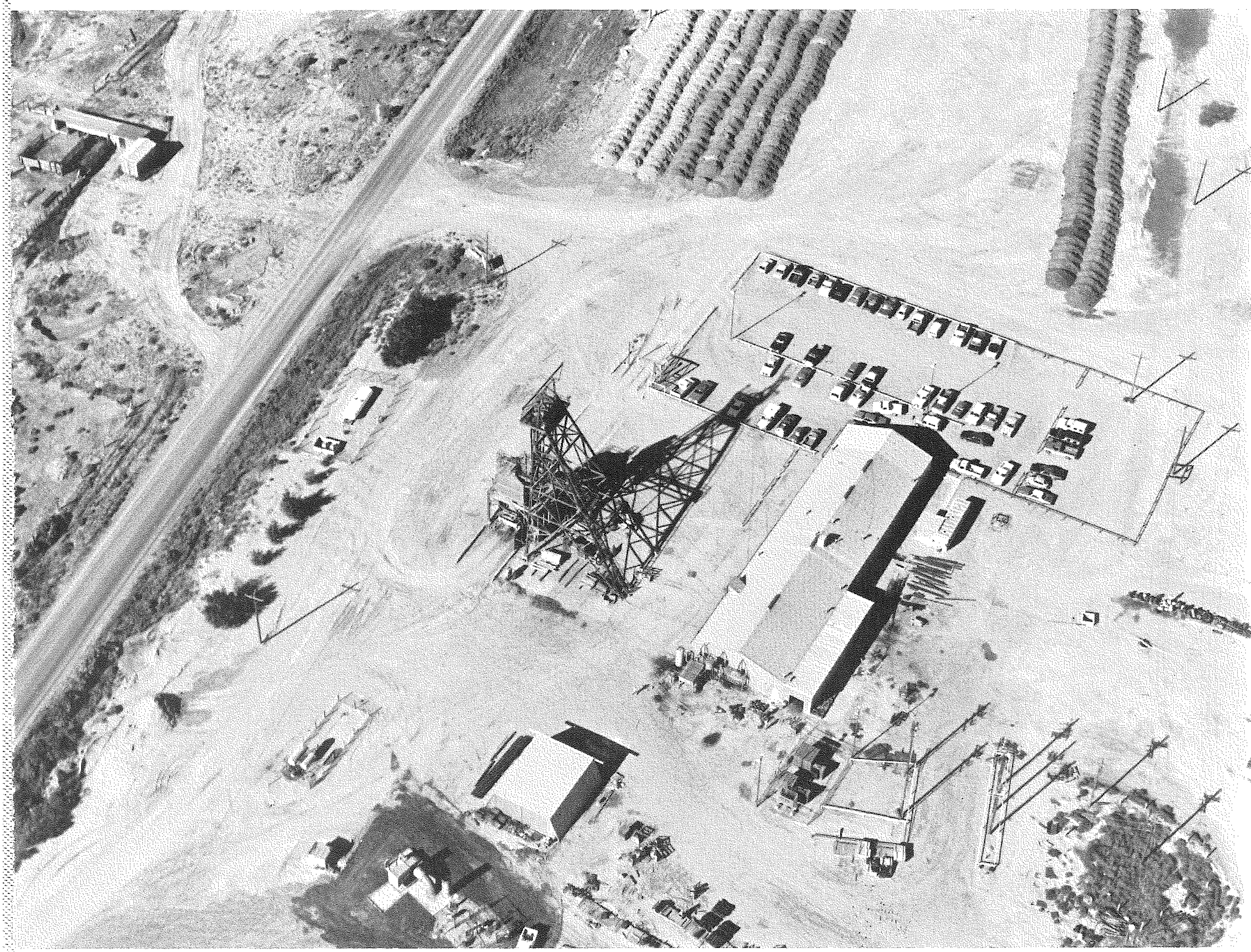
<u>Indian Tribes</u>

- Laguna Pueblo Council
- Navajo Tribal Council
  - Navajo Water Commission
  - Navajo Tribal Minerals Department
  - Navajo Environmental Protection Commission

The responsibilities of each agency are specific but occasionally overlap. Chart XI-1 (in pocket) was prepared in an effort to sort out the various jurisdictions and to provide an aid to understanding of the complexities of legal constraints on uranium development.

CHAPTER XIII

OPTIONS OPEN TO DECISIONMAKERS



Chapter XIII

OPTIONS OPEN TO DECISIONMAKERS

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Chapter XIII

Summary

The study disclosed impacts from current and prospective uranium development in the basin that are felt to merit prompt attention. For example, it found:

--A need for increased research into radon and its effects on humans.

--A need for completion of regulations on radon emissions.

--The lack of a unifying force in the checkerboarded area.

--A need for more environmental monitoring.

--Gaps in existing data and scientific knowledge.

--Inadequate communication with Indian inhabitants by companies, the BIA and Navajo tribe.

--Inability of Navajo communities to incorporate or make planning efforts to meet growth, due to lack of tribal legislation.

--Possible future shortages of municipal operating funds as uranium area towns seek to maintain public services during rapid growth.

Among possible actions to deal with these or other problems, the study team suggests:

--Establishment of a task force to deal with regional conditions.

--Strengthening of environmental enforcement by the BIA, USGS and BLM.

--Increased collection and analysis of basic data, especially pertaining to radionuclides.

--Improved communications with Navajo communities.

--Steps to facilitate planning in Navajo towns.

Chapter XIII

Options Open to Decisionmakers

INTRODUCTION - KEY IMPACTS

When the San Juan Basin Regional Uranium Study began, there were many unknowns concerning the region, its people, and the nature and pace of energy development in their midst. There was the lack of a clear overview of current and potential levels of development and resultant impacts. Fragmented data gave rise to concerns that some types of impacts might be going unmitigated; it was suspected that the checkerboarding of differing land statuses might frustrate easy solutions to problems.

After three years, it is felt that the study has provided the needed overview, along with the likely levels of development, resultant impacts, data gaps, possible solutions, and related information and analyses. Study efforts will be used to augment federal NEPA compliance in the region and as a guide to planning and further research activities. The results are not intended to substitute for further data collection and analysis by the responsible agencies.

Since completion of the study, the study team has observed the growth of other efforts to accumulate baseline data and has confirmed the difficulties introduced by jumbled jurisdiction from land status checkerboarding.

Chart XIII-1 (in pocket) summarizes key impacts, problems, and mitigation suggestions (solutions) outlined or implied in Chapters IV through XII. The chart classifies impacts in two ways: 1) by occurrence at the regional, subregional or site-specific level; and 2) by classification within divisions of the environment, such as air, water, etc. The attention of the reader is called to the complexities of a regional analysis, as suggested by the chart.

The most significant region-wide impacts or problems include overall stress from lack of a central authority able to pull together key actors, fragmented or incomplete data, large scale ground water drawdown and creation of large amounts of surface water, sporadic environmental monitoring, lack of radon regulations covering mine and mill emissions, current uranium production slowdown, drawing of the region into the mainstream of American life, large severance tax income to the state, pressure on public services, and great long-term economic growth potential.

Other impacts such as Navajo community concern become more significant at the subregional or site-specific levels of analysis, with "on-reservation" versus "off-reservation" often the key variable. This is largely due

to differences in culture, laws, and agencies charged with mitigating impacts.

Land and population based impacts are expected to occur in a triangular area running roughly from Shiprock to Gallup, and over to Mount Taylor. This represents an expansion of the current uranium development area to the northwest and center of the study area. (See Maps VII-2 and VII-4). Profits, taxes, and strains on the resources of agencies, governments and companies will occur as far away as Window Rock, Albuquerque, Santa Fe, and Denver.

In general, significant negative impacts are seen as solvable, assuming key actors are willing to devote much attention and stretch their budget resources toward ensuring proper enforcement of laws and regulations, planning, communication, and cooperation, as well as creation of an ongoing data base which is adequate for defining problems. Research to date indicates little risk to residents from radionuclides; however, this subject requires further study before definitive answers can be given.

It must be added that impacts are generally controlled through enforcement of laws and regulations. In the natural environment, discrete numerical impacts are usually covered by specific permits. In the human environment, movement of people can be regulated somewhat by planning and zoning; however, feelings and attitudes cannot be legislated.

In the study area, the Navajo tribe and the State of New Mexico have not passed laws providing overall controls on siting and timing of uranium development as a way to control impacts and population growth. They rely instead on specific permits and local zoning power (off-reservation). NEPA type compliance applies only to Indian lands, to surface disturbance on Bureau of Land Management (BLM) lands, and eventually to all milling activity.

This places the burden of controls on specific enforcement agencies and basin towns, intensifying the need for good regional and subregional data to provide a context for evaluating specific actions.

However, even with existing laws (except for radon emissions) and a possible improvement in data, enforcement agencies have serious problems of understaffing, employee turnover, and lack of necessary budget. These result in sporadic environmental regulation.

KEY IMPACTS NEEDING IMMEDIATE ATTENTION

Below are outlined seven of the most urgent of the key impacts or problems identified by the study. They need immediate attention, if possible. Discussion of the Department of the Interior (DOI) role in pursuit of solutions follows. Other significant impacts or problems of a less immediate nature, along with potential solutions, are noted in Chart XIII-1 and discussed in earlier chapters.

1. Radon Research and Regulations. At the national level, the broader scientific community must press on with the task of developing a

complete understanding of the effects of radon (carried in the air, water and food chain) on the human body. More specifically, the current lack of Environmental Protection Agency (EPA) regulations governing radon emissions inhibits management by environmental agencies. The EPA should be encouraged to remove all administrative barriers to completion of these regulations, although they will be constrained by the pace of needed scientific research mentioned above.

2. Lack of Unifying Force. There is great stress on the entire region from the lack of a central force able to pull together conflicting governments, companies, agencies, organized interests, and residents.

3. Sporadic Environmental Enforcement and Monitoring. This occurs region-wide due to a lack of budget and staff for almost all agencies involved.

4. Data Problems. Region-wide and site-specific impact analysis is hampered by scattered, non-existent or insufficient baseline and emissions data; and gaps in scientific knowledge.

5. Negative Navajo Community Attitudes. Community concern over the implications of uranium development on Navajo tribal and allotted lands points to a lack of communication, information, local control, and local input into uranium development decisions.

6. Impediments to Navajo Town Planning. Local control of town growth is currently not legally possible, either inside the reservation boundary or beyond (Crownpoint).

7. Non-Indian Town Operating Funds Shortage. Off-reservation towns may have serious public service delivery problems due to a potential future lack of municipal operating expense money.

THE ROLE OF THE DEPARTMENT OF THE INTERIOR

Although the Department of the Interior is not the only key actor responsible for addressing the above problems, it is in a unique position to take a major role in the region's environmental enhancement through its various agencies.

As manager of public lands, trustee of Indian lands, and owner of many federal reserves and national parks, the Department controls by far the largest percentage of land in the basin. Much of the impetus for environmental protection comes from national legislation and regulations under which the Department has been given responsibilities. It has also been given responsibilities in the development of energy fuels. In addition, the Department has a primary responsibility for safeguarding Indian interests.

Below are outlined ways the study team feels the DOI could operationally contribute to solving five of the seven pressing impacts identified above: by 1) creating a task force; 2) increasing resources for environmental enforcement; 3) expansion of data gathering, analysis and research;

4) increased communication with Navajos; and 5) consideration of reservation town growth problems. These efforts will require reallocation of budget and staff to the area.

The study is also including suggestions and recommendations directed toward the Navajo tribe. Although the tribe is a sovereign entity, the Department's trust responsibility through the Bureau of Indian Affairs (BIA) requires close cooperation and coordination. Other solutions lie with other agencies and authorities, which should receive maximum cooperation from the Department of the Interior.

POTENTIAL DOI SOLUTIONS TO KEY IMPACTS AND PROBLEMS

I. TASK FORCE FOR REGIONAL COORDINATION AND IMPACT MANAGEMENT

Impact or Problem. There are signs of great personal, organizational and potential ecological stress on northwest New Mexico from uranium and energy development due to lack of a central force capable of pulling together companies, governments, organized interests, and residents. This leaves them less able to resolve conflicting goals, procedures, and jurisdictional claims, and without a central, comprehensive source of objective information as to levels of development and resultant impacts. The result is slow, piecemeal solving of environmental problems.

Impediments to Solutions. A search for a central authority reveals two sometimes conflicting sovereign entities in the region, the State of New Mexico and the Navajo tribe. EPA permitting and Nuclear Regulatory Commission (NRC) licensing overarches but does not provide leverage for cooperation. National legislation would be necessary to create the possibility of a "compact" between governments for impact management, similar to various interstate commissions. Also, neither the tribe nor state has laws creating broad controls over industry. Thus the burden is placed on voluntary cooperation between all entities. (The DOI has authority to bring the BIA, BLM and U.S. Geological Survey [USGS] together, with close ties to the Navajo tribe and the State of New Mexico.)

Solution: Task Force. Key actors in uranium development should foster a task force coordinating a cooperative effort toward impact management in northwest New Mexico. This could be pursued by the Department of the Interior at the Secretarial level. It could involve all parties involved in development at a maximum, or relevant Department agencies at a minimum. The focus could be solely on uranium or expanded to include all forms of energy development.

The task force could coordinate data gathering problems and enforcement responsibilities, clarify conflicting goals, and create common understanding. With the dissolution of the San Juan Basin Regional Uranium Study, this group could coordinate its updating among various agencies. Other functions could include sponsoring a study of all energy development in the area, expediting the permitting process, and addressing the issue of simplifying problems associated with checkerboarded land status.

I. TASK FORCE, cont.

One possible model would include:

Department of the Interior
- USGS Mine Supervisor
- BIA Area Director(s)
- BLM State Director
- Secretary's Representative

State of New Mexico, Governor's Representative

Navajo Tribe (and others deemed necessary), Chairman's Representative

Industry Representatives

Other region-wide and national efforts that should be noted: 1) the newly formed McKinley and Western Valencia County Energy Planning Council, representatives from energy companies laying the groundwork for future co-operative projects with local governments; 2) Senate Bill 2728 calling for an intergovernmental task force monitoring nuclear resource development health hazards as they relate to Indians (Department of Energy [DOE], EPA, Occupational Safety and Health Administration [OSHA], DOI, Health and Human Services [HHS]).

Resources Needed - Minimal. Staff time.

Outcome - Increase in trust, and more efficient and faster solving of environmental problems.

Other Relevant Agencies. These include NRC, EPA, DOE, HHS or Indian Health Service (IHS-PHS), New Mexico Environmental Improvement Division (EID), New Mexico State Engineer, New Mexico Department of Finance and Administration (Planning Division), counties, towns, companies, citizen interest groups, Laguna tribe, Acoma tribe.

II. STRENGTHENING OF ENVIRONMENTAL ENFORCEMENT: Agency Staffing, Laws and Regulations

Impact or Problem. Perhaps the most urgent of the seven impacts listed earlier is sporadic environmental monitoring and enforcement of laws and regulations throughout the region. This is largely caused by a lack of budget and staff to meet current expanding and potential future demand on almost all active agencies: the BIA, USGS, Navajo Tribal Environmental Protection Commission (EPC), and State of New Mexico EID.

Also, there is a need for regularization, consolidation and coordination of environmental administrative prcedures within the BIA and between the BIA and USGS. The roles of BIA and the tribe (perhaps the EPC?) need to be clarified relative to EPA permitting and NRC licensing on tribal and allotted lands. All of the above is aggravated by checkerboarding of Indian and non-Indian lands, and employee turnover and recruitment problems.

It must be remembered that the study's conclusions regarding impacts on the natural environment assume adequate enforcement of current laws and

regulations. Lack of overall siting and timing controls over uranium development by the tribe and state places an increased emphasis on individual permits and specific procedures and agencies.

Problems associated with data gathering and analysis required by monitoring are treated in the next section. This section pertains to administration, laws, and regulations only.

Impediments to Solutions. Jurisdictional concerns preclude having one common environmental authority over Indian-checkerboarded land. The checkerboard area is a mix, at the surface and subsurface levels, of tribal allotted, public domain, state, and private land.

Basic federal anti-pollution laws apply to all lands; NPDES permits, Clean Air Act, NRC licensing. The tribe and BIA must officially oversee the monitoring and enforcement of these laws on Indian lands and be the ones to explicitly delegate these powers to an agency. The State of New Mexico EID enforces these laws on all other lands.

Specific federal laws pertaining to Indian land and minerals are enforced by the BIA and USGS. The BLM enforces special federal laws applying to public lands and minerals. State laws are enforced by the state on non-Indian land only and tribal laws on tribal lands, with many unanswered questions regarding tribal authority over allotted lands.

The BIA has particular difficulty in hiring environmental expertise due to early retirement for non-Indian employees, current lack of technically trained Indian applicants for Indian preference hiring, and relative isolation of the reservation.

Solutions (By Agency).

1. BIA - Navajo Area and Crownpoint: More Monitoring Staff. Increasing demands for BIA environmental monitoring (rights of way, permits, lease compliance, damage claims, environmental analysis and EIS's, and oversight of USGS supervision of mining operations) puts great pressure on the Division of Resources Management. This monitoring, including environmental analysis, permitting, and enforcement, is part of BIA's trust responsibility and is performed on both tribal and allotted lands. This agency and its offices must be given the resources to strengthen its staffing and technical capacities.

   BIA: Regularized Administrative Procedures. Environmental review, monitoring, and enforcement should be consolidated as much as possible. A mechanism or set of procedures should continue to be devised regularizing and coordinating these functions within the BIA, linking to human services departments, with the USGS and the Navajo tribe.

BIA: Laws and Regulations. (See also "IMPROVING NAVAJO COMMUNITY RELATIONS" and "NAVAJO TOWN PLANNING.") The BIA needs to determine its position regarding oversight of EPA and NRC licensing and permitting on allotted lands, look into obtaining EPA funds, determine who has the authority, the BIA or tribe, to enforce these functions on allotted lands, and assist the Navajo tribe (EPC) with the above on tribal lands.

Real Property and Environmental Quality staff members would be well-advised to continue to seek ways to strengthen leases as an environmental mitigation tool by such means as including measures currently found in the USGS mine plan.

BIA: Community Relations. (See also "IMPROVING NAVAJO COMMUNITY RELATIONS.") The BIA should develop a visible monitoring presence in the community and, with the DOI Solicitor, increase its capacity to handle claims of environmental damage and lease violations promptly; and support the Eastern Navajo Land Commission in its claim settling efforts.

Resources Needed - Budget for staff and contracting, and special recruitment help to overcome problems of Indian preference hiring.

Outcome - Contribution to regularizing the monitoring function over Indian land.

2. USGS - Albuquerque: More Monitoring Staff. The USGS Conservation Division Mining Office needs budget and resources to expand its staff to handle an increasing workload. Most important, the office should have more staff to allow it to collect its own data for lease and mine plan enforcement purposes on Indian land rather than relying solely on company-provided data, as it now does.

USGS - BIA Relationship. Not only should BIA oversight of mine plans be strengthened, but also the USGS should consult frequently with the BIA (and tribe) regarding the complexities of operating on Indian lands, especially Indian law and community relations. Also, the USGS will have a major enforcement presence on Indian lands and can fill gaps for the BIA and tribe.

Resources Needed - Budget and staff.

Outcome - Stronger USGS enforcement position regarding leases and mine plans.

3. BLM, BIA, USGS: Cooperative Agreement. A cooperative agreement between these three agencies, and new BLM regulations covering surface disturbance and reclamation from uranium mining would cover a large percentage of land in the basin.

Resources Needed - Minimal.

Outcome - More efficient broad-based monitoring. Some consolidation of checkerboarding.

4. BLM: Land Exchanges. Land exchanges and clarification of title should be encouraged to consolidate checkerboarding of land. Forthcoming regulations for 43 CFR 3809 allow the BLM to take firmer control of federal minerals, requiring reclamation of uranium related surface disturbance on public lands and NEPA review.

   Resources Needed - Budget and staff.

   Outcome - More efficient monitoring of impacts. Extension of monitoring over surface disturbance on public lands.

5. National Park Service: Enforcement staff. The NPS suggests the need for enforcement staff by all agencies having archeological site protection laws: BIA, BLM, state, tribe, etc.

   Resources Needed - Budget and staff.

   Outcome - Application of laws and the preservation of archeological sites.

6. Navajo Tribe: Strengthening Environmental Monitoring. It is suggested that the tribe consider strengthening its environmental monitoring role, possibly through securing and allocating funds to such agencies as the Tribal Environmental Protection Commission and also determining the tribal position regarding oversight of EPA permitting and NRC licensing on tribal lands. The Environmental Protection Commission might be used to carry out specific enforcement duties.

   Resources Needed - The tribe should continue to seek support from the BIA and USGS, including technical support, data gathering backup, and possible budget resources. The tribe should obtain EPA funds for monitoring directly and not through the State of New Mexico.

   Outcome - Regular and broad-based environmental monitoring on Navajo tribal lands. Control over major permitting in the area in the hands of the tribe as a sovereign entity.

Navajo Tribe: Comprehensive Control of Development. The tribe should consider adopting land use codes or some type of authority to control siting and timing of uranium and other development on tribal lands. This should be backed up with a cost/benefit analysis of alternate resource usage scenarios on tribal lands.

Outcome - Overall subregional control of development and resultant impacts.

Navajo Tribe: Environmental Review. The tribe might consider instituting an environmental review process involving the Tribal Council, going beyond federal NEPA compliance. This, plus more active tribal involvement in the federal NEPA process, would help provide data to augment overall controls suggested above.

Outcome - Broader review of environmental monitoring on tribal lands to ensure efficiency and thoroughness.

Navajo Tribe: Land Exchanges. The tribe should continue to pursue exchange and purchase of lands.

Outcome - Consolidation of checkerboarding.

Navajo Tribal Water Commission: Water Code. The Commission is encouraged to continue development of a tribal water code and water rights permitting system for tribal water rights. The tribe is currently in litigation over water rights with the State of New Mexico.

Outcome - Control of water use and depletion in accord with the goals of the Navajo Tribe.

Other Relevant Agencies. Providing technical assistance, cooperation, or funding: NRC, EPA, DOE, State of New Mexico.

III. INCREASED DATA GATHERING: Impact Monitoring, Data Bank, Research

Impact or Problem. Region-wide, subregional and site-specific impact analysis is hampered by scattered, non-existent or insufficient baseline and emissions data and gaps in scientific knowledge. There exists a region-wide need for expanded and regularized collection of baseline data and ongoing centralization and sharing of existing and future data.

Specifically, for the natural environment, there should be expanded and regularized collection of background and emissions data, especially pertaining to radionuclides; for the human environment, a permanent capability to model population growth and human services needs is needed. There is also the need for an ongoing capacity to track and forecast energy development for the area.

Scientific research is needed concerning the patterns of transport and chemistry of radionuclides in air, water, and biota. Scientific study is also desirable to spell out alternatives for beneficial use of potentially large amounts of surface water discharged from uranium mines. Air-radon emissions impacts should be remodeled for the Crownpoint area as new data emerges.

Impediments to Solutions. Multiple under-funded agencies have had to stretch scarce data gathering resources with unclear or conflicting guidelines as to their jurisdiction in the checkerboard area. Data are collected for one organization's goals and may be incompatible for use by others. The issue of tribal desires for confidentiality may hamper sharing of some USGS data.

The lack of broad controls over siting and timing of uranium development in the area puts the burden of control of regional impacts on each specific permit or mine plan, raising the importance of good data and analysis for each site and its regional context.

Solutions (By Agency). The study recommends the expansion of individual BIA, USGS, and EPC environmental monitoring staff to collect baseline (background and emissions data) and analyze impacts, especially pertaining to radionuclides. It also suggests expansion of BIA staff to collect data pertaining to attitudes, population, and human services needs.

The study also recommends a consolidation of this information in a USGS natural science data bank and a BIA data bank for the human environment. Specific types of data gathering and research topics are suggested below.

The study has observed that baseline data collection for the natural sciences is beginning or scheduled, but in a fragmented manner, with ad hoc communication as to what is being done between the BIA, PHS, EPC, USGS, EID, and EPA.

1. USGS - Albuquerque: More Monitoring Staff. The study term sees an urgent need for more staff and budgetary resources for the USGS Conservation Division Mining Office to allow it to collect baseline and emissions data and perform its own impact analysis rather than rely on company provided data as it now does for lease and mine plan enforcement on Indian lands.

   USGS: Baseline Data Gap Filling. Increased staffing would begin to allow for data collection in all areas of the environment: air, water quantity and quality, (surface and subsurface: streams, wells, aquifers, mine discharge) and biota, as deemed necessary. On-site data collection, before and after lease issuance, should be broadened into off-site data collection both for monitoring purposes and to fill regional baseline data gaps in geographic areas most likely to experience future uranium development.

   With increased staff, the USGS could provide data backup to the BIA and EPC as they expanded their roles and staff, and to other agencies issuing licenses and permits in the area.

   Expanded monitoring should also include extensive on-site and off-site data collection regarding in situ leaching and identification of abandoned mine sites on Indian lands.

Resources Needed - Increased budget and staff for USGS Conservation Division Mining Office at Albuquerque.

Outcome - Expansion and regularization of baseline and impact data collection for a large percentage of the basin, and data collection backstopping of other agencies while they seek expanded resources would lead to more efficient and rapid definition of impacts and needed solutions.

USGS - Albuquerque: Data Bank - Natural Sciences. The USGS is the logical choice for this project due to its technical capabilities as a research organization and its mandate to collect uranium-related impact data as part of lease and mine plan monitoring on Indian lands. The USGS also has access to federal lands and works with the Navajo tribe, other DOI agencies, and the State of New Mexico. (Further elaboration of this idea can be found in Buchanan, 1980, No. 71.)

Operationally, the data base might consist of a library of uranium-related documents, a geographically based computer storage and retrieval system for all data, and regularly and widely disseminated bulletins. This system could be modeled after "A Methodology for Post-EIS Monitoring" (Marcus, 1979). This system would build upon the current impact data base from planned USGS off-site and on-site monitoring, with materials added from other contributing agencies and companies. Possible areas covered are listed below.

1. Radiation levels in the air, water, soils, plants, and animals in the basin.
2. Air quality.
3. Water: surface water flow and quality, sediment loads, ground water flow and quality; refine and expand USGS water quantity model.
4. Land: locations of abandoned, active and planned mines and mills and other active and planned energy development; land areas disturbed and reclaimed for mines and mills; volumes of mine and mill waste material.
5. Inventory of all active monitoring programs in the basin area.
6. Hook up to the NPS basin-wide data bank of archeological sites.
7. Computer model based on a refined version of the San Juan Basin Regional Uranium Study methodology for projecting future exploration, mine and mill sites and resultant outputs (emissions, number of workers, etc.) impacting the area.

Regular bulletins derived from the data base could be distributed widely to all key actors and institutions involved in uranium development.

Problems in implementing the above would arise from incompatibility of different agencies' research methodologies and computer storage techniques. Matching funds could be given to encourage compatibility.

Resources Needed - Budget and staff from USGS.

Outcome - A savings in staff time and expenses for data collection could be expected. Rapid data retrieval and data gap identification, plus rapid ability to evaluate the efficiency of the current monitoring network should lead to faster identification and mitigation of impacts at both site-specific and regional levels of analysis.

USGS: Water Quality Research. Primary research is needed to establish patterns between variables for better understanding of baseline data collection and for impact analysis. The USGS could contribute by performing research 1) delineating the relationship of uranium drilling and mining to interaquifer and intra-aquifer pollution; 2) into transport or migration of chemical constituents in mine water in abandoned mines; 3) into the mechanisms or reactions affecting chemicals in mine water, especially radionuclides, as it percolates through surface stream beds and underground alluvium; and 4) into the local and subregional effects of in situ leaching.

Resources Needed - Budget for staff and contracts.

Outcome - The above research would provide analytic data for more accurate impact analysis, especially as it helped define problems associated with human consumption and use of water.

2. BIA - Window Rock - Crownpoint: More Monitoring Staff - Data Collection. More staff will be needed by the Division of Resources Management, Real Property and Environmental Quality, to collect data needed for increased activities detailed for the BIA under "Strengthening of Environmental Enforcement".

Resources Needed - Budget and staff.

Outcome - Sufficient data for impact management.

BIA - Window Rock: Data Bank - Human Environment. The BIA should develop a data base for the human environment parallel to the suggested USGS effort for the natural environment. Such a data base could consist of a computerized population model for on and off reservation towns, with the resultant human services needs. This data would be immediately available for town planning efforts and EIS's.

Resources Needed - Budget for staff and contractor research.

Outcome - More effective definition of and solutions to human services problems on Indian lands.

BIA: Research to Update SJBRUS. If the task force alluded to earlier is not formed, the BIA should take the lead in updating the San Juan Basin Regional Uranium Study, for the purpose of continuing to provide an overview of regional impacts.

Resources Needed - Budget for staff and contractor research.

Outcome - Continuing definition of regional impacts in the face of fluctuations in the uranium industry.

BIA: Boomtown Research. It is suggested that research be funded to explore the special nature of a hypothetical Indian boom town and resultant problems, to supplement "boomology" research for non-Indian towns.

Resources Needed - Budget for staff and contractor research.

Outcome - More effective definition of and solutions to human services problems on Indian lands.

BIA: Remodeling of Air Impacts. The BIA should consider remodeling San Juan Basin Regional Uranium Study radon-related air impacts for the Crownpoint subregion, using new baseline and emissions data. The BIA might well become an advocate for more research and baseline data collection relative to radon in the air.

Resources Needed - Budget for contract.

Outcome - More definitive look at possible radon air pollution problems due to potential placement of mine vents and tailings piles in more heavily inhabited regions, e.g. Crownpoint.

BIA - PHS: Food Chain and Radon Research. The BIA should follow closely the PHS's efforts to obtain resources for food chain research and data collection on the Navajo reservation and the development of more specific mine vent radon emissions data. The BIA should provide advocacy assistance and request backup help from the USGS if necessary.

Resources Needed - Staff time.

Outcome - Decrease in food chain data gap and possible analysis of this impact on Indian lands.

BIA - Navajo Tribe - Window Rock: Alternate Energy Usage Scenarios. The BIA and Navajo tribe should consider studying the financial, social and environmental costs of alternate ways of developing tribal resources, considering tribal goals, objectives, and constraints.

Resources Needed - Budget and staff.

Outcome - Information vitally needed for economic planning purposes.

3. BIA - USGS - BLM: Study of All Energy Development. These three agencies should consider looking at impact oriented interrelationships of all forms of energy development for northwest New Mexico.

Resources Needed - Budget and staff.

Outcome - Combined understanding of major region-wide impacts.

4. BLM: Contributions to Data Bank. The BLM can contribute land use planning, range and water information, coal-related baseline and impact data, and uranium related surface impact data to the proposed USGS data bank.

Resources Needed - Staff.

Outcome - Better data coverage of checkerboard area for impact analysis.

5. Bureau of Mines: Technical Research. The Bureau of Mines should be encouraged to do technical research to improve mine ventilation (radon removal) equipment and radon monitoring devices. The Bureau's manpower could also assist the USGS in inventorying abandoned mine sites on Indian lands.

Resources Needed - Funds for research, staff time for inventory.

Outcomes - More cost-efficient elimination of radon in the air near mine sites. Better idea of scope of problem of abandoned mine sites and ore piles.

Bureau of Mines: Typical Uranium Development "Outputs". The Bureau of Mines could also pursue development of standard or average "outputs" (events, emissions, expenses, manpower, etc.) of uranium development activities to assist in future impact analysis.

Resource Needed - Budget and staff.

Outcome - Better standards for more refined impact analysis.

6. Water and Power Resources Service: Water Use Study. In conjunction with the BIA and USGS, this agency should consider a study of beneficial uses of surface water produced by uranium mining. The study should consider all of the goals and objectives of northwest New Mexico, the Navajo tribe and the allottees separately.

   Resources Needed - Contractor grant money and staff time.

   Outcome - The above would help provide data to encourage more efficient use of water as a byproduct of uranium mining.

7. Navajo Tribe: Impact Monitoring Data Collection Staff. If the Navajo tribe assumes EPA permitting and NRC licensing functions and enforcement of any tribal codes, an increase in staff for data collection and analysis will be necessary.

   Outcome - Development of data collection capacity to enhance tribal sovereignty over environmental regulation.

Other Relevant Agencies. Cooperative collection of baseline data: PHS, EID, State Engineer, State Mine Inspector, New Mexico Department of Finance and Administration, Councils of Governments, counties, cities, companies. Cooperation with or funding of local research: NRC, EPA, DOE, HHS (PHS), Economic Development Administration, EID, State Engineer.

IV. IMPROVING NAVAJO COMMUNITY RELATIONS: Communication, Local Control

Impact or Problem. Community concern on the Navajo reservation and in allotted areas has been generated by the presence of uranium development activities.

Impediments to Solutions. Lack of local community control or structured input into the uranium development process.

Solutions (By Agency).

1. BIA - Window Rock and Crownpoint: Resources for Community Relations. The Division of Resources Management and the Crownpoint Agency should be given more staff to handle this aspect of mineral and energy development, especially to deal with the day to day informational needs of community people. An education program, covering the leasing process, technology of uranium development and impacts, and mitigation measures applicable to differing land statuses would be helpful. BIA circulation of the audio-tape cassette portraying findings of the San Juan Basin Regional Uranium Study in Navajo (George, 1980, No. 61) is suggested.

Federal regulations covering allottee leasing should allow at least for maximum allottee involvement in the leasing process, since there is little chance of a legal mechanism to allow for community input outside the exterior boundary of the reservation. BIA and tribal leases might contain clauses governing company conduct and ways companies could contribute to local communities, as well as explicit plans and responsibilities covering accidents and emergencies. Rapid BIA response to lease violation claims against companies would also be helpful, as well as close BIA cooperation with the Eastern Navajo Land Commission.

It would also be helpful if BIA (and the tribe) could provide an orientation for companies planning to operate on Indian lands, considering such things as the legal and political meaning of sovereignty, community dynamics, and the importance of affirmative action hiring and management.

BIA or tribal sponsored case studies of different Navajo communities' reactions to uranium development could lead to further mitigation insights.

Resources Needed - Budget for staffing, contracting and technical assistance from DOI will be necessary.

Outcome - There is the possibility of more reasoned consideration of uranium development, and less chance of fear, manipulation, and community dissention.

2. Navajo Tribe: Local Control. The tribe might be encouraged to explore a way of allowing community input into the decision to develop tribally leased or owned uranium in a specific area.

Outcome - Some local control of development may slow or reduce economic return to the tribe, but would reduce the instability of political dissent.

V. NAVAJO TOWN PLANNING: Impediments Needing Study

Impact or Problem. Currently, there is no legal mechanism on the Navajo reservation or in the allotted area that allows an urbanizing locale to become a town and control its own growth in the face of an influx of non-local residents.

Impediments to Solutions. Any new tribal law allowing for local community incorporation or planning and zoning powers would not extend beyond the disputed exterior boundary of the Navajo reservation. (Any tribal laws encumbering property do not apply beyond the exterior boundary of the reservation.) This leaves some allotted areas such as Crownpoint with only the BIA trust approval over individual allottee real property decisions.

Solutions (By Agency).

1. BIA, DOI, Navajo Tribe Window Rock: Joint Study. The BIA, the DOI Solicitor and the tribe should jointly study the legal and governmental complexities of this problem and see if a mechanism for zoning or incorporation can be derived for reservation and allotted lands. Meanwhile both federal and tribal agencies need to develop population growth data and any ad hoc method possible to promote cooperative efforts to deal with growth. (Also, problems of state versus tribal law enforcement jurisdiction in the checkerboard area need attention. The collapse of cross-deputization leaves the area without adequate police protection.)

   Resources Needed - Commitment of staff time, funding, and a planning position in Crownpoint.

   Outcome - Reduction of boom type growth impacts either marginally or overall.

2. BIA - PHS - Navajo Tribe: Budget Shifts. The BIA, PHS, and the Navajo tribe should be prepared for the need for rapid budget shifts to the Eastern Navajo area that might be necessitated by inmigrating Navajo families.

   These agencies should keep a close watch on and fund Crownpoint PHS outpatient facilities, Shiprock fire apparatus, Crownpoint and Shiprock social services and law enforcement, and the entire Eastern Navajo road system. Adequate data should be collected for budget advocacy.

   Resources Needed - Budget and staff, federal and tribal.

   Outcome - Keeping up with increased demand for human services, and avoiding boomtown conditions.

SUMMATION

As mentioned earlier, this analysis focuses on what the Department of the Interior might contribute toward solving those impacts or problems deemed by the San Juan Basin Regional Uranium Study to merit prompt attention. (See Table XIII-1). Efforts would largely involve organized cooperation between the BIA, BLM and USGS; more budget for staff, baseline and impact data gathering and research for the BIA and USGS; and more BIA and USGS technical assistance and information giving support to the Navajo tribe and local communities.

Table XIII-1

Solutions Recommended to Department of the Interior and Navajo Tribe - Most Pressing Impacts

Department of the Interior:

Secretarial Level
- Create uranium task force for northwest New Mexico.

BIA, BLM, USGS
- Cooperative monitoring.

Bureau of Indian Affairs
- Fund more staff and expand monitoring activity.
- Work out role with EPC, EPA, NRC.
- Assist EPC in securing more resources.
- Strengthen leases.
- Increase communication with local people; education programs.
- Create Human Resources Data Bank and monitor human services needs.
- Budget shifts for town growth.
- Fund research on nature of Indian boomtowns.
- Re-model "air pollution" for Crownpoint.
- Update SJBRUS.
- Address town planning problems.
- Track food chain & radon related research.

U.S. Geological Survey
- Increase monitoring staff and activities.
- Provide backup for BIA and EPC.
- Create Data Bank for Natural Sciences.
- Research water-related impacts.

Bureau of Land Management
- Continue land exchanges.
- Develop uranium impact monitoring.
- Clarify title to checkerboard land.

Bureau of Mines
- Research mine vent technology.

Water and Power Resources Service
- Study beneficial use of water.

National Park Service
- Assist in increase of enforcement capacities for preservation of archeological sites.

Navajo Tribe:

Tribal Council
- Consider creating an environmental review process.
- Explore local control of development.
- Increase communication with locals.
- Consider codes for town planning and government.
- Consider developing Tribal water codes.
- Expand environmental monitoring.
- Consider codes controlling timing and siting of development.
- Budget shifts for town growth.

Environmental Protection Commission
- Secure more staff and resources.
- Resolve role with EPA, NRC, and BIA.

Navajo Water Commission
- Study development of water codes and water rights permitting system.

PART 5

APPENDIX

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GLOSSARY

Acre foot--The quantity of water required to cover one acre to a depth of one foot. It is equal to 43,560 cubic feet or 325,851 gallons.

Alluvium--Clay, silt, sand, gravel, etc., deposited by running water.

Alpha particle--A positively charged particle emitted by certain radioactive materials. It is made up of two neutrons and two protons bound together, hence is identical to the nucleus of a helium atom. It is the least penetrating of the three common types of radiation (alpha, beta, gamma) emitted by radioactive material, being stopped by a sheet of paper. It is not dangerous to plants, animals, or man unless the alpha-emitting substance has entered the body.

Ambient--A term referring to conditions in the vicinity of a reference point, usually related to the physical environment (e.g., the ambient temperature is the outdoor temperature).

Aquifer--A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield a significant quantity of water to wells or springs.

Atom--A particle of matter indivisible by chemical means. It is the fundamental building block of the chemical elements. There are about six sextillion (6 followed by 21 zeros, or 6×10^{21}) atoms in an ordinary drop of water. An inner core (the nucleus) is composed of protons and neutrons, while one or more much smaller electrons orbit the nucleus.

Backfilling--A reclamation technique which returns the spoils to mined cuts or pits.

Background level--In air pollution studies, the concentration of a pollutant that would exist in the absence of the particular source under study; a "standard" against which the contribution of the particular source can be compared.

Background radiation--The radiation in man's natural environment, including cosmic rays and radiation from the naturally radioactive elements.

Baseline projection--For this study, the changing environment in the San Juan Basin region from the present through 2000 assuming that no additional uranium development were to occur and existing development were to wind down naturally.

Basin--A geologic or land-surface feature which is lower in the center and higher at the sides. Geologic basins may be filled with sediment and not visible from the surface.

Beneficial use of water--The use of water by man for any purpose from which benefits are derived, such as domestic, municipal, irrigation, livestock, industrial, power development, and recreation. Under the New

Mexico constitution beneficial use is the basis, the measure, and the limit of the right to use water; therefore, beneficial use of public water diverted or impounded by manmade works is an essential element in the development of a water right.

Beta particle--An element particle emitted from a nucleus during radioactive decay, with a single electrical charge and a mass equal to 1/1837 of that of a proton. A negatively charged beta particle is identical to an electron. Beta radiation may cause skin burns, and beta-emitters are harmful if they enter the body. Beta particles are easily stopped by a thin sheet of metal.

Biota--The animal and plant life of a region.

Breeder reactor--A nuclear reactor that produces more fissile material than it consumes.

Brine--Water saturated with salt; a strong saline solution.

Btu--(British thermal unit) The amount of energy necessary to raise the temperature of one pound of water by one degree Fahrenheit, from 39.2 to 40.2 degrees Fahrenheit.

Checkerboard--An area in western New Mexico consisting of a mixture of federal, state, Indian and private ownership and jurisdiction.

Climax--(A) A relatively stable stage or community of plants that is achieved through successful adjustment to the environment, (B) the final stage in ecological adjustment.

Coal gasification--The process of coal mining and the subsequent chemical conversion to a high-Btu, clean-burning, sulfur-free, substitute natural gas.

Colorado Plateau--A physiographic province covering approximately 390,000 square kilometers in Arizona, Colorado, New Mexico, and Utah. The San Juan Basin is part of the Colorado Plateau.

Cubic foot per second (ft^3/s or cfs)--The rate of discharge representing a volume of one cubic foot of water passing a given point during one second. It is equivalent to 7.48 gallons per second, or 448.8 gallons per minute.

Cultural resources--All evidences (structures, fields, skeletal materials, artifacts, environmental data) which can be used to reconstruct prehistoric and historic lifeways, interpret human behavior, and predict future courses of cultural and biological evolution. Also, districts, structures, objects, etc., important to a culture or community for traditional, religious, educational, or interpretive reasons.

Curie--A curie measures the radioactivity level of a substance; i.e., it is a measure of the number of unstable nuclei that are undergoing transformation in the process of radioactive decay. One curie equals the

disintegration of 3.7 x 10^{10} (37 billion) nuclei per second, which is approximately the rate of decay of one gram of radium.

Daughter--A nuclide formed by the radioactive decay of another nuclide, which in this context is called the parent.

Decay, radioactive--The spontaneous transformation of one nuclide into a different nuclide or into a different energy state of the same nuclide. The process results in a decrease, with time, of the number of the original radioactive atoms in a sample. It involves the emission from the nucleus of alpha particles, beta particles (or electrons), or gamma rays; or the nuclear capture or ejection of orbital electrons; or fission.

Depletion (water)--Water supply consumptively used and no longer available as a water source.

Detrital--Made up of loose material resulting from disintegration or wearing away.

Discharge--Rate of flow at a given instant in terms of volume per unit of time. With respect to water underground, the movement of water out of an aquifer.

Dissolved solids--Chemical compounds in solution.

Drainage basin--A part of the surface of the earth that is occupied by a drainage system, which consists of a surface stream or body of impounded surface water together with all tributary surface streams and bodies of impounded surface water.

Dose--An amount of radiation absorbed.

Dose commitment--The total dose that an organism is expected to receive in its lifetime from a given quantity of radioactive material deposited in the body.

Drawdown (ground water)--The depression or decline of the water level or potentiometric surface in a pumped well or in nearby wells caused by pumping. At the well, it is the vertical distance between the static and the pumping level.

Ecology--The totality or pattern of relations between organisms and their environments.

Ecosystem--The complex of a community and its environment functioning as an ecological unit in nature.

Effluent--Waste material discharged into the environment.

Electron--An elementary particle consisting of a charge of negative electricity and having a mass when at rest of 1/1837 that of a proton.

Element--Any of more than 100 fundamental substances that consist of atoms of only one kind and that singly or in combination constitute all matter.

Energy--The capability of doing work.

Enrichment--The process by which the percentage of the fissionable isotope U-235 is increased above that contained in natural uranium.

Ephemeral stream--A stream or portion of a stream which flows only in direct response to precipitation.

Evapotranspiration--The process by which water is returned to the air through direct evaporation or by transpiration of vegetation.

Fissile material--Uranium-233, uranium-235, or plutonium-239. A label for an atom that will fission upon absorption of a low energy neutron.

Fission--The splitting of an atomic nucleus, resulting in the release of energy.

Fluvial--Of or pertaining to a river or rivers. Produced by the action of a stream or river.

Food chain--An arrangement of the organisms of an ecological community according to the order of predation in which each uses the next usually lower member as a food source.

Fossil fuels--Coal, petroleum, and natural gas; this term applies to any fuels formed from the fossils of plants and animals that lived eons ago.

Fugitive dust--A type of particulate emission made airborne by forces of wind, man's activities, or both, such as unpaved roads, construction sites, tilled land, or windstorms.

Fusion--The combining of certain light atomic nuclei to form heavier nuclei resulting in the release of energy.

Gamma radiation--Short-wavelength electromagnetic radiation emitted in the radioactive decay of certain nuclides. Gamma rays are released energy belonging to the same family of electromagnetic radiation as light, ultra violet, radio waves, etc. X-rays are also quanta of gamma radiation produced in a little different way. The energy of both is expressed in electron volts or more normally millions of electron volts (MEV).

Gaging station--A particular site on a stream, canal, lake, or reservoir where systematic observations of gage height or water discharge are obtained. A streamflow gaging station is a gaging station on a stream.

Gravity model--An analysis which uses a computer program based upon mathematical equations to distribute population over a geographic area.

Gross alpha--The total rate of alpha particle emission from a sample, without regard to energy distribution or source nuclide.

Gross beta--The total rate of emission of beta particles from a sample, without distinguishing energy distributions or source nuclides.

Habitat--A specific set of physical conditions that surround the single species, a group of species, or a large community. In wildlife management, the major components of habitat are considered to be food, water, cover, and living space.

Half-life--Time required for a radioactive substance to lose 50 percent of its activity by decay. Each radionuclide has unique half-life.

Headframe--The framework erected over the mine shaft to support pulleys on which the shaft elevator cables ride.

Hydraulic gradient--The rate of change of water pressure or head with distance in the direction of flow.

Hydrocarbon--Any of a large class of organic compounds containing only carbon and hydrogen, comprising paraffins, olefins, members of the acetylene series, alicyclic hydrocarbons (such as cyclic terpenes and steroid hydrocarbons), and aromatic hydrocarbons (such as benzene, nephthalene, and biphenyl), and occurring in many cases in petroleum, natural gas, coal, and bitumens.

Igneus--Resulting from the intrusion or extrusion of molten magma or volcanic activity.

Ion--An atom or group of atoms that carries a positive or negative electric charge as a result of having lost or gained one or more electrons.

Ion exchange--A phenomenon in which ions in one phase or material exchange with related ions in another phase. In this report, ion exchange usually refers to a particular process in an aquifer or treatment plant: the exchange of ions in the water for ions in or on the rocks or treatment media.

Ionization--The process by which a neutral atom or molecule acquires a positive or negative charge.

Infrastructure--The underlying foundation or basic framework of a system or organization including delineation of the internal structure and relationships.

Internal radiation--Radiation from a source within the body as a result of deposition of radionuclides in body tissues by ingestion, inhalation, or implantation.

Inversion--(A) A reversal of position; (B) A reversal of the normal atmospheric temperature gradient.

Irradiation--Exposure to any form of radiant energy.

Isotope--A species of atom characterized by the constitution of its nucleus and hence by the number of protons and the number of neutrons in it. In most instances an element can exist as any of several isotopes, differing in the number of neutrons, but not the number of protons, in their nuclei. Isotopes can be either stable isotopes or radioactive isotopes (also called radioisotopes).

Micro--A prefix meaning small. Usually meaning it cannot be detected without the use of a microscope.

Mineral processing--The removal of waste and unwanted or deleterious substances from an otherwise useful product. Also separation of mixed minerals into distinct species.

Morrison Formation--Part of the Upper Jurassic of the Rocky Mountain region, consisting of floodplain stream-produced deposits which in some places contain dinosaur bones. The Morrison Formation contains most of the uranium deposits in the San Juan Basin.

National Environmental Policy Act (NEPA)--Public Law 91-190, 83 Stat. 852 (1970) as amended by Public Law 94-93, 88 Stat. 424 (1975).

Neutron--An uncharged elementary particle that has a mass nearly equal to that of the proton and is present in all known atomic nuclei except the hydrogen nucleus. Neutrons sustain the fission chain reaction in a nuclear reactor.

Nuclear fission--The splitting of an atomic nucleus (as by bombardment with neutrons), especially into approximately equal parts, resulting in the release of enormous quantities of energy when certain heavy elements such as uranium or plutonium are split.

Nuclear fuel cycle--The complete series of steps involved in supplying fuel for nuclear power reactors. It includes mining, refining, the original fabrication of fuel elements, their use in a reactor, chemical processing to recover the fissionable material remaining in the spent fuel, reenrichment of the fuel material, refabrication into new fuel elements, and management of radioactive wastes.

Nuclear fusion--The union of atomic nuclei to form heavier nuclei, resulting in the release of enormous quantities of energy when certain light elements unite, as in the combination of heavy hydrogen nuclei to form helium nuclei that takes place in the sun or in a hydrogen bomb.

Nuclide--Any species of atom that exists for a measurable length of time. A nuclide can be distinguished by its atomic weight, atomic number, and energy state. The term is used synonymously with isotope. A radionuclide is the same as a radioactive nuclide, a radioactive isotope, or a radioisotope.

Nuclear reactor--A device by means of which a fission chain reaction can be initiated, maintained, and controlled. The essential component of a nuclear reactor is a core with a fissionable fuel.

Particulates--Any liquid or solid particles suspended in or falling through the atmosphere.

Pasquill Stability Classes--Indications used by air quality specialists to measure atmospheric stability. The less stable conditions are, the better the prospects for dispersion of possible pollutants.

Radiation--(A) The process of emitting radiant energy in the form of waves or particles; also, the combined processes of emission, transmission, and absorption of radiant energy. (B) A term which embraces electromagnetic waves, particularly X-rays and gamma rays, as well as streams of fast-moving charged particles (electrons, protons, mesons, etc.) and neutrons of all velocities.

Radioactivity--The spontaneous decay or disintegration of an unstable atomic nucleus, accompanied by the emission of radiation.

Radionuclide--See nuclide.

Radon--(A) A heavy, radioactive, zerovalent gaseous element; in group O (inert gases) of the periodic table formed by the disintegration of radium. Symbol, Rn; atomic number, 86; mass number of the most stable isotope (atomic weight) 222. (B) Radon is the heaviest known gas. Colorless as a gas; yellow to orange-red, phosphorescent, opaque crystals. Soluble in water and slightly soluble in alcohol and in organic liquids. All 18 known isotopes from radon 204 to radon 224 are radioactive. Radon-222 emanates from radium; half-life, 3.823 days; and an alpha particle emitter. One part of radon exists in 1 sextillion parts of air.

Radium--A radioactive metallic element in group II of the periodic system; one of the alkaline-earth metals. The metal is silvery-white and resembles barium in its chemical properties. It occurs in pitchblende, in carnotite, and in other uranium minerals and it is separated from these minerals to obtain the radium salts of commerce. All 13 known radium isotopes (radium 218 to radium 230) are radioactive.

Raptor--Birds of prey with sharp talons and strong notched beaks; hawks, owls, vultures, eagles.

Seismicity--Measure of frequency of earthquakes.

Subsidence--(A) A sinking down of a part of the earth's crust. (B) The lowering of the strata, including the surface, due to underground excavations.

Transmissivity--The rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient.

Uranium ore grade--The percentage of uranium in an ore.

Uranium oxide--A chemical compound whose molecules are made up of three atoms of uranium and eight atoms of oxygen; designated as U_3O_8. Used as the measure of refined uranium. For uniformity and comparison, weights of other forms and compounds of uranium and uranium ore are usually converted to the equivalent weight of uranium oxide.

U_3O_8--Uranium oxide. (Also see text, p. I-4.)

Working level--The underground level or area that mining is taking place. (For terms "working level" and "working level month" in connection with radiation exposure, see text, p. IV-37.)

Yellowcake--The yellowish product of the milling process containing a concentrated compound of uranium. Measured in its equivalent weight of U_3O_8.

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